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Blue Crab Does Run Full Moon: Using Indigenous (Aboriginal/Native) Ways of Being, Knowing, and Doing Science to Enrich School Science Curricula.

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ABSTRACT

The study investigates the nature of the science of the First Nations people of Trinidad, and then integrates it with western science into a mini-curriculum. This ethnographic, exploratory case study utilised a variety of data collection strategies. Semi-structured interview of their Elders provided the primary data for analysis. Small amounts of participant observation and document analysis were used to gain entry to the research site, and to better understand the context of the study. Email interviews of expert science educators informed the introductory chapter. A reflexive researcher's diary also contributed at various stages of the study. A complex adaptive theoretical system (as opposed to mixed methods) was able to accommodate the contradictory, yet interacting, theoretical positions of western and indigenous science. Mixed methods would account for the contradiction between theories but not for their interaction. The First Nations science of Trinidad was found complex adaptive; empiricist/positivist; hypodeductive; relational; holistic; to view self-actualisation as the primary aim of scientific knowing; and was focused more on the intervention methods of science, as opposed to depicting those methods as theories or other representations. The evolution of scientific knowledge via paradigmatic shifting was not seen in the nature of the science of the participants. The findings were then used to inductively derive the curriculum using a connected model of integration. Continued investigation is suggested into: the nature of indigenous science, its relationship with western science, and the use of complex adaptive systems as a theoretical framework to do so; ethical research procedures for Indigenous (Aboriginal/Native) Caribbean peoples; the development of accepted oral research reporting formats; refinement of the interview protocol; and pilot-testing and expansion of the mini-curriculum via a complex adaptive method of integration (e.g. a networked or immersed model). The nature of Trinidadian science may also be a worthwhile continuation of this study.

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Common Abbreviations and Acronyms used in the Thesis

Abbreviation	Meaning
CAS	Complex Adaptive System
IS	Indigenous Science
NS	Native Science
NOS	Nature of Science
WMS	Western Modern Science/Conventional Science/The Standard Account of Science

DISCLAIMER

The mini-curriculum of work utilised stories depicting the epistemology of First Nations peoples from the Mohawk and Seneca nations of North America as such stories have not been catalogued by similar groups within Trinidad. The stories were taken from 'The Heritage Book of American Indian Legends' published in 1968 by the now defunct Heritage Press of The George Macy Companies, Incorporated. This disclaimer firstly addresses that I have tried to contact the publishers for permission to use these stories without success. The stories do represent far less than 10% of the work from which they were extracted (which is the usual amount allowed for photocopy by copyright law).

The front matter of the book (no page number), says that the legends are "from the writings of Henry R. Schoolcraft, George Bird Grinnell, Franz Boas, and others". Rightfully so, all of the stories within the book have listed the First Nation from which they have emerged. The first story that I utilised within the curriculum was 'The Discovery of Fire' (Reproduced from The Mohawk Nation, 1968), and the second 'The Origin of the Medicine Society' (The Seneca Nation, 1968).

Whilst I acknowledge and respect the publisher's rights, I must confess that I was uncomfortable appealing to them for the use of Indigenous knowledge that belongs to the Mohawk and Seneca Nations of First peoples. These peoples practice an oral tradition and their tales are passed through the generations by word of mouth: can/should/does an author who plucks those stories out of the invisibility of words and fixes them onto paper own them? I have been careful then whilst using an author-date method of referencing to ensure that I have acknowledged both the ownership of the First Nations of these stories, as well as the published book from which I extracted them. I do not know if in time this will reveal itself to have been the most ethical means of reproducing these stories, and I continue to call for protocols that more strongly dictate the use, representation, and ownership of Indigenous knowledge systems within academic research.

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DEDICATION

This thesis is dedicated to my parents Ann and Zaid for being the wind beneath my wings: for your love, guidance, and unfailing belief in my abilities. And to my children Anthony and Stephan for all the life that we have missed together because of it.

CHAPTER 1

INTRODUCTION

1.1 Aims of the Chapter

The dissertation focuses primarily on the nature of First Nations, Aboriginal science in Trinidad, and suggests how this knowledge can be used to enhance science curricula. This chapter introduces the issue, its background, and the research's purpose, questions, and significance.

1.2 Statement of the Issue

To describe the background from which the issue emerges, this subsection firstly discusses what is science, and the problems arriving at such a summary through a consideration of definitions for both western modern science, and for indigenous science. It is then suggested how the colonial/postcolonial influence has carved scientific practice within Trinidad so that these two types of sciences (western and indigenous) have become interwoven to produce a new science hybrid in real life practice. Lastly, it is suggested that this new hybrid justifies, for Trinidad, a multicultural school science curriculum that creates student experiences which allow them to choose if the artefacts of western or indigenous science best suit the needs of their everyday lives (this is called autonomous acculturation).

1.2.1 Defining Science

Within "science education, the definition of science is a *de facto* gatekeeping device for what can be included in a school science curriculum and what cannot" (Cobern & Loving, 2001, p. 52).

The contemporary literature refers to mainstream science as the 'standard account', 'conventional', and 'western modern'. The terms 'standard' or 'conventional' beg

the question ‘standard and conventional to whom?’, and suggest that these terms represent a science whose worldview is not necessarily globally representative. Moreover, the term ‘western modern’ indicates that ‘conventional’ and ‘standard’ scientific practices are built on a western (European) worldview which was popularised by the scientific revolution (Basalla, 1967). This thesis hence adopts the term ‘western modern science’ – abbreviated to WMS throughout – to refer to the standard or conventional account of science.

Given the possibility of a plethora of sciences, how is science and its nature to be defined? The postcoloniality of the site of this study also complicates definition because Trinidad’s local scientific practices are a tapestry of that of its First Nations people as well as the sciences of the lands of the people who were brought, or who came, to the island (e.g. African slaves, Indian and Chinese indentured labourers, and Western European colonisers).

This thesis considers only part of Trinidad’s scientific-tapestry: the nature of science of the Aboriginal people with subsequent recommendation of how it can be used to enhance science curricula. Given the complexity of Trinidadian science, to help me define science and its nature, within this introductory chapter I have supplemented a review of the literature with interviews of experts who understand its multidimensionality. The experts are all Trinidadian scientists and science educators. An inclusion of the views of Caribbean experts was thought paramount since the literature is often dominated by positions of powerful science education bodies such as the American National Science Teachers’ Association (NSTA). The NSTA’s definition of science embraces one nature of science (closely aligned to western science) and does not paint an adequate picture of how we do science in Trinidad. The NSTA posits that

> All those involved with science teaching and learning should have a common, accurate view of the nature of science. Science is characterized by the systematic gathering of information through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. The principal product of science is knowledge in the form of naturalistic concepts and the laws and

> theories related to those concepts. (National Science Teachers' Association, 2000b , "Preamble")

Science curricula utilised within Trinidad also reflect similar allegiances to western science as does the NSTA document. For example, Trinidad's newly revised national draft of the primary school curriculum states that

> Science is a distinct form of human activity, which involves a dynamic way of exploring ourselves, the world in which we live, and beyond. Scientific progress comes from rational, systematic work and from creative insights, built on a foundation of respect for evidence. Scientific knowledge is not fixed and it is this on-going quest that makes science a valuable knowledge system. (Trinidad and Tobago. Ministry of Education, 2013, p. 21)

Moreover, Trinidad's lower secondary science syllabus views science similarly, as

> the study of the biological and physical environment. It is a method of problem solving which requires that all the necessary resources and skills be used to gather objective evidence, analyse and synthesize that evidence, then make inferences and draw conclusions. These activities require specific skills and habits of mind, such as accuracy, discipline, and integrity in the application of scientific principles, which are fundamental to scientific activity. (Trinidad and Tobago. Ministry of Education, 2008, p. 22)

All of the definitions above that were extracted from the literature support western modern science (WMS). Three of the six Caribbean science teacher-educators who were interviewed via email replied, and responded to the lone question, "What is science?" Their responses (Western Modern Science (WMS)-Experts 1, 2 and 3) are treated as interview data and are summarised below. Each of their definitions agree with the positions already stated, but some have additional reflections and have helped to enrich the definition of policy documents (as stated above) about how Trinidadian science is done.

Western Modern Science-Expert 1 (WMS-Expert 1) holds a PhD in Astronomy and has been a science educator for 15 years. She defines science as "a systematic process which helps us to understand the structure and behaviour of the physical and natural world through observation and experimentation".

Western Modern Science (WMS)-Expert 2 (WMS-Expert 2) holds a PhD in Teacher Education. She has been a science educator for 29 years. In her interview she defined "science as the unfolding to humankind of the laws of nature that God instituted in the universe at creation". WMS-Expert 2 cited the evidence in 'Table 1' in support of her position.

Table 1: Science Confirms the Bible (Living Waters, n.d.)

The Bible (2,000–3,000 Years Ago)	Science Then	Science Now
The earth is a sphere (Isaiah 40:22).	The earth was a flat disk.	The earth is a sphere.
Innumerable stars (Jeremiah 33:22).	Only 1,100 stars.	Innumerable stars.
Free float of earth in space (Job 26:7).	Earth sat on a large animal.	Free float of earth in space.
Creation made of invisible elements (Hebrews11:3).	Science was ignorant on the subject.	Creation made of invisible elements (atoms).
Each star is different (1 Corinthians 15:41).	All stars were the same.	Each star is different.
Light moves (Job 38:19-20).	Light was fixed in place.	Light moves.
Air has weight (Job 28:25).	Air was weightless.	Air has weight.
Winds blow in cyclones (Ecclesiastes 1:6).	Winds blew straight.	Winds blow in cyclones.
Blood is the source of life and health (Leviticus 17:11).	Sick people must be bled.	Blood is the source of life and health.
Ocean floor contains deep valleys and mountains (2 Samuel 22:16; Jonah 2:6).	The ocean floor was flat.	Ocean floor contains deep valleys and mountains.
Ocean contains springs (Job 38:16).	Ocean fed only by rivers and rain.	Ocean contains springs.

Table 1 (continued): Science Confirms the Bible (Living Waters, n.d.)

The Bible (2,000–3,000 Years Ago)	Science Then	Science Now
When dealing with disease, hands should be washed under running water (Leviticus 15:13).	Hands washed in still water.	When dealing with disease, hands should be washed under running water.

Though WMS-Expert 2's position is Bible based, the beliefs listed in 'Table 1' that she has cited as evidence supports the knowledge content of WMS.

Western Modern Science-Expert 3 (WMS-Expert 3) holds a PhD in Health and Family Life Education. She has been a science educator for the last 45 years. In her interview she defined science as

> a) body of knowledge about our understanding of the natural world around us – how it works, what it is made up of, what evidence we have to support this knowledge, etc., and b) a process that guides the way the body of knowledge is accumulated.

WMS-Expert 3 expands her definition to include what she terms 'formal' and 'informal' science (phenomena whose parallel terms in this thesis are 'school' and 'home' science).

> I also believe that there is formal science – the body of knowledge agreed upon by persons who have tested theories that provide explanations, or collected based on the hard evidence/data and reviewed over time. This is the science mostly of Western scientists (mostly male and white), that is documented and which finds its way into the science academies, and curriculum of schools. I also believe that the processes for 'discovering formal science' are multiple, in that a process may follow strict rules that involve coming up with a hypothesis, collection and analysis of data and establishing findings which could be corroborated by others and generalized; a process may consists [sic] of observation of phenomena over a period of time; or the intuition that some people have about an event, phenomenon, that is investigated and confirmed.

> I also believe that there is informal science, the body of knowledge about the natural world that is understood and shared by individuals or groups in societies, for example people in 'non-western cultures' including Trinidad and Tobago. This body of knowledge and the processes involved are seldom documented but passed on in an oral tradition or simply shared through modelling so that younger generations are inducted into the same way of knowing and doing.

Science then means many things to different people, even if they are experts. Moreover, if one does not hold to uniformitarianism, (that the world we are trying to know is fixed and operates by constant rules), then how and what we think about science too is suggestively developmental and resists stable definition (Suchting, 1995). After many decades of debate there is still no universal answer to the questions seeking what is science or what is science's nature (Abd-El-Khalick & Lederman, 2000; Cobern, 2000a; Kang, Scharmann, & Noh, 2004; Lederman, 1992). The nature of science deals with how and what knowledge is created about the world around us. However, the debatable nature of the reality of that world complicates accepted methods by how that reality should, or can, be known. That is, which methods of knowledge creation are most *scientific* or create *scientific knowledge* (as opposed to metaphysics for example). The plethora of instruments used to measure the nature of science differ in their categories and dimensions – that is, in their definition of the nature of reality and how it should be measured or can be known (e.g. of these instruments include Aikenhead & Ryan, 1992; Cobern, 2000b; Elby, Frederiksen, Schwarz, & White, n.d.; Halloun, 1997; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Maryland Physics Education Research Group, 1997; Nott & Wellington, 1993; Pomeroy, 1993; Rubba & Andersen, 1978). In summary,

> 'scientific thought', considered as a 'practical' concept denoting both a process by which a certain result is arrived at and the result itself, should be tackled by identifying (in a purely referential sense) a relevant paradigm, and then explicating the 'sense' of that paradigm in both its generic and specific aspects. (Suchting, 1995, p. 5)

This suggests that any model of science, or the nature of science, guiding practical activities or research are more efficiently discussed as a referential or guiding

paradigm chosen for its broad utility, as well as its relevance to the context in which it is employed.

Even so, attempts to describe/define *a* (as opposed to *the*) nature of science (NOS) have arrived at some agreed broad characteristics of what NOS is or addresses, namely: the content of science and by application the products (e.g. theories, laws) that it can make; the processes by which science is done and by which it creates this knowledge content; and finally the values that are associated with scientific knowledge and its creation (Abd-El-Khalick, Bell, & Lederman, 1998; Clough, 2006; Lederman & Lederman, 2004). These three broad categories can be thought to represent/reflect the ontological, epistemological, and axiological considerations within definitions of science (i.e. content, process, and values).

1.2.2 Indigenous Science

Indigenous science (IS) may be considered as an alternative model to western modern science. IS is itself a type of indigenous knowledge or an indigenous knowledge system developed by a community. Indigenous knowledge is

> a body of knowledge associated with the long-term occupancy of a certain place. This knowledge refers to traditional norms and social values, as well as to mental constructs that guide, organise and regulate the people's way of living and making sense of their world. (Dei, Hall, & Rosenberg, 2000, p. 6)

Indigenous knowledge is constructed within local societal settings by ordinary lay members of a particular community in response to, and to help them navigate, the environments of their everyday lives. Indigenous knowledge construction requires creativity and ingenuity to craft novel solutions to daily issues and tends to be passed between generations orally, though some cataloguing of indigenous knowledges has begun (George, 1999). In fact, "indigenous science relates to both the science knowledge of long-resident, usually oral culture peoples, as well as the science knowledge of all peoples who as participants in culture are affected by the worldview and relativist interests of their home communities" (Snively & Corsiglia, 2001, p. 6). WMS-Expert 3's (see p. 20) informal science also aligns with such

definitions of indigenous science. The science practices of Trinidad's Aboriginal peoples is an indigenous science in itself, *and* then a subset of the indigenous science of Trinidad. As demarcation then, the science of Aboriginal/First Nations peoples is referred to in this document as 'native' science, or sometimes as the native-indigenous science in Trinidad. When 'indigenous' science is used, it refers to the general class of such sciences.

To be clear, indigenous science is a type of indigenous knowledge (see the definition by Dei, Hall, & Rosenberg, 2000 in section 1.2.2). In keeping with this definition indigenous science is the scientific knowledge that a people who have lived in a particular place develop over a long time to help them to thrive successfully within that terrain. Trinidad as a particular geographic area has its own indigenous science that our people have developed. Our indigenous science contains both WMS and our own particular beliefs of the world and our own special ways of coming to know the world and has been described in George's (1986 as cited in George, 1999) taxonomy (in section 1.2.3.2). A particular example of how this enacts within the lives of everyday Trinidadians is described through the experiences of Mrs. S and Trinidadian WMS-Expert 3 in section 1.2.3.3. Some of these particular beliefs and our own special ways of coming to know the world include the science of our native First Nations peoples. The science of our First Nations peoples is itself an indigenous science. To demark it from the wider indigenous science of Trinidad of which it is a part, it is referred to in this thesis as native science or the native-indigenous science of Trinidad.

1.2.3 Trinidadian Science

The email interviews presented earlier with WMS-Experts 1,2, and 3 indicate the science of Trinidad as a tapestry of western and indigenous sciences. This tapestry may be accounted for by the colonial impact on Trinidad, itself a postcolonial nation.

1.2.3.1 How Science Grows in Colonial/Postcolonial Countries

Science historian George Basalla (1967) postulated a process comprising three overlapping phases, as a heuristic device to promote understanding as to how western modern science (WMS) spread and became entrenched in the non-west; or more accurately non-western European countries settled through western European political, economic, and cultural expansionist agendas. My experience with the scientific endeavour within Trinidad has indicated that his three phased heuristic is applicable for us.

Firstly, Basalla (1967) admits that his is a "simplified model"(p. 620). Moreover, his paper utilises a glaringly positivistic frame about which he demonstrates little reflexivity, and which stands dissonant to indigenous science in many ways. Even so, the author admitted in his conclusion that future scholarship might begin to indicate the impact of context and culture on participation in, as well as conceptual development within, science: musings that have been proved correct by modern day scientific practice (of which this thesis is example).

In phase one, as Europeans expanded their settlement in foreign lands, they used western modern science (WMS) to investigate the habitability of the new territory, particularly through an assessment of its natural flora, fauna, and geographic resources. The settled territories then became sites for the practice of WMS. Phase two is considered as a period of colonial science during which the scientific practice within the conquered, colonial territory is reliant upon the services, practices, and methods of a society considered more scientifically advanced (in terms of WMS). For example, even though Trinidad is an independent republic, our very practice of science predominates around the worldview of WMS and many of our scientists are still educated at universities abroad. Moreover, we utilise apparatus and materials manufactured in foreign countries to carry out scientific experiments whose findings are then predominantly disseminated through the more highly regarded foreign academic journals and conferences. In phase three, the scientific enterprise of a country is so entrenched that it has become a self-reliant entity. The country has strong educational programmes to train and induct new scientists, and sufficient services and knowledge resources to develop the tools (e.g. apparatus and materials)

necessary to carry out science. At stage three a country will also command a variety of channels for knowledge dissemination (e.g. academic journals and conferences) that are respected and trusted by the scientific community for the quality of their contributions. In stage three the country is able, and tends to, make noteworthy contributions to the growth of the scientific discipline. Such efforts are usually visible in the country's global prize recipients (e.g. the Nobel Prize) or scientific discoveries. Within the third phase, scientific practice is uncapped as it has the ingredients necessary for its almost exponential growth and promotion (Basalla, 1967).

1.2.3.2 Impact of Colonialism on the Nature of Trinidadian Science

Trinidad sits squarely within Basalla's (1967) phase two and is still labouring to shift into phase three. I suggest an extension to Basalla's phase three which is difficult to consider from within the positivist bounds of his theoretical framework. Whilst I agree with Basalla that phase three is about establishing "an independent scientific tradition" (Basalla, 1967, p. 17), I think for postcolonial states such as Trinidad, that this extends past the entrenchment of a system aimed at replicating and pushing the boundaries of western science. I suggest that the establishment of an independent scientific tradition should also include a self-discovery of the very ways through which science is done locally, that is the nature of local science. This may be key to indicating not only the contextual limitations that will need to be addressed to facilitate an entrenchment of phase three, but also in directing the course of how phase three can be promoted.

Below is the only taxonomy of Trinidadian scientific knowledge:

> CATEGORY 1 The indigenous practice can be explained in conventional science terms. For example, the indigenous practice of using a mixture of lime juice and salt to remove rust stains from clothes, can be explained in conventional science in terms of acid/oxide reactions.
>
> CATEGORY 2 A conventional science explanation for the indigenous knowledge seems likely, but is not yet available. For example, a brew made from the plant 'vervine' (Stachytarpheta) is used in the treatment of worms

> in children. This plant is considered in conventional science circles to have pharmacological properties, but appropriate usage has not been verified [by conventional science].
>
> CATEGORY 3 A conventional science link can be established with the indigenous knowledge, but the underlying principles are different. For example, the indigenous admonition that eating sweet foods causes diabetes links diabetes with sugars, as does conventional science. However, whereas the indigenous system claims that sugars cause diabetes, conventional science claims that when one is diabetic, the ingestion of sugars can worsen one's condition.
>
> CATEGORY 4 The indigenous knowledge cannot be explained in conventional science terms. For example, there is no conventional science explanation for the indigenous knowledge claim that if one cuts one's hair when the moon is full, the hair will grow back to an increased length. (George 1986, as cited in George, 1999, p. 85)

Investigation of these descriptors indicate Trinidadian science as a hybrid of western science (conventional science), and Trinidad's own indigenous scientific practices. If western modern science in Trinidad is considered as a colonial remnant, analysis of the 1994 work of Homi Bhabha, 'Location of Cultures', may promote understanding of its hybridity.

> Bhabha shows how postcoloniality always involves the 'liminal' negotiation of cultural identity across differences of race, class, gender and cultural traditions. He argues that cultural identities cannot be ascribed to pre-given, irreducible, scripted, ahistorical cultural traits. Nor can 'colonizer' and 'colonized' be viewed as separate entities that define themselves independently….Instead, Bhabha suggests that the negotiation of cultural identity involves the continual interface and exchange of cultural performances that in turn produce a mutual and mutable recognition of cultural difference. (Rizvi, Lingard, & Lavia, 2006, p. 253)

I have suggested elsewhere (Boisselle, 2016) that if Bhabha's position is applied to the scientific endeavour then it can be extrapolated that George's (1986, as cited in 1999) taxonomy may indicate the 'liminal negotiation' between western modern science (WMS) and the indigenous science that occurs within scientific practice in Trinidad. That is to say, indigenous science within Trinidad is a mix or hybrid of WMS and indigenous science. However, the indigenous science of Trinidad is itself

a hybrid, and contains the scientific practices of all Trinidadians: that is, the First Nation peoples; all of the peoples who landed or were brought here (e.g. African slaves, and East Indian and Chinese indentured labourers); those born right here (e.g. Creoles or descendants of the other groups); and of course elements formed from the interactions of the sciences of each of these factions as the groups interact communally. This hybrid that George (1986, as cited in 1999) describes may be described as a postcolonial indigenous science (compared to the pre-colonial indigenous science of the Aboriginal people who lived here before the colonisers). Even so, though Trinidad arguably has two indigenous sciences – a precolonial and a postcolonial variety – none of these are represented in curriculum policy documents of Trinidadian school science which are still strongholds of WMS. This thesis is not expansive enough to consider the nature of Trinidadian science (which it recommends as a continuation of this work), and as an introduction focuses on the precolonial (First Nations) native-indigenous science of the country. There are many landed groups in Trinidad of whom many of us are descendants; for example the Indo-Trinidadians, Afro-Trinidadians, Chinese-Trinidadians and Creoles like me. There is often tension surrounding exactly what Trinidadian means – what practices, people, culture – are Trinidadian; and what 'indigenous' means for our country. With little argument though, the First Nations peoples are the original Trinidadians and their history and practices belong to all of us. It is their Aboriginal – Trinidad's native-indigenous – science on which this study focuses.

1.2.3.3 The Integration of Native-Indigenous Science into School Science Curricula: Justifying a Multicultural Science Education

The recognition that students' culture affects how they learn is not a new one, and theories such as collateral learning (Jegede, 1995), situated cognition, and the varieties of constructivism, support. Geertz (1973) views culture as webs of meaning spun by an individual that enmeshes them, and from within which and through which, they reach out to experience and make sense of the world. Within such a scenario it would be impossible for an individual to do and make science outside of the enmeshment of their distinctive culture. Hence, not only is Maddock's (1981) proposition of science and science education as cultural pursuits unsurprising, but so too is the conception of a variety of sciences – each being

discerned from within a particular web of meaning. As far back as 1975 the American Association for the Advancement of Science (AAAS) validated one of these sciences – the native science of the First Peoples of the Americas:

> Be it resolved that the Council of the Association (a) formally recognize the contributions made by Native Americans* in their own traditions of inquiry to the various fields of science, engineering, and medicine, and (b) encourage and support the development and growth of natural and social science programs in which traditional Native American approaches and contributions to science, engineering, and medicine are the subject of serious study and research.
> *The term 'Native American' refers to the descendants of the aboriginal inhabitants of the Americas, often referred to as American Indians. Adopted by the AAAS Council, January 31, 1975.(American Association for the Advancement of Science (AAAS), 1975)

Some 40 years later no comparative statement on native sciences has been made by Caribbean regional bodies similar to the AAAS, for example the Caribbean Science Foundation (CSF), and Trinidad's National Institute for Higher Education, Research and Technology (NIHERST). There is also no official national Trinidadian policy position on multicultural science education, the nature of science, or on science/scientific literacy. The absence of an official policy does not represent a decided position on the role of these constructs within our school curricula but more so highlights the urgent need for debate around these issues.

A multicultural science pedagogy is linked to 'science for all' initiatives and the US National Science Teachers' Association's preamble on multicultural science education asserts that

> Science educators value the contributions and uniqueness of children from all backgrounds….a country's welfare is ultimately dependent upon the productivity of all of its people. Many institutions and organizations in our global, multicultural society play major roles in establishing environments in which unity in diversity flourishes….science literacy must be a major goal of science education institutions and agencies. We believe that ALL children can learn and be successful in science and our nation must cultivate and harvest the minds of all children and provide the resources to do so. (National Science Teachers' Association, 2000a , "Preamble")

The international scholarly literature has long supported that a multicultural science education should give people the literacy to efficiently traverse their life space, and that an inclusion of the ways that a people/society might practice science can have a beneficial role within their school curricula (e.g. see Aikenhead, 2001; Barton, 2000; Cobern & Loving, 2001; Jegede, 1995; Kawagley, Norris-Tull, & Norris-Tull, 1998; Roth & Lee, 2004; Sutherland & Swayze, 2012). For decades, too, the Caribbean scholarly literature has held a similar position (e.g. see George, 1986, 1993; George & Glasgow, 1988). Some other considerations that argue for a multicultural science curriculum are:

- a recognition of WMS as only one way of coming to know the world better enables students to cogently participate in modern scientific discourse (Stanley & Brickhouse, 1994);
- students' cultural beliefs impact on their ability to successfully pursue a WMS curriculum (Jegede & Okebukola, 1991);
- to encourage the scientific participation and success of ethnically diverse students (Bazron, Osher, & Fleischman., 2005; Gay, 2002);
- the promotion of inclusivity and science for all (Kawagley et al., 1998);
- to rediscover and begin to preserve cultural epistemological systems desecrated by colonialism and to begin to reorient scientific practice and science education within postcolonial societies (Quigley, 2009);
- to delineate theoretical systems that can house the ontological and epistemological dichotomies of various sciences (especially of native and western science) within science instruction (Mpofu, Otulaja, & Mushayikwa, 2014).

How a multicultural science education is enacted within classrooms is debatable, but for the most part it usually recognises western modern science (WMS) as its ultimate goal. For instance, regardless of methodologies, the US standards for science education hold that school science should reflect "the intellectual and cultural traditions that characterize the practice of contemporary science" (National Research Council (NRC), 1996, p. 21). The next iteration of US standards since 1996, the New Generation Science Standards (NGSS), (National Research Council, 2012) are in the process of being debated and ratified across the United States. Investigation of the NGSS indicates a much more carefully (and inclusively) worded document than the previous standards. The NGSS aims at educational equity through the use of students' cultural experiences but still facilitates student

learning primarily within a western modern science framework. Similarly, an investigation of Trinidad science syllabi reveals WMS as our de facto stance (see the positions in Trinidad and Tobago. Ministry of Education, 2008; and in Trinidad and Tobago. Ministry of Education, 2013 as discussed earlier).

Even in the face of the lack of inclusion of indigenous science content knowledge in Trinidad's curricula policy documents, there is an even louder absence of a recognition of any type of indigenous science, native or otherwise. My 21 years of experience within Trinidadian science classrooms indicates that most science teachers are unaware of, and/or unfocused on, indigenous science. Indigenous science is generally utilised within Trinidadian classrooms particularly to ascertain students' indigenous science knowledge so that an efficient pedagogical strategy to cross them into the realm of western modern science (WMS) can be derived. Such practices of border crossing seem to indicate that indigenous science is flawed in some way because students' learning is valid only when it shifts towards or mimics WMS. I agree that pedagogical strategies need to be derived to successfully walk students from their everyday culture into science's subculture, the two often being different: that is, that "the norms, values, beliefs, expectations, and conventional actions of students' life-world subcultures assume a legitimate place in a cross-cultural science curriculum" (Aikenhead, 1996, p. 30). I, though, view border crossing solely as a zone of proxima that exists between different conceptions of science rather than an attempt to bring 'non-conventional' sciences into the promised land of WMS.

What then could a multicultural science pedagogy that embraces native sciences look like? For Trinidad indigenous sciences is a big part of how we as a people do science as evidenced by George's (1986, as cited in 1999) taxonomy, and may be argued as a relevant piece of a place based, multicultural curriculum. Indeed, curricula sympathetic to indigenous knowledge are showing up in locations with strong Indigenous and Native peoples' presence and lobbies. Some of these locations include Alaska (Alaska Native Knowledge Network, n.d.), Australia (Australian Curriculum Assessment and Reporting Authority, n.d.), and Canada (Ontario Secondary School Teachers' Federation, 2012). However, once the practices of indigenous sciences enjoy widespread utility they threaten to be

absorbed into the standard account of science (Cobern & Loving, 2001). Hence, native science may be better taught juxtaposed against western modern science, to which it would act as a critique.

> If students can also learn how the purposes of scientific activity have varied in different cultures and historical times, and how other cultures have developed sciences to meet these purposes, then they can also learn that the form of contemporary Western science is not universal, inevitable, or unchangeable. This kind of understanding is needed to encourage the critical thinking about the purposes Western science has served, and how these could be changed to create future sciences that better meet the needs of the diverse societies that support them. (Stanley & Brickhouse, 1994, p. 396)

A pedagogical strategy that facilitates a critical juxtaposition of indigenous (including Aboriginal) and western sciences can treat each one as a subculture. This will provide opportunities for students to manage, and be critically aware of, their own crossings of the cultural borders between sciences as their life experience necessitates. Within such a system of autonomous acculturation students would utilise the knowledge of any science that helped them to navigate their environment (Aikenhead, 1996). This border crossing between scientific subcultures requires a shift across the worldviews that particular sciences use to validate knowledge as well as between their beliefs, suppositions, and traditions and protocols (Aikenhead, 1996). I am suggesting then that a useful end product of a multicultural science curriculum incorporating WMS and native science would be autonomous acculturation in which students could critically compare and contrast the worldviews and content of these various sciences without necessarily *believing* them.

Autonomous acculturation already impacts on science practices within Trinidad. Consider the following two cases. Firstly, Mrs. S lives in a Trinidadian village on the rural north-eastern coast of the island and the case looked at how she utilised conventional and traditional/indigenous science within her everyday life.

> Throughout her conversations, Mrs. S used conventional science terms and in so doing, exhibited varying levels of understanding of their meanings. There did not seem to be any conscious distinction made between

> conventional science terms and traditional ones. Mrs. S seemed to be using whatever terms/concepts she thought could best describe the situation at hand. At times, she used the science terms alongside traditional concepts. (George, 1995, p. 254)

A second case of autonomous acculturation is also evident in WMS-Expert 3's definition of science which I continue here:

> I also believe that the formal science taught in schools is sometimes at odds with the informal science that offers everyday explanations of phenomena. I personally have held conflicting views of some phenomena, but have learned to draw on the appropriate explanation depending on the context. I will use explanations from formal science in academic circles, or formal situations, but in informal situations I will fall back on informal explanations. For example, I know that the formal explanation for the common cold is that it is caused by a virus, but I will make sure to cover my head if the temperature falls drastically, or if it is raining or snowing, because I might 'catch a cold'.
>
> I also believe that there is a lot of 'informal science knowledge' that has not been documented, but could offer alternative ways of understanding the natural world, or might even offer corroboration of explanations provided by formal science.

The school science of Trinidad is predicated on western modern science as is evidenced in our national policy documents (see excerpts from Trinidad and Tobago, Ministry of Education, 2008 and 2013 in section 1.2.1). Western modern science is presented in these curricula with attributes regularly associated with WMS such as empiricism/positivism, hypo-deduction, falsification, and knowing through paradigm shifts and scientific revolutions or through representations and interventions (each of these are discussed in sections 2.3.2 to 2.3.6). There is recognition too that the nature of WMS is contested and unclear (see section 2.3.10). Even so, students bring their cultural understandings of science gained from their participation in the daily living of their communities into the school classrooms with them and it has been advised that these cultural understandings need to be recognised in order to facilitate efficient instruction (Aikenhead, 1996; Aikenhead & Jegede, 1999; Aikenhead & Ogawa, 2007; Barton, 2000; Bazron, Osher & Fleischman, 2005; Herbert, 2008). Trinidadian science has been described

by George (1986 as cited in George 1999) using a four level taxonomy which indicates that Trinidadians practice science culturally as a mix of western and indigenous science (see section 1.2.3.2) and that even our scientific experts themselves science teachers and teacher-educators, embedded within and practicing members of our culture, also share similar scientific practices (see section 1.2.1). Science instruction within Trinidadian classrooms in my experience tries to honour both our policy allegiance to WMS as well as our cultural allegiances to our indigenous practices and to who we are as a people. Admittedly, I have witnessed tension between these two aims within Trinidadian science classrooms as moving students from their cultural scientific practices across the border (Aikenhead, 1996) into WMS suggests that they abandon cultural practices that are in many ways part of our Trinidadian identity. This issue has not been made patent in our policy documents and I suggest in this section what multicultural science education might look like.

In summary, I am suggesting the possible worth of curricula designed to promote the cultural inclination towards autonomous acculturation demonstrated in the cases above. This may enable students to become more conscious and critical about their border crossings within the western modern-indigenous science hybrid of Trinidadian science. Within a focus on the native-indigenous science of Trinidad, the first step is the preparation of a non-age specific, 'stand-alone' unit of work/mini-curriculum that allows users to become aware of the nature of the native science of Trinidad's First Nations peoples, and to enter into a critical juxtaposition between it and WMS. The curriculum has been prepared for the primary representative group of the First Nations peoples in Trinidad, The Santa Rosa First Nations Community. It has been prepared for use in their educational outreach, and museum activities.

1.3 Participants: The Santa Rosa First Nations Community of Trinidad

The historical material in this section is summarised from, and triangulated over, artefacts held by the Santa Rosa First Nations Community including brochures and displays at their museum (see Appendix A).

The Santa Rosa Community is the only organising and representational body of the Amerindian First Nations peoples of Trinidad and Tobago, and can trace its lineage back to the first native Trinidadians. The modern history of the Santa Rosa community began in 1970 when the present Chief was elected. Santa Rosa was incorporated as a company in 1970, gained government recognition as the legitimate representative of Aboriginal peoples in Trinidad and Tobago in 1980, and shifted to non-governmental organisational status in 1991. The community is led by its Elders and main knowledge keepers – Chief, Ricardo Bharath Hernandez; Medicine Man, Cristo Adonis; and Queen, Jennifer Cassar. The community has received the Chaconia Silver Award, one of Trinidad's highest, for their work in culture and community service. They have also successfully lobbied to have the 14th October designated as 'Amerindian Day' in recognition of the First Nations' contributions to Trinidad, and around which an annual week-long celebration is held.

The ancestors of the First Nations peoples in Trinidad migrated from the South American mainland over 7000 years ago. Trinidad was called Caeri, or 'The Island', as it was so compared to their original mainland home. Later on the Lokono (Arawak) Nation named it 'Iere' or 'Land of the Hummingbird' as it is still fondly called today by many Trinidadians.

The First Nations peoples numbered about 40 000 by the time Christopher Columbus arrived in 1498 and claimed Caeri for the Spanish Crown, renaming it La Trinidad or the Trinity. The Aruaca, Garini, Nepuyo, Shebaio, and Yaio Nations that were on Iere at the time proudly resisted Spanish domination for some 100 years at a cost of a 75% reduction in their population. There were two major historic wars during that century. In 1532 the Garini Nation was able to expel the agent of the Spanish crown, Antonio Sedeño, who abandoned the island soon after. It was not until 1592 that the first coloniser settlement San José de Oruña, (the modern day town of St. Joseph), was built on top of the decimated village of the Garini Chief, Goanagoanare. Still, there was resistance by the First Nations peoples and in 1636/1637 the Nepuyo war Chief, Hyarima of Arima, destroyed St. Joseph, the only settlement of the Spanish coloniser on Trinidad at the time, causing them to flee the island. The Spanish returned a few years later and were able to defeat

Hyarima who is suspected to have been tortured for his efforts at defending his home, the way of life of his people, and protecting his land.

After this the encomienda system, started with the establishment of St. Joseph, became more deeply entrenched. The surviving Aboriginal peoples were gathered into encomiendas whose lands were gifted to Spanish colonists in return for their service to their monarchy. Each encomienda owner was responsible for the care of Aboriginal peoples therein and was responsible for their conversion to Christianity. Though the status of the Aboriginal peoples was relegated far below that of the colonists, the encomienda system surprisingly brought some measure of stability compared to the previous century-long period of resistance. Being allowed to live together on the encomiendas allowed Aboriginal peoples to preserve their ancestral ways of life and to continue reproducing their societal ways of being, knowing, and doing. Towards the end of the 18th century three encomiendas still existed – the Nepuyo Nation villages of Cuara, Aruaca and Tacarigua. In 1785 the new European immigrants were given the lands of these nation villages, and the First Nations peoples who lived in them clustered together and went to live in Arima at the then new Mission of Santa Rosa de Arima. Missions were at the time run by Spanish Roman Catholic priests who converted the Aboriginal peoples to Christianity and used them for labour.

The Santa Rosa Mission welcomed non-Trinidadian Amerindians from other communities including those fleeing persecution from the neighbouring isle of St. Vincent, and the civil wars of Venezuela. Non-Amerindian peoples also joined the Mission. By 1849 it comprised a group of intermarried descendants known as the Gens d'Arima. They were primarily of Amerindian, African and Spanish descent, became increasingly creolised, and integrated into the wider national culture. Within the Mission there was a second group of Amerindians who lived in the area of present day Calvary in Arima who continued to practice their native culture, buoyed by continual Amerindian immigration into the group. The Mission was important to the cause of the Amerindians because it provided them with financial support and prevented their eviction from their own lands. The Roman Catholic Church of Arima, then and to date, celebrated the feast of its patron saint, St. Rose

of Lima, a festival that still gives space for the Aboriginal community to re-affirm its presence and spiritual and cultural connections to their ancestors.

Santa Rosa (St. Rose) was born in Arima whilst her Spanish parents were en route to Peru in 1586. She was of Incan descent and dedicated her life early on to prayer and charity work with the ill and poor of Lima. At 20 she joined the Third Order of St. Dominic and died in 1617 at age 31. The Elders of the First Nations peoples, through the oral tradition, have told the story of three Carinepogoto Nation hunters, Raimundo, Punya, and Puyon, who found a girl who was unable to speak, in the Pinto forest, by a spring near to where the white river lilies grew. Thinking her lost, they are said to have brought the girl back to the Mission priest, but she subsequently disappeared. They found her again, but she once again disappeared. After her third and final capture, the priest explained that she was the Spirit of Rosa of Lima who had been canonised in Peru as the first saint of the new world. He told them to make a statue of her image because on her next disappearance she would not return. After completing the statue she disappeared, and on returning to the forest the hunters found at the place where they had first met her, roses of pink, yellow, red, and white weaved into a crown and necklace. The necklace was believed to have miraculous power and was worn by the Queen of the Nation as a mark of sovereignty but has since disappeared. Anacoana, the daughter of Hyarima, is thought to be the first to convert to Roman Catholicism and is considered as the ancestress of the Carib Queens.

In 1797 the British seized Trinidad from Spain, and in 1849 the Missions lost their power. The Amerindian lands were again appropriated to the newest settlers as the town of Arima continued to be expanded. Today, two major festivals mark the calendar of the Aboriginal people: the festival that honours Santa Rosa is held the last Sunday in August in observation of the feast of Santa Rosa de Lima, and the First Nations Heritage week is held the week encompassing First Nations Day, the 14th October. The First Nations Heritage week focuses on issues reflecting their Aboriginal belief systems, in particular: water, forests and mountains; animals, birds and protection of marine life; sustainable agricultural practices, food and culinary practices; traditional handicrafts; local self-governance; language and spiritual traditions; and music/dance. In 2014 Amerindian Nations from six

Caribbean islands attended the First Nations week held in Trinidad: Suriname, Dominica, Belize, Honduras, Trinidad and Guyana.

1.4 My Purpose

This ethnographic, exploratory case study utilises a complex adaptive theoretical framework to describe how the Aboriginal science of Trinidad might enhance school science curricula.

A complex adaptive system (CAS) is a network whose members are connected and inter-reacting. As changes enter a CAS, how members adjust the interactions between themselves in response will determine if the system will successfully adapt, evolve, and thrive. Complexity thinking has emerged as an intelligible conversation just within 30 years (Davis & Sumara, 2006) and has roots in such fields as chaos (Doll, 1993; Fleener, 2008), cybernetics, systems theory, the natural sciences, and information science (Davis & Sumara, 2006; Alhadeff-Jones, 2008). In the 1990s complexity science began to register heavily in the activities of social science including books, articles, conferences and workshops (Urry, 2005, p. 2). Its growth is indicated by its representation as a Special Interest Group (SIG) of the American Educational Research Association (AERA), and in the birth of institutions such as the New England Complex Systems Institute and the Complexity Institute at Nanyang Technological University in Singapore. Some applications of CASs include the improvement of learning in biology at the high school level via professional development and classroom intervention (Yoon, Koehler-Yom, Anderson, Lin, & Klopfer, 2015); to facilitate health promoting schools (Keshavarz, Nutbeam, Rowling, & Khavarpour, 2010); and to the role of creative communication in education (Sometsky, 2005). Within this study a complex adaptive system (CAS) is proposed as a methodological framework as it is thought a good representation of the context in which the study is taking place and provides an unbiased learning space for the integration of western and native science. There has been concern about the relegation of native science below western modern science (Aikenhead, 2014) and I suggest that a complex adaptive system may help to alleviate such worries. Firstly, a CAS gives equal footing to both western and native science. Secondly, native science has been thought of as

having characteristics better measured using qualitative means whilst the characteristics of western science are often thought to be better measured using quantitative means. A CAS would allow both the attributes of western and native science to be considered within one space such as in the integrated science unit that is an outcome of this thesis. Arguably Mixed Methods Research (MMR), defined here as a third methodological paradigm in which any individual study embraces both the methods and philosophy of qualitative and quantitative research (Cresswell & Plano-Clark, 2007; Denzin & Lincoln, 2011; Greene, 2008; Tashakkori & Teddlie, 2003) may also be used for this study. However, MMR treats qualitative and quantitative components of a study as separate things which occur either in a parallel or sequential time period within the study, but which do not interact with nor change each other. Complex adaptive systems give space for the components to interact with, and hence modify, each other. This is an important point given that the Trinidadian context in which the study is occurring already exhibits some sort of interaction between its indigenous (including the native science of the First Peoples) science and western science as indicated by George's (1986 as cited in 1999) taxonomy (see section 1.2.3.2)

Presently there is a dearth in the literature regarding the indigenous science of Aboriginal people in general, and more so of those of Trinidad and the Caribbean. The study is firstly a reconnaissance mission to map the ways in which the First Nations peoples of Trinidad do and make science: that is, the content of their sciences; how such content is developed; and how this content and the ways by which it is developed, are shared among members within their community. Secondly, the study suggests how Trinidad's native science might be used to enhance school curricula. Hence, as an outcome, the research produces a stand-alone, age independent curriculum that juxtaposes the nature of western science against that of Trinidad native-indigenous science. The curriculum is built for use by the Santa Rosa First Nations Community within their outreach educational activities.

1.5 Research Questions

Question 1: What is the nature of the indigenous science of the First Nations peoples of Trinidad:

a. What are the elements/content of this science?

b. What are the specific methods/strategies/circumstances through which native science is developed?

c. How are the following passed from experts to neophytes within the community?

a. the elements/content of native science

b. the methods/strategies used to develop native science

Question 2: How might these indigenous ways of being, knowing, and doing science in Trinidad be used to enrich school science curricula?

1.6 My Positionality

Trinidad is the larger island within the Caribbean twin-island independent, republic of Trinidad and Tobago. Trinidad is my home. When I am exhausted, I stand in the water of her sea with my feet on the sand of her earth with fire deep in its belly, and fire in the sun high above my head in the sky, as her wind and water move around me, and in this way the Spirit of this place rejuvenates me. My paternal great grandmother is from the Nepuyo Nation of Arima in Trinidad. My maternal great grandmother is Garifuna from the island of St. Vincent.

I am trying here to introduce myself as an Aboriginal, Indigenous person.

> The protocol for introducing one's self to other Indigenous people is to provide information about one's cultural location, so that connections can be made on political, cultural and social grounds. (Martin & Mirraboopa, 2003 p. 204)[1]

[1]Martin *is* Booran Mirraboopa by her Quandamooka Nation name. The literature lists Martin *and* Mirraboopa as authors of this work. To honour her Aboriginal ancestry I refer to her as Martin-Mirraboopa within this document.

I am a Creole; a descendant of the European settlers and the African slaves within the Caribbean and South American countries. My ancestors are Chinese, Welsh, African, French, Portuguese and Amerindian. Reading Linda Tuhiwai Smith (2012) has led me to realise that I can be labelled as an Indigenous person and I am left wondering indigenous to where? My very blood betrays me as my DNA scatters backwards to the land of the colonisers, their slaves, the Amerindians they decimated, and the indentured labourers that were brought here. Even my own countrymen sometimes seem to have no space for me. My physical appearance often causes me to be mistaken for what my people call a 'dougla' or a mix of the two dominant ethnicities on my island – African and East-Indian. My Christian mother jokes that if Trinidad ever descends into civil war between these groups that we are sure to get a beating or 'licks' as my countrymen call it – from either faction. My Muslim father's warning decades ago has come home to rest: I have up to now not found a racial or ethnic group that will accept me as a fully-fledged member. My hue is either too dark or not dark enough; my hair too wavy or not wavy enough. My upbringing and life-walk has left me feeling unbound to any race, ethnicity or religion. People are just people to me (Boisselle, 2015).

Being Creole, I have had to explain 'me' so many times yet every time I say it, it becomes new again, brings me deeper understandings, and bores me all at the same time. I know that I write and research who I am because that is the only lens that I have through which I can make sense of the world. I know then that my research has in part become therapy because in looking at the world through such a lens I am simultaneously looking at me – but part of me wants to 'just be': a desire for a simple world where there is no call for explanation of myself. Myself, my-'self', as if it is something that stands outside of me that I happen to possess and own and is hence just a shadow of who I am (and which of course leaves the question of exactly who that is, unanswered). And because the truth is that my cultural space is so complicated (as are all cultural spaces I suppose) that in the end, regardless of the constant probing, all it possibly can be is what it is. It can only 'just be'. Just as I 'just am'. So here I go, continuing to introduce my-'self.'

For the last 21 years I have taught WMS. For the first 13 of these I taught Chemistry and Integrated Science to 11 to 18-year-olds as a graduate teacher and

head of department. Since then I have been a science teacher-educator. My coming to terms with what it means to be Creole and Trinidadian has begun to interrogate all spheres of my life including my practice as a western scientist which at many points antagonises my indigenous scientific practices. This research considers the sciences of my country and is partially autoethnographic because it helps me to understand my Trinidadianess. It is in many ways a reflection, therapeutic, and a search for identity.

The research looks at the science of my people; the same science that has taught us to hunt for blue crabs when the full moon calls them out of their underground homes in copious streams. I cannot remember how I came to learn that 'blue crab does run full moon' nor do I know how my people came to know it. It feels though as if I have always known in the same way that I know to go to the sea when I am tired and stand on her sand to revitalise myself. This is a knowing that sits somewhere in my belly, stands against my western scientific training, and has begun to contradict my newly constructed understandings of being a Trinidadian scientist.

Hence, I am angered when Martin-Mirraboopa talks about how her research frame honours her Aboriginal people's ways of knowing, ways of being, and ways of doing (Martin & Mirraboopa, 2003) because I am unaware of what those things mean for my own people. Martin-Mirraboopa (2003) says too that "it is through ontology that we develop an awareness and sense of self, of belonging and for coming to know our responsibilities and ways to relate to self and others" (p. 206). Like Martin-Mirraboopa I do not want this study to be western research done by an Indigenous person and so I seek to make this indigenist research by using Trinidadian ontology to guide the framework of the research. As we Trinidadians say, it is here that the bacchanal begins. So what are the ontological and epistemological frames of my own people? And who might these people be? Can a thing (or a person) be quintessentially Trinidadian and what is that really in this rainbow, hodge-podge of a place? For me, being Trinidadian, that hodge-podge is about being Creole as that honours all of my ancestors. Somewhere along the life that I have spent in this country, I have created my own 'creole' to guide my ways of knowing about this land. My Amerindian self sometimes feels like that is all that

there is that connects me to this land. Focusing on the Amerindians in this study then gives me roots and helps to calm this quake in my belly that sometimes whispers to me, "You are a child of the wind, you belong to nowhere".

Yet, it is this voice of the wind too that has led me to see God Spirit, in the water, the earth, the people all around me. And for me God cannot be left out of it. In many spaces there is a snuffing out of the spiritual voice through a favouritism for the mainstream Euro-centric voice, reward structure and cultural milieu of the academy (Dilliard, Abdur-Rashid, & Tyson, 2000) which snubs God Spirit and metaphysics as superstitions. This might be considered as "a[n] (sic) act of violence against us and those like us whose cultural norms dictate the centrality of spirituality in our lives" (Dilliard et al., 2000, p. 449).

I am neither a polytheist, a monotheist, nor an atheist. To articulate it in terms that can convey shared understandings I say that I believe in God. It might be more correct though to say that I believe in God Spirit because I do not believe in God as an individual, omnipotent, omniscient being. It is my personal belief that all there is, is energy, vibrating at different frequencies so that lower vibrations are dense like solids and higher vibrations are, well, like love and fairies. I believe that this Spirit is a whole, existing in many pieces in the wind, the water, the earth and in all living beings. For me then, when I serve the Earth I serve God, I serve Spirit, I serve myself, and I serve every sentient being because I believe that we are all connected within a communal intelligence. Loving God for me is loving the wind, the water, the earth, the fire, and the people around me. My friend Manju's Mum used to say, (as Manju tells me), that we all breathe the same air: meaning to say that there is nothing here that I can hide from you, or you from me, because we are part of the same Spirit. For me then, spiritual ways of coming to know about the land, the water, the sky, the wind, and its occupant sentient beings are valid. I believe that one can only see God with the eyes of one's heart and this is the belief of my heart. For me everything is about Spirit, and I cannot separate that even from science, and I also consider myself to be a scientist.

There is also the side of my-'self' that subscribes to the standard account of science which is positioned on western philosophy and ontological positions. The

empiricism, hypodeduction, and falsification through which western science collects and authenticates knowledge seems dissonant with the part of me that speaks to trees and water, and listens for the voice of Spirit on the wind. One night my mother said to me that "there are no stars in the sky" meaning to say that rain is likely. I sat at my desk almost 24 hours later and could smell the rain coming on the air. My mother tells me too that her Garifuna grandmother could look at the sky and tell if there would be many fish to catch that day. She laments that she did not listen closely enough to "an old lady talking chupidness", as her youthful self-opined, so that the knowledge was not passed down and part of me is sad about that too and encourages me to pursue this work. Hence, I too:

> In providing these details, I am claiming and declaring my genealogy, my ancestry and my position as a researcher and author. The purpose is to locate myself firstly as an Aboriginal person [for me, an Indigenist Creole of Amerindian descent] and then as a researcher. As a researcher, this clearly presents the assumptions upon which my research is formulated and conducted. This also allows others to locate me and determine the types of relations that might exist. So, in providing these details, I am also identifying, defining and describing the elements of [this] Indigenist research. (Martin & Mirraboopa, 2003, p. 204)

1.7 Significance of the Study

Science curricula within Trinidad are all based on a western modern scientific (WMS) model and though science teaching and learning within the region are relatively understudied, there does exist a fair amount of research regionally and nationally on science pedagogy. In glaring contrast, there is a severe dearth of studies in the literature describing the traditional (indigenous) scientific beliefs and practices of Trinidadians (e.g. George, 1995), and how these can be utilised within science lesson planning (see as some examples Coard, 2013; Herbert, 2003, 2008; Simon, 2013; Wong, 2007). Furthermore, given the understudy of the *nature of conventional* science on the majority of our science education policy documents on the island, it might be unsurprising that the *nature of indigenous science* as an ontological, epistemological and axiological system is also not considered. In a country with a uniquely hybrid scientific practice comprising WMS and indigenous elements, our schools are not generating an awareness of how we as a people

realistically do, use, and live science. Informal conversations over the years have indicated to me that many Trinidadians do not even realise our indigenous science practices are a science. Understandably then, the indigenous scientific practices of our country lay largely undocumented. Moreover, I have not been able to locate any documentation on the nature of the sciences (NOS) of our First Nations peoples suggesting that it is probably unwritten (notably, they have an oral tradition). The study might then help to begin to catalogue the NOS of the Aboriginal peoples of Trinidad. The curriculum produced by this thesis can be accessed as a stand-alone, age-independent application. It is produced for use by the First Nations peoples themselves within the educational programmes held at their museum or within their outreach work, and as an outcome of the research posits learning objectives and strategies illustrating how the First Nations science of Trinidad can enhance science curricula.

The inclusion of a more user-friendly brand of science in closer alignment with the familiarity of pupils' home science can begin to re-imagine science classrooms, and to be more egalitarian and welcoming within the Trinidadian context. A science curriculum that contains indigenous science content as well as utilising teaching and learning methods built upon indigenous ways of being, knowing, and doing can possibly aid in the arrest of a falling national interest in science. The nature of science pedagogy has borne the culpability for rising disinterest in studying science or of working in a science career (Burnsed, 2011; Mitchell & Hoff, 2006). Indeed, there has been a marked worldwide decrease in interest in science and science education (Broad, 2004; Commonwealth Scientific and Industrial Research Organisation, 2005; Fackler, 2008; Haas, 2005; Kroto, 2007; Organisation for Economic Co-operation and Development, 2012). The Caribbean's regional examination body has also noted a decrease of students registering to study and be examined in science subjects from 2009 through 2011 (Caribbean Examinations Council (CXC), 2010, 2011). The curriculum proposed herein could make both the content of science and the ways in which it is taught more relevant to Trinidadian students and help them to begin to develop a sense of national identity within this postcolonial land. Rebranding science to be more attractive to nationals may help to develop the scientific literacy necessary for global living in a world progressively dominated by science and scientific products.

Looking forward into the medium and long-term, deeper societal understanding and awareness of indigenous sciences may promote research and careers in the field. Firstly, the findings from within indigenous science could be applied to the creation of relevant solutions to local problems. Furthermore, Trinidad's economy is driven by oil and natural gas exports and the country urgently needs to promote other industries if its economy is to remain prosperous into the future. The depletion of these non-renewable resources increases the anxiety for diversification. Scientific and technological advancement are believed to be of the utmost importance to the improvement of the quality of life in the Caribbean (Ahmad, 2000; A. Johnson, 2000). Indeed, the non-profit organisation, The Caribbean Science Foundation (CSF), has been launched with a mandate "to assist with the diversification of the economies of the Caribbean Region by harnessing science and technology for economic development, and to help raise the standard of living" (Caribbean Science Foundation, n.d., "Mission"). Under such auspices, indigenous entrepreneurship that creates, manages, and develops "new ventures by Indigenous people for the benefit of Indigenous people" (Hindle & Lansdowne, 2002, p. 4) can promote and utilise indigenous sciences and technologies. Indigenous entrepreneurship has the power to engender a culture of enterprise that "respects Indigenous traditions [and] empowers Indigenous people as economic agents in a globally competitive world" (Hindle & Lansdowne, 2002, p. 2).

1.8 Chapter Summary

I took extreme care in this opening chapter to try to present what some may say is a complicated issue simply, by taking time to explain the backdrop and guiding concepts of the study. The chapter began to unravel the complexity of what is indigenous science within Trinidad and to locate the study's focus on native Aboriginal science within that. To do so the difficulty in defining science was explored; indigenous and native sciences were introduced as alternatives to western science; Trinidadian science was defined from George's (1986, as cited in George, 1999) taxonomy, and its development traced against Basalla's (1967) three phased model. Lastly, the chapter argued the importance of a multicultural science education to justify the study's production of a curriculum illustrating how Trinidadian Aboriginal indigenous science maybe integrated within science

curricula. I have revealed here too my Aboriginal ancestry and the pursuit of this thesis as a piece of my search for identity. I hope that this helps the reader to understand and be able to critically assess for themselves, the lens (and its possible impact on this work) through which I am re-presenting the reality of the introduced participants.

1.9 Layout of the Document

The document unfolds across seven more chapters.

The literature review is split across chapters two and three. Chapter two continues the introduction in this chapter of the nature of science and the variety of ways by which knowing in science occurs. Chapter three discusses the qualities of a complex adaptive system (CAS) and proposes why these make it suitable as a conceptual and methodological framework for the study, as well as a model for the proposed curriculum. Specifically, the review proposes a CAS framework as capable of accommodating the dichotomy between a substantivist western modern science, and a relational native science. Additionally, the thesis suggests how substantivist and relational theories can be housed within a CAS which might also accommodate interactions between these dichotomous theories.

Chapter four, the methodology, explores the case study design; the utilisation of analytic- and auto- ethnographic methods; issues surrounding the implementation of the study and gaining access; and ethical considerations surrounding the research.

Chapters five, six, and seven are each individual pieces of the section ‘Resolving the Research Questions’. Chapter five justifies the main instrument by which data was collected and discusses how data analysis occurred. Chapter six responds to research question one, and chapter seven to research question two.

The study culminates in chapter eight that presents summary responses to the research questions, and discusses the implications of findings, limitations of the study, and recommendations for further research.

CHAPTER 2

LITERATURE REVIEW 1:
HOW WE 'KNOW'

2.1 Introduction to the Literature Reviews

The Literature Review section unfolds across chapter two: 'Literature Review 1: How We Know'; and chapter three: 'Literature Review 2: Complex Adaptive Systems'. The Literature Review informed the research's design, execution and data analysis, and was used to draw conclusions and make recommendations for further work.

2.2 Aims of the Chapter

The thesis is trying to ascertain the ways by which the Aboriginal people of Trinidad determine scientific knowledge, and to build a science curriculum upon these methods of determination. My original intention was to separately represent the epistemological systems of western science, and that of native science. My reading has led me to suspect that native and western science do not have clear lines that demarcate them. Instead then, I have opened the chapter with a discussion of some of the myriad ways by which humankind comes to know the world. I have tried to choose those most popular in the literature and relevant to the needs of the study. Some of the epistemological routes that have been presented are often thought of, and discussed as, western scientific (WMS), others as native scientific. However, there seems to be noted overlaps in how WMS and native science hold that knowing occurs, though the literature has not been very overt at indicating such. At this point I cannot yet respond on my position as to which of these epistemological routes are purely western and which purely native, though some do seem to belong more to one camp than the other (e.g. positivism is thought western scientific and relationality native scientific). By its end, the chapter suggests utility in the noetic sciences, or the merging of western modern and native science practices of knowing as a more efficient way of learning about the world. Lastly,

the chapter discusses that such a merger may be effected within a multicultural science education with aims towards border-crossing, collateral learning, and scientific literacy.

2.3 Experiencing and Knowing the World

> The wrong view of science betrays itself in the craving to be right; for it is not his possession of knowledge, of irrefutable truth, that makes the man of science, but his persistent and recklessly critical *quest* for truth. (Popper, 2005, p. 281)

I am trying to use language that respects both western and native sciences' ways of experiencing the world. However, native science's (NS) relationality opposes the anthropocentrism of western science. Anthropocentrism endows humankind god-like status at the centre of a universe that is unfolding about us, which we are striving to understand, and of which we have a right to know. My first title for this section was 'Philosophies and Methods of Knowledge-Making in Science (WMS & NS)'. This title represented 'knowledge' as a *discrete and cognitive* entity divorced from other facets of humankind's holism (e.g. affect), and was hence at odds with the way that Native people believe they experience the world. My remedial title, 'Experiencing and Coming to Know the World Around Us', again proved to be at odds with the relationality of Native people who believe that us and the 'world around us' are synonymous.

The derivation of the present sectional title is part of my continual attempts at reflexivity – and my research diary has been a useful tool – about my ontological, epistemological, and axiological stance. For similar reasons I have used equivalent capitalisation and representation when discussing both western modern (WMS) and native science (NS) knowledge systems, and especially capitalise 'Indigenous' or 'Native' when referring to such *peoples* (Aikenhead, 2014) only.

2.3.1 Knowing through Metaphysics

Metaphysics is concerned with the nature of reality. However, the methods by which it makes claims about the world are often a priori, and do not necessarily sprout from sensory observations. These claims also tend to be about generalities such as value say, as opposed to specifics such as justice. For these and other reasons metaphysical concepts are often thought impractical and anemic (Fine, 2012).

Metaphysical concepts tend to be transparent; that is, there is no significant gap between the concept and the entity that it supposes to represent. For example, the concept of water and actual water are very different so that the concept of water is hence said to be opaque. However, the concept of identity and identity itself are very similar (as they are both conceptual) and the concept in this case is said to be transparent (Fine, 2012).

Even so, metaphysical concepts tend to form a basis for other enquiries (Fine, 2012). For example, the metaphysical beliefs of a mind-independent reality, and of uniformitarianism both support empiricist enquiry.

2.3.2 Knowing through Empiricism/Positivism

Contemporarily, positivism has been absorbed into empiricism and I use the two terms interchangeably. Positivists are anti-metaphysicists as they are against "untestable propositions, unobservable entities, [or] causes" (Hacking, 1983, p. 42). Ironically, positivists are sometimes called metaphysical realists as they assume, or have faith in, a mind-independent reality. Like behaviourists, empiricists hold observable behaviour as the indicator or sum product of the constitutive parts of a phenomenon. So, positivists propose that the rules governing the functioning of reality can be discovered through experimentation, and the physical sense observations of humankind. These rules can be portrayed as hypotheses and theories about how the world works; hence, "the empirical sciences are systems of theories" (Popper, 2005, p. 37). As realists, positivists suggest theories can at least

approximate, and at best mimic, reality. Positivists also submit that the entities that theories postulate actually exist (Hacking, 1983).

Realism can be considered from two vantage points: 'realism-in-general' and 'realism-in-particular'. For example, one could believe that the existing theory about the general behaviour of light is true (realism-in-general), but disbelieve that this behaviour is caused by photons (realism-in-particular). Whilst realism-in-particular tends to rely on observations of how nature behaves, realism-in-general is more closely aligned to old metaphysics. Even so, realism-in-general and realism-in-particular have been entwined during formative periods of humankind's history (Hacking, 1983). Illustratively, as Hacking (1983) notes, N.R. Hanson recognised that over time metaphysical faith in long-standing theories' ability to mimic reality tends to increase. Hacking (1983) goes on to explain that many theories are initially postulated as a model to help us manipulate nature and not as a representation of nature (realism-in-general). However, the entities associated with the theory (realism-in-particular) tend to be discussed in an increasingly realistic way as time passes – research is the final arbitrator in these contention.

Positivism's 'logical derivation of facts' is based on empirical evidence collected through the five senses, and is supported by the early Wittgenstein's verifiability principle which says that the meaning of a proposition is equivalent to the collection of experiences that make it true. Given the impossibility of proving that one person's experience/empirical observation of a phenomenon is identical to another person's experience of that same phenomenon, Wittgenstein's verifiability principle can degenerate science into a subjective activity (Passmore, 1967). Indeed, both Popper and Carnap have suggested that absolute verification is an impossibility (Carnap, 1936). Initially, Carnap had posited that meaning can only be credited to the verifiable (Passmore, 1967). However, this negates, for example, scientific laws which are impossible to determinately verify (Carnap, 1936) as "there is no set of experiences such that having these experiences is equivalent to the truth of a scientific law" (Passmore, 1967, p. 56). This was one reason that 'verifiability' was eventually replaced by 'confirmability' and later on 'testability' (Passmore, 1967); with 'testability' being akin to 'falsifiability' (see section 2.3.4). Hence, any statement can only be confirmed more and more but with a lack of absolutism that

resists verifiability (Carnap, 1936). This suggests that either the universe is doing a striptease and revealing itself slowly, or perhaps expanding as Edwin Hubble said and may hence be non-uniform. This would contradict positivist's metaphysical faith in uniformitarianism – that the behaviour of matter and energy (aka the universe around us) is governed by constant rules that are consistent across time, place, and space (Popper, 2005).

Though we cannot verify any lawlike statement, (again, such as a scientific law), at every possible spatial-time point, the law though unverifiable, may be testable. The more times testing reveals a law say, to hold, the more confirmable – and so rigorous and trustworthy – is the law (Carnap, 1936). However, any statement that is confirmable is not necessarily testable: though our observation may allow us to confirm it, we may lack the methods/instrumentation to set up experiments to (re)produce these observational experiences, and so test them (Carnap, 1936). Moreover, there is a 'conventional component' or a subjective reckoning, necessarily built into the decision about whether a given set of observations, (deemed objective), verify a statement. It is taken that the presence of the non-conventional elements of objective observations far outweigh that of the conventional elements (Carnap, 1936). Schlick also suggested that only the structure, and not the content or scientific experience is important, so for example, once we agree on the position of a colour on the colour wheel, it is unimportant how individuals experience that colour (Passmore, 1967). Even with the possible innate subjectivity of observation, verifiability, confirmability, and testability give empiricism an intrinsic auto-correct mechanism that dissuades epistemological fanaticism by encouraging an on-going skepticism as part of the mind used to develop rigorously defined scientific knowledge.

2.3.3 Knowing through Hypo-deduction

One may recognise through empirical observation that there is always water present anytime a piece of iron rusts, and may hence generalise that water is needed for rusting. This is induction: the cause of a set of repeated, apparent coincidences can be inferred/generalised from the conditions empirically determined to be associated with all of the coincidences. The generalisation or hypothesis governing causation

of the event under study can subsequently be used to collect data to deduce whether the hypothesis is true. For example, one may experiment by placing many different samples of iron in water to see if its presence is necessary for rusting (Theobald, 1971). This inductive-deductive spiral is the hypo-deductive method.

Deduction moves from generalisations to data, is necessarily truth preserving, and produces a logically valid argument once the premises on which it is based are true. Induction is not so seamless and has been suggested as metaphysical (Popper, 2005). Problems associated with induction include the impossibility of observing every incidence of a phenomenon before formulating a generalisation to explain its occurrence. Secondly, the leap of induction that occurs between observed phenomena and an explanatory, derived hypothesis requires creativity and imagination (and hence may be socioculturally influenced, and cannot necessarily be logically mapped or reproduced). Moreover, in suggesting a hypothesis to explain any observed behaviour involves metaphysical faith in uniformitarianism or the assumption "that instances, of which we have had no experience, must resemble those, of which we have had experience, and that the course of nature continues uniformly the same" (Hume, 1739-40, p. 159).

Shortcomings of the hypo-deductive method have also been noted within experimental work. These include its inability to clearly demarcate between correlation and causation; its unreliability in situations where multiple causes may be responsible for a phenomenon; its lack of recognition that different hypotheses can lead to the same deduction; and its bind to the 'impartial' hypothetical lens that it has created through induction, which guides the study, and may hinder pronouncements about observations/deductions made outside of this lens (Guthery, 2007).

2.3.4 Knowing through Falsification

Idea creation, as occurs within the inductive leap, does not require, nor is it susceptible to, logical analysis. Idea creation is also irrelevant to the logical analysis of scientific knowledge, which is not about questions of fact, but rather of the justification and validity of scientific knowledge (Popper, 2005). Arguably,

determining scientific knowledge as valid should consider the production of its constitutive ideas. Given the instability of induction, Popper proposed falsification as a method to logically judge the worth of (or as he called it, to corroborate), scientific knowledge. He asserts too that though scientific laws are not verifiable, they are falsifiable.

Popper believed that scientific knowledge should be capable of being falsified. Scientific knowledge is corroborated because it is testable. That is, we can formulate some experiment to deduce if it is a valid knowledge construct as agreed by the scientific community, and through rigorous attempts that fail to falsify it, deem it corroborated. Scientific knowledge strengthens and grows through a quasi-inductive approach which allows theories to be deductively tested, corroborated, and hence eventually be replaced by another theory of higher universality that incorporates the earlier one (or at least an approximation of it). In a continuous upward spiral these broader universal theories are deductively tested with the help of the less universal theories that they incorporate. The question does arise as to why not proceed in the direction from grandiose universal statements immediately and try to prove these instead of making this slow ascent upwards. The answer is that universal statements beyond the power of present-day science to test through experimentation risk being formulated into a metaphysical system (Popper, 2005) unrecognised by western modern science.

2.3.5 Knowing through Paradigm Shifts and Scientific Revolutions

Thomas Kuhn proposed the idea that leaps in the growth of scientific knowledge occur via revolutionary paradigmatic shifts. A paradigm accounts for content; the science from which the particular paradigm emanated; the methods; problem-field; and the standards of solutions of a mature scientific community at some time point (Kuhn, 1970). “Without commitment to a paradigm there could be no normal science” (Kuhn, 1970, p. 100) as research tends to occur using, and be bounded by, the widely accepted instrumental and conceptual tools of the day. Indeed, as tried and trusted tools are used to solve relevant problems, knowledge is built in a cumulative fashion (Kuhn, 1970).

Sometimes new ideas about the behaviour of nature come along that challenge the status quo so much that they lead to crisis. This sparks a revolution aimed at crisis resolution through "the proliferation of competing articulations, the willingness to try anything, the expression of explicit discontent, the recourse to philosophy and to debate over fundamentals" (Kuhn, 1970, p. 91).

Revolutions normally start within a small group of practitioners who share an initial, and subsequently growing realisation, that an old paradigm fails to accurately predict or explain the behaviour of nature in areas where it had previously been the forerunner (Kuhn, 1970). The revolutionary crisis deepens as more practitioners begin to support the new paradigm and form a camp against practitioners still believing in the efficiency of the old paradigm (Kuhn, 1970). Resolution using arguments predicated on the 'normal' scientific paradigm of the day is impossible as the two camps are opposed at fundamental paradigmatic levels. The chasm in values and premises between the competing camps retards any from convincing the other through reasonable or logical argument/experiment. "When paradigms enter, as they must, into a debate about paradigm choice, their role is necessarily circular. Each group uses its own paradigm to argue in that paradigm's defense" (Kuhn, 1970, p. 94). Scientific revolutions and how they are settled tell us about the nature of science (Kuhn, 1970) and do not necessarily occur from "some methodologically lower to some higher type" (i.e. they expand knowledge non-cumulatively) (Kuhn, 1970, p. 108). During a paradigm shift

> some old problems may be relegated to another science or declared entirely 'unscientific'. Others that were previously non-existent or trivial may, with a new paradigm, become the very archetypes of significant scientific achievement. And as the problems change, so, often, does the standard that distinguishes a real scientific solution from a mere metaphysical speculation, word game, or mathematical play. The normal-scientific tradition that emerges from a scientific revolution is not only incompatible but often actually incommensurable with that which has gone before. (Kuhn, 1970, p. 103)

2.3.6 Knowing through Representations and Interventions

In this model of knowing science comprises representations (public products/knowledge, e.g. theories or physical objects); and interventions (i.e. processes or experiments by which it creates or discerns knowledge).

> Science is said to have two aims: theory and experiment. Theories try to say how the world is. Experiment and subsequent technology change the world. We represent in order to intervene, and we intervene in the light of representations. (Hacking, 1983, p. 31)

The 'truth' of a representation, or the degree to which a representation is believed to approximate reality, is subjective and determined from within the philosophy of the observer. Regardless of our representations though, "the final arbitrator in philosophy is not how we think but what we do" (Hacking, 1983, p. 31). Certainly,

> if you want to understand what a science is, you should look in the first instance not at its theories or its findings, and certainly not at what its apologists say about it; you should look at what the practitioners of it do. (Geertz, 1973, p. 5)

Admittedly, there exists in some quarters a caste ranking of experimenters/interveners below theoreticians/representers (Hacking, 1983). Science as a practical entity is both experimenter *and* intervener; this duality can mitigate "a single-minded obsession with representation and thinking and theory" (Hacking, 1983, p. 131) that can become dogmatic about what is real and 'true'.

2.3.7 Knowing through Quantum Theory

Science history may reckon that "when paradigms change, the world itself changes…led by a new paradigm, scientists adopt new instruments and look in new places" (Kuhn, 1970, p. 111). Similarly, conventionalists believe that the reality that we see is determined and limited by our theoretical lens – the instrument through which we view and measure the world. Natural science for the conventionalist then is a logical construction rather than a replica of nature; a system of conventions

developed by man to explain how the world works. Scientific laws are not falsifiable through observation within conventionalism as these self-same laws determine what constitutes observation, and what is an instrument (Popper, 2005).

Instrumentalism is similar to conventionalism. It is naturally utilitarian and considers the worth of instruments such as physical apparatus, theories, and models at consistently predicting and analysing data about nature and its workings. Unlike conventionalism, instrumentalism does not consider the nature of reality.

Similarly to conventionalism and instrumentalism, quantum theory suggests that measurement determines the characteristics of an object. Within quantum theory objects are considered multi-dimensional and can exist in more than one state at the same time. For example, an electron can spin in opposite directions within the same spatio-temporal point. Quantum mechanics suggests that measurement forces objects to assume a state definable by that measurement. The multi-dimensional states also seem to be linked so that attempting to measure the state of the object in one dimension freezes the property of its twin located at distance in another dimension (Meerali, 2015). This is known in Physics as 'spooky action at a distance'.

2.3.8 Post-positivist Views of Knowing

Relativists, or post-positivists believe that as individuals experience the world, they interpret these experiences, and so create personal understandings of phenomena. An individual's view of reality is hence a personal mental construct. Consequently, constructivism is "a theory of knowing, not of being" (von Glasersfeld, 2001, p. 41), and does not suggest or defend any view of reality, only the ways by which that reality can be known. Constructivism is instrumentalist and restricts science to experiential realms ordered and managed by scientific theories, themselves conceptual models capable of being replaced based on new constructs (von Glasersfeld, 2001). Realising science as a human construction, as opposed to an objective exercise disconnected from the human experience, may help to alter beliefs that scientific development should occur outside of ethical and moral

standards (von Glasersfeld, 2001). Three major schools of constructivism exist: cognitive, radical, and social.

Cognitive constructivists are Piagetian and believe that knowledge is a cognitive construction formulated independently by individuals from bits and pieces of their past. Through a process of adaptation (comprised of assimilation and accommodation), a learner independently constructs knowledge from his/her experiences. Piaget suggested that humankind's ability to think at increasingly sophisticated levels developed sequentially through age governed phases. By adulthood the human should be able to independently construct (and subsequently manipulate), abstract representations of the world created from his/her experience. Piaget termed this cognitive development genetic epistemology (with 'genetic' here referring to the 19th century meaning of 'developmental' and not of references to biology) (von Glasersfeld, 1995).

Radical constructivism posits that since reality is unknowable, one can only construct a stand-in for it based on one's experiences. I cannot know if my constructions of any object in reality is the same as another person's such that "what we make of experience constitutes the only world we consciously live in" (von Glasersfeld, 1995, p. 1). Radical constructivism has been compared to solipsism or the belief that everything is 'in your head' and so 'viability' or 'functional fit' have been used to explain the validity of knowledge that has been suggested to have been radically constructed. Radical constructivism was built on Piaget's theory of cognitive constructivism which suggests that humankind's cognition cannot reveal or lead to models of a mind-independent reality. Cognition could though, help humankind to adapt to, and hence survive in the world in which it lives (von Glasersfeld, 2001). Functional fit extends from a biological perspective of adaptation through which any species that does not adapt to its environment perishes. Adaptation does not require that the species duplicate some ontic world but rather adjust to the world of experience by overcoming/avoiding/adapting to obstacles to survive (Piaget, 1970). Extrapolated to a world of cognition, coming to know does not require the knower to acquire a duplicate version of the ontic world but rather, "to possess ways and means of acting and thinking that allow one to

attain the goals one happens to have chosen. Thus, to know is to have viable procedures" (von Glasersfeld, 2001, p. 40) of adaptation.

Within social constructivism (Vygotsky, 1978) knowledge creation is not an independent activity as in its cognitive and radical counterparts. Here a more able guide utilises communication to help the novice cross the divide (zone of proxima) from the things that they know, to the things that they are trying to learn or master. Fundamentally a social activity, social construction of knowledge is hence socio-culturally, and historically influenced.

The many epistemological twists and shades categorised under post-positivism are too numerous to detail here. One example, contextualism, suggests that both scientific knowledge, and the processes of scientific knowledge creation are influenced by the sociocultural milieu in which scientists live and do science (Wellington & Ireson, 2008). Within a second example, situated cognition, the learner apprentices with a cognitive mentor. Cognitive mentorship focuses on teaching the domain knowledge as well as heuristic strategies; control strategies (or which heuristic to use when); and learning strategies (which embody the previous three, promotes metacognition, and so teaches the learner to guide their own learning) (Collins, Brown, & Newman, 1989). How and what the learner learns is determined by individual and group activity, and the sociocultural and contextual milieux in which learning is embedded (Brown, Collins, & Duguid, 1989).

There are also mixtures of positivism and post-positivism. For instance, even though Piaget and von Glasersfeld felt that it was impossible to create constructions about a mind-independent reality (von Glasersfeld, 2001), critical-realist schools hold that individuals can create their own personal construction of a fixed, mind-independent reality that is universally experienced.

2.3.9 Relational Ways of Knowing

Native peoples speak of the Entities of Land, People, Waterways, Animals, Plants, Climate, Skies and Spirits (capitalised to show respect for their animate identity); all of whom exist in relational equity with each other. A relational ontology defends

"the interconnectedness of physical, mental, emotional, and spiritual aspects of individuals with all living things and with the earth, the star world, and the universe" (Lavallee, 2009, p. 23). Here relations between Entities are more ontologically significant than the individual Entities. Comparatively, in a "substantivist ontology…entities are ontologically primary and relations ontologically derivative" (Wildman, 2010, p. 55). As example, both positivist and post-positivist ways of knowing are substantivist, with the first being focused on the nature of reality, and the second on the experiences of the knower: neither focuses on the relationship between the knower and what s/he seeks to know, as relationality does. A relational ontology hence stands against habits that propose "objectivism, by reducing the world to a collection of things [which] places the knower in a field of mute and inert objects that passively succumb to his or her definitions of them" (Palmer, 1983, p. 56).

A relational ontology is also a complex adaptive system (see section 3.3).

2.3.10 Ways of Being, Ways of Knowing, Ways of Doing

Simply put, science is about knowing the world around us. Within western practices knowledge is accumulated as a commodity and a doorway to power. Within indigenous practices coming-to-know is an experiential process that happens over time (Ermine, 1995; Sutherland & Dennick, 2002).

To know the outer world-space in which they reside, Aboriginal peoples turn inwards to their inner-space or Soul, Spirit or Self. This inner-space is thought to permeate and extend outwards into outer-space. The inner and outer-space of all existence are connected forming a whole that enmeshes the individual within itself (Ermine, 1995).

The interconnectedness of inner and outer worlds means that to come to know oneself is to know the world and vice versa. The process of self-actualisation in itself then may be considered as a process of gaining scientific knowledge. Consequently, 'knowing' is an impossibility in the absence of the belief in, or invocation of, All-That-Is.

A relational existence becomes for any Entity within the whole, a personal experience of the others as one makes one's way through life (i.e. holism). "If everything is animate, everything has spirit and knowledge. If everything has spirit and knowledge; then all are like me. If all are like me, then all are my relations" (Little Bear, 2000, as cited in Aikenhead & Ogawa, 2007, p. 558). For Aboriginal peoples then ontology, epistemology, and axiology are hence all relational, experiential, and participatory. It is an active philosophy in which, regarding the other as self and vice versa, Entities honour their relatedness by seeking ways to be in harmony with each other. There is no stratification or split say of gender, or mind-body-emotions and it is respected that reality is multi-layered, contextual, and related to the knowledge-holder (Moreton-Robinson & Walter, 2009). The life journey is itself epistemological, a journey of coming-to-know or of *developing* (as opposed to gaining/discovering) wisdom (Aikenhead & Ogawa, 2007). Ways-of-doing thus honour: the relatedness of Entities; the individual knowledge of each Entity gained from their connectedness, their being, and experience of the world; the translation of knowledge between Entities from personal witness of experience, or from any other Entity within the overall relations such as Ancestors, Spirit, the Dream World, Nature, or Stories (Moreton-Robinson & Walter, 2009). For Aboriginal people speaking to the Wind or learning from the Tree constitutes scientific research (Colorado, 1988), and metaphysical ways of being, knowing, and doing are valid. As example, metaphysicists suggest a zone of no thought (or at least no thought in forms of which we are aware), and this thesis posits that silence may be the highest, most creative form of language. This zone is akin to what the Iroquois Native Indians call Skanagoah or 'great peace'; the exhilarating and heightened awareness experienced when walking through the deep forest whilst in silent relation with everything (Colorado, 1988).

Native ways of being, knowing, and doing science are illustrated in the use of medicine wheels which were created by Aboriginal ancestors who "recorded their findings in the inner-space in simple stone, and it is only by analyzing and synthesizing the truths of inner-space that we can fully decipher the messages of the wheels" (Ermine, 1995, p. 106). The four cardinal points are represented on a medicine wheel as Native peoples believe that each one is linked to a great Power. The wheel helps a seeker to align with this great Power and access its energy or

medicine to bring healing through alignment of their spiritual, physical, and emotional realities. Medicine here is personal cure.

Aboriginal people are considered to have a mission to seek metaphysical knowledge and to apply these inner-space discoveries practically (Ermine, 1995). For these people, knowledge is not categorised into types, so that scientific knowledge is not seen as a specific kind which comes to be known through a special way-of-knowing, or whose ways-of-being and doing are separate to other types of knowledges. For Native peoples scientific knowledge, like other knowledges, honours the wholeness or oneness of the universe, includes metaphysical means, and must benefit the wider community. Conversely, western science is fragmentary and dissects the outer world into units for observation and measurement in reductive supposition that the sum of how all of these little parts work will reveal the functioning of the whole; it holds no consideration that there might be an interaction between constituent parts (Ermine, 1995). Indeed, within indigenous ways, mystical experiences are considered the "only way to grasp certain intangible laws of the universe" (Beck & Walters, 1977, p. 164).

Native scientific knowledge is readily accepted as a construction, an emanation from the user's experience of inner-space manifested onto the outer-world; that is, "aboriginal epistemology is grounded in the self, the spirit, the unknown" (Ermine, 1995, p. 108). Contrastingly, western science (WMS) has an externally focused epistemology which considers the metaphysics of inner-worlds as non-scientific and superstitious. Consequently, WMS fragments the inner-world from the outer-world.

As an indigenous knowledge system, native science (NS) is more concerned with its users' ability to successfully live and navigate the personal space in which they reside (Dei et al., 2000; Snively & Corsiglia, 2001). Hence, native science tends to be technologically oriented: the intervening part of science. NS does not traditionally strive to accumulate, record, or represent the processes by which it intervenes. This is not to say that these methods are never recorded (as in medicine stones), but that the primary method of representation is also for intervention. In addition to being a facility of oral peoples, NS may be more concerned with intervention (than representation) as it does not seek to validate any experience as 'valid scientific truth' but rather, everything being guided and determined by the

Great Spirit, is real for the participant. There are similar views within WMS as to the importance of intervening:

> There are surely innumerable entities and processes that humans will never know about. Perhaps there are many that in principle we can never know about. Reality is bigger than us. The best kinds of evidence for the reality of a postulated or inferred entity is that we can begin to measure it or otherwise understand its causal powers. The best evidence, in turn, that we have this kind of understanding is that we can set out, from scratch, to build machines that will work fairly reliably, taking advantage of this or that causal nexus. Hence, engineering, not theorizing, is the best proof of scientific realisms about entities. (Hacking, 1983, p. 274)....The experimental argument for realism does not say that only experimenter's objects exist. (Hacking, 1983, p. 275)

The methods of western modern science (WMS), often considered as a model of objectivity and rationality, have been prevalently used as the ideal by which knowledge is determined rational and hence 'true' (Hacking, 1983). The teachings of metaphysics embraced by native science, have long been thought meaningless to the positivism of WMS which expects knowledge to be verified through empirical data accumulated via the five senses. Empiricism does hold that if a 'factual' proposition is not based in sense data that it can still be considered 'true' if it is a tautology. Metaphysical knowledge fits into neither class and is hence indicated as nonsensical. Metaphysics then is not considered scientific because it does not utilise ways of making knowledge that are acceptable to the 'logic' of WMS. Unlike the empiricist scientist, metaphysicists are challenged in the formation of testable experiments that can duplicate and hence validate the epistemological construction route between their experiences and hypotheses (Mead, 1965). That is, because metaphysics seems to lack specific and resilient methods of knowledge making it is hence considered non-scientific by western science standards. For instance, the medicine stones of Aboriginal peoples can be used for self-introspection and personal development and act as a mirror to any *sincere* person (Ermine, 1995). This suggests that knowledge itself is responsive to, and activated by, the qualities of the user. Here native knowledge is recorded in such a way that it requires walking in the inner worlds to decipher it. Contrast this to the written protocol of a scientific report in WMS which aims to make research accessible for peer review

and validation, and is so ubiquitous that it has arguably led to the promotion that it represents *the* scientific method (Ryan & Aikenhead, 1992). This literature review has highlighted a variety of propositions that WMS might harness to create knowledge (see specifically sections 2.3.2 to 2.3.6). Even so, many characteristics of WMS continue to be highly debated and Mc Comas (1996) summarises 10 myths that have emanated about the nature of WMS, namely: hypotheses become theories which in turn become laws; a hypothesis is an educated guess; a universal scientific method exists; carefully accumulated evidence will result in sure knowledge; science and its methods provide absolute proof; that science is procedural more than creative; science and its methods can answer all questions; scientists are particularly objective; experiments are the principal route to scientific knowledge; and that scientific work is reviewed to keep the process honest.

Native scientists also create constructions and hypotheses about how the world works from their empirical observations (Colorado, 1988; Moreton-Robinson & Walter, 2009) which might of course expand past data collected through only the five senses. I posit too that "why should there be *the* method of science? There is not just one way to build a house, or even to grow tomatoes. We should not expect something as motley as the growth of knowledge to be strapped to one methodology" (Hacking, 1983, p. 152). The sciences of Native peoples have served them well for millennia. Is the question then *if* indigenous sciences work? Or more so of how, or what are the scientific methods by which indigenous science knows, still needing to be uncovered and tested? Nor am I suggesting that extant western science testing methods are sufficient philosophically, methodologically, or methodically to describe the nature of indigenous sciences, though I do, like the realist belief in our ability to describe reality, have faith in humankind's ability to eventually delineate such means and suggest that the noetic sciences might have a role.

2.4 Noetic Science: Negotiating a Peace Accord between Western and Native Sciences May Help to Grow Scientific Knowledge

> "It is not thinking about the world but changing it that in the end must make us scientific realists" (Hacking, 1983, p. xiv)

Children are believed to be biologically wired to do science, to learn about the world around us (French, 2004), and said to be "born investigators" (National Research Council, 2012, p. 24). Seminal logical positivists such as the early Wittgenstein suggest that "it is impossible in principle to pass beyond our language in order to discuss what our language talks about", and Carnap supports that ontological statements are then meaningful assertions about the relationship between our world and our language (Passmore, 1967, p. 55). However, Piaget (1970) disagreed that scientific and mathematical logic was "nothing but linguistic structures" (p. 8) and argued that logical scientific behaviour in children predates language acquisition. Piaget's (1970) genetic epistemology goes on to suggest that cognitive development in humans, and the logic of science and mathematics, seem to follow similar patterns and to evolve in similar ways. Moreover, science has also been considered to be in our DNA; that children display natural curiosity, and proclivities towards exploration of their environment, and to experimentation (deGrasse Tyson, 2012). If all of these thinkers are correct, then the quest of science, or knowing the world in which we live, may indeed be a quintessential human activity before labels of 'western', 'indigenous' or 'native' can even be applied.

Mach's general doctrine holds "that science is, fundamentally, the description of experience" (Passmore, 1967, p. 52). The noetic sciences are a new field which is trying to marry rigorous western scientific (WMS) methodology of knowledge creation with the intuitive ways of knowing whose methods are not yet understood well enough to be easily duplicated, and so confirmed/corroborated. There is already evidence of this liaison within the mainstream. For instance, a former head of the UK Ministry of Science has indicated that some of the ways by which he comes to know include both WMS and intuition (Leach, 2008). Kekulé's dream of a snake eating his tail led him to decipher benzene as a cyclic compound. Native people would say that Spirit brought him the dream. Spooky action at a distance of particles, (see section 2.3.7), suggests a communication between the two forms of an entity that is instantaneous, (much like thought and intuition), and so travelling faster than the speed of light which is itself presently taken to be the fastest speed physically possible (Meerali, 2015).

The methods western modern science (WMS) uses to know has allowed it to develop vast applications that have brought many benefits to humankind's quality of life. The part that WMS has played in the developmental trajectory of first world nations has also made its propagation attractive to developing nations (such as Trinidad and Tobago) seeking similar gains (Brown-Acquaye, 2001). Certainly the applicability of WMS' theories and laws, and their replicability within any context give them the power of universal utility. This is no small thing and helps us to understand why WMS has made a great impact on the world and enjoys widespread credibility. That is, regardless of a problem's context, an appropriate WMS solution will work. For instance, all things being constant, antibiotics help to eliminate bacterial infections within the metropoles of Europe just as well as in rural Africa.

The 2014 movie "The Theory of Everything", showcases the life of Stephen Hawking and his desire to formulate one elegant equation that explains the workings of the universe (Marsh, 2014). Western science has always had this particular bend towards monism; as far back as 1965 it was asked (and possibly stands even more true today in a post-positivist world) – can western science at this point in history 'dis-verify' that there may not be only plural ways of viewing the world, but of explaining how it works? (Mead, 1965). It has already been suggested that "there is no single scientific method that would guarantee the development of infallible knowledge" (AAS, 1993; Bauer, 1994; Feyerabend, 1993; NRC, 1996; Shapin, 1996, all as cited in Lederman et al., 2002, p. 501). Moreover, if the universe is expanding as Edwin Hubble suggests; or languaged in a native-indigenous way: that All-That-Is is an evolving consciousness seeking to know itself through self-actualisation; then there can be no such thing as infallible knowledge, points of absolutism, or god-codes.

> There has been a regrettable tendency of many scientists to claim that science is so powerful and all-persuasive that in the not-too-distance future it will provide an explanation in principle for all phenomena in the world of nature, including man, even of human consciousness in all its manifestations….Popper has labeled this claim as promissory materialism, which is extravagant and unfulfillable. Yet on account of the high regard for science, it has great persuasive power with the intelligent laity because it is advocated unthinkingly by the great mass of scientists who have not

> critically evaluated the dangers of this false and arrogant claim. (Eccles, 1979, p. i)

Arguably, the vast application, utility and benefit of western scientific knowledge (WMS) has allowed it to develop a sort of hegemony compared to other knowledges. However, the uniformitarianism on which WMS is predicated conceivably restricts knowledge growth

> For it implies no more than this, that like objects have always been plac'd in like relations of contiguity and succession; and it seems evident, at least at first sight, that by this means we can never discover any new idea, and can only multiply, but not enlarge the objects of our mind. (Hume, 1739-40, p. 157)

Additionally, there is deep awareness of how WMS has been misused and contributed to some of the present intractable issues, such as environmental degradation, that confronts our species. Humankind currently faces "global challenges such as climate change, population growth concentrated increasingly in megacities, financial crises, and infectious diseases, human society is at a tipping point in the next half century and must find new ways of solving problems" (Lane, 2014, para. 1). These new solutions will require creativity and an interdisciplinary, multinational response (Gijzen, 2013). WMS is still expected to play a major role, but will require an enhanced capacity through the formation of useful liaisons – and there is much to be learnt from native sciences (NS) especially regarding environmental issues and sustainability. There is evidence of these applications within the practical (though not so much the theoretic arena) as useful facilities. On inspection these applications reveal elements of both NS and WMS somehow interwoven and possibly inter-relating despite what are thought to be dissonant epistemological systems or ways of knowing. Examples include the use of cures for cancer developed around an individual's DNA (Gravitz, 2014) just as NS formulates user-specific cures; and the extensive use of sensors with the possibility to mimic extra sensory perception and walking in the inner worlds:

> The modern world is filled with network-connected electronic sensors, but most of the data they produce are invisible to us, 'siloed' for use by specific applications. If we eliminate these silos and enable sensor data to be used by

> any network-connected device, the era of ubiquitous computing will truly arrive....a likely possibility is that electronic sensors embedded in the environment will function as extensions of the human nervous system.…sensors and computers could make it possible to virtually travel to distant environments and 'be' there in real time. (Dublon & Paradiso, 2014, p. 37).

A possible explanation for the new liaisons between WMS and NS might be that WMS is beginning to unravel in some quarters the methods by which NS functions. This would say that NS is far from hocus-pocus magic, but more so comprises methods and content that can be of extreme utility to the benefit of humankind. Hence, a WMS vs NS (as opposed to one of mutual understanding) stance may slow scientific development. I am suggesting this to be the possible start of a quiet revolution that has the capacity to bring radical shifts to science as a way of being, science as a way of knowing, and science as a way of doing. This in my estimation is a good thing because good science is about continued attempts to falsify our hypotheses and so prove them rigorous.

> Its [science] advance is, rather, towards an infinite yet attainable aim: that of ever discovering new, deeper, and more general problems, and of subjecting our ever tentative answers to ever renewed and ever more rigorous tests. (Popper, 2005, p. 281)

2.5 Border-crossing, Collateral Learning, and Scientific Literacy.

WMS itself is demarcated by specific conventions, boundaries and values, is hence itself an ethnoscience, and western scientific knowledge a cultural belief (Franklin, 1995; Herbert, 2008; Sutherland & Dennick, 2002). 'Border-crossing' proposes that the learner exists in a variety of cultural worlds including that of their home, peers, science, and school science, making science instruction (including for western students) an adventure in acculturation between each of these subcultures (Aikenhead, 1996).

Whenever two different cultures come into continuous first-hand contact there is acculturation. Acculturation represents both the psychological experiences (e.g. stress, self-esteem, and changes to routines); and the sociocultural adjustments (e.g.

in collective activities and social institutions, such as learning a new language), that are made within both cultures (i.e. acculturation is a two way process). At the individual level, acculturation and adaptation can occur to different degrees (i.e. assimilation, integration, separation, and marginalisation). As this paper focuses on how individual students are learning science, it does not broadly discuss acculturation at the wider group level (Sam & Berry, 2010): such as how WMS and IS will adjust to each other within a shared space as George's (1986, as cited in George, 1999) taxonomy addresses to some extent.

A well-adapted individual adjusts ably both psychologically and socioculturally and acculturates through integration; that is, by participating in both their heritage and the new culture. Less well-adapted individuals acculturate by aligning themselves either to the new culture (assimilation) or to their heritage culture (separation). Some individuals will rebuke either culture and acculturate through marginalisation (Sam & Berry, 2010).

In border-crossing autonomous acculturation allows the student to be an inter-cultural borrower who could voluntarily cross into the ethnoscience of western modern science (WMS) to borrow, in a purist or modified form, aspects of WMS necessary to explain or navigate their world space. Autonomous acculturation was proposed to militate against the cultural assimilation of indigenous knowledge that normally occurs when it comes into contact with western knowledge systems (Aikenhead, 1996). As western scientific knowledge is usually the end goal of school curricula, school science instruction usually privileges a unidirectional movement of knowledge from WMS to the student's world/indigenous space, and so implies western scientific knowledge as superior to indigenous knowledges. I suggest that border-crossing should promote a multidirectional autonomous acculturation. A science-practitioner, bilingual in WMS and indigenous science (IS), would be able to access relevant content from the pertinent knowledge system and assemble it into cogent, bricolage solution. Here autonomous acculturation can be an example of adaptation through integration and so does not relegate WMS to IS, or IS to WMS, but allows practitioners to use whichever knowledge system is of practical utility. In time, this may help to develop a mutually respectful, bilingual nomenclature representative of processes highly similar across the two genres of

science, and which can help to promote the discussion between them. Mixed Methods Research (MMR) faces a crisis too of marrying the seemingly opposing worldviews of the quantitative and qualitative genres into a singular methodological system. Within MMR there exists similar movement towards a bilingual nomenclature (Creswell, 2011; Morse, Barrett, Mayan, Olson, & Spiers, 2002; Tashakkori & Teddlie, 2003). As example, the term 'legitimation' has been recommended to assume both the 'validity' of quantitative research and its counterpart of 'trustworthiness' in qualitative research (Onwuegbuzie & Johnson, 2006).

The goal of this study is to produce a curriculum that promotes reflective border-crossing so that students are aware of the cultural divide and of their journeys across. The curriculum actually does not require acculturation (though this might occur on some levels) of students to be successful; but rather their ability to critically compare the two knowledge systems, *and their interaction and influence* on each other. This is a form of anthropological teaching as it mimics anthropologists' need *to not* embrace their subjects' culture in order to participate in, or comprehend, it (Aikenhead, 1996).

Consider Mrs. S's infusion of WMS with traditional/indigenous medicinal practices discussed in section 1.2.3.3. Notice that Mrs. S is unaware of her movements across the border divide of western and indigenous science. Mrs. S shows a similar disposition to WMS-Expert 3's email interview in chapter one. However, WMS-Expert 3 shows a greater awareness of her border-crossings between the different sciences. There is a similar occurrence when school children in the Caribbean are learning the standard account of English whilst speaking Creole at home: that is, an interlanguage develops (a phenomenon witnessed by anyone learning a second language). As the learner grasps the second language they over generalise its rules and/or intermingle rules from their first language with it. Within this inter or third space there is a language that is neither the speaker's mother tongue nor the target language, and which operates by its own set of rules. Collateral learning (Jegede, 1995) has been used to describe the development of what I suggest is an interscience as non-western (and 'western' continues to be used not as a geographic

but more so a sociocultural position) learners, homeschooled in their indigenous science, try to learn western science.

> Collateral learning represents the process whereby a learner in a non-Western classroom constructs, side by side and with minimal interference and interaction, Western and traditional meanings of a simple concept. Collateral knowledge, therefore, is the declarative knowledge of a concept which such a learner stores up in the long-term memory for strategic use in either a Western or a traditional environment. (Jegede, 1995, p. 117)

There are four types of collateral learning and they stretch along a continuum from parallel-, to simultaneous-, to dependent-, and finally to secured- collateral learning (Jegede, 1995). Parallel collateral learning sees the learner housing the WMS and IS knowledge constructs around a shared topic within separate non-interacting schema. "Students will adduce and use a scientific concept, idea, or explanation of a topic while in school, but then quickly revert to the commonsense or life-world explanation of the same topic in their everyday life" (Ezeife, 2003, p. 182). Over time the learner becomes familiar with the WMS and IS knowledge constructs sitting side by side in their mind and *simultaneously* learns or commits them to long-term memory (Jegede, 1995): here concepts from one worldview promote the learning of a similar or related idea in the opposing worldview (Aikenhead & Jegede, 1999). In dependent collateral learning, schema from opposing worldviews come into conflict. The conflict is resolved through adaptation that adjusts currently held knowledge constructs of the learner and assimilates (as opposed to the Piagetian accommodation) it into existing schema; "no radical restructuring of an existing knowledge base occurs" (Jegede, 1995, p. 120). Finally, we have reached the pole extreme to parallel collateral learning. In secured collateral learning the learner is conscious of (Ezeife, 2003; Herbert, 2008), and has found ways to explain and reconcile in their minds, knowledge constructs from the opposing worldviews of WMS and IS that may have initially seemed to be in conflict with each other (Sutherland, 2005).

Within classrooms where plural views of science exist as occurs in multicultural student populations, border-crossing with aims of autonomous acculturation aided by secured collateral learning may be useful additions to the competencies of a

scientifically literate individual living in a diverse and global world. A scientific literate has a variety of faces. They may be a socially, politically, and civic minded individual capable of participating in, and building a strong democracy (Yoon, 2008) through their engagement in cogent discussion about governmental propositions to scientifically based projects such as health-care (Hartmann, 2013; Wightman, 2011). Other scientific literates may be part of a highly skilled workforce, or a member of a competitive global network of scientists capable of expanding scientific knowledge boundaries. Scientific literacy also promotes science for all and hence encourages gender and cultural equity (Yoon, 2008). Science literacy is hence context and need driven (Moore, 1995; Roth & Lee, 2004) and should be inherently useful to the lives of users (Feinstein, 2011).

2.6 Chapter Summary

The chapter has investigated how western (WMS) and native-indigenous sciences know the world about them. Reforms in science education have begun to recognise a plurality of sciences and it is opined that WMS, like any indigenous science, is a sociocultural construct. Moreover, within creolised, multicultural spaces as occur in Trinidad, there are no stark demarcations between western and indigenous science. The essay then has taken pain to present the plurality of positions by which it is suggested one can know the world and tries not to separate or categorise these as belonging to either a western or indigenous knowledge system. Instead, the paper begins to suggest science as a utilitarian activity to which western and native-indigenous sciences may make substantial contribution – individually and/or as a conjoined force – to the expansion of the frontiers of human knowledge. Lastly, the chapter advocates for science instruction within multicultural classrooms which promotes scientific literacy. This literacy is fostered through classroom experiences aimed at secured collateral learning through a promotion of autonomous acculturation as a critical border-crossing between western and indigenous sciences.

2.7 The Next Chapter

It has been suggested that indigenous sciences may be “better off as a different kind of knowledge that can be valued for its own merits, play a vital role in science

education, and maintain a position of independence from which it can critique the practices of science and the Standard Account [WMS]" (Cobern & Loving, 2001, p. 50). The next chapter justifies a complex adaptive system (CAS) framework as a theoretical model that can accommodate the apparently conflicting worldviews of WMS and native science. It is hoped then that a CAS can act as a mutually respectful platform that brings WMS and native science into a safe place from which they and any intersciences between them can be inspected, and compared and contrasted. This may help address concerns about native science practices that enjoy broad utility but whose assimilation into the standard account of science can continue to disintegrate indigenous knowledge systems.

CHAPTER 3

LITERATURE REVIEW 2: THE USE OF A COMPLEX ADAPTIVE SYSTEM AS A CURRICULUM INTEGRATING FRAMEWORK AND AS A METHODOLOGICAL FRAMEWORK

3.1 Aims of the Chapter

Literature Review 1' discussed how western and native science made knowledge. This chapter acts as postscript to 'Literature Review 1' as it continues the literature review. It is a separate chapter as it discusses all the ways that complex adaptive systems (CAS) are used in the study. CAS systems are new to educational studies and it was thought important to isolate their use in the thesis so that their applicability could be more strongly described.

A complex adaptive system (CAS) is used in two primary ways in this study: as an organising curriculum integration model for integrating native-indigenous science into a western modern school curriculum with which it is philosophically dissonant; and as a methodological framework.

3.2 Introduction to the Chapter

A thesis is indeed a journey. As I re-read my earlier writings I am amused by their air of certainty and definitiveness. I had thought then that this is how an expert speaks. I had expected my research to provide secure responses to the questions that I posed at its start. I have begun to suspect that the answers that I will uncover may provide relief to the tension within the inquiry lanes of the research questions, but will resist definitiveness and finality as they emerge fresh paths of reflection and exploration. The chapter looks at how a CAS can be used as an integrating curriculum framework, and as a methodological framework. The proposition as to how a CAS is to be used as a methodological framework is mine. I have proposed

here a new use for how a complex adaptive system can be used as a methodological framework to integrate multiple, diametrically opposed philosophies into a singular study. In this way a CAS competes with the only research paradigm, mixed methods research (MMR), that is presently able to entertain diametrically opposed philosophies within a singular study. The proposition is new, and the scope of this study does not permit me the space to hammer out what a CAS might look like as a possible, new multidimensional research paradigm. Within the bounds of this study I have then decided to expand the open sharing of my uncertainties with the reader as I continue to confess the problems that I encounter as I pursue the research. Hence, I write often in the present tense (Becker, 1983, 2008). In this way the process of my research is made patent in attempts not to compromise the epistemological robustness of the work (Becker, 1984). I have not altered the tone of my earlier writing so that the change in my own thinking with time is obvious as the document unfolds so that my research is presented more transparently and ethically.

As a reminder, the thesis has two main research questions. The first seeks the nature of the science of the First Nations peoples of Trinidad. The second seeks to integrate this native-indigenous science into the school curriculum, which is one of western modern science.

The chapter contributes to the resolution of the research questions through two main aims to justify a complex adaptive system (CAS) within this study as a:

1) suitable methodological framework or foundation upon which data collection and analyses occur.
2) suitable curriculum integration model to include the native First Nations science into a regular school curriculum of Trinidadian schools.

It might be useful to note that the paper distinguishes between a methodological and theoretical framework and views the latter as a framework that forms conceptual bounds, whilst the former acts a foundation upon which the methods of the study are built. Theoretical bounds to me (indicated by the conceptual bounds of the literature reviews), incorporate the methodological framework.

To achieve these two aims the chapter will first remind of the application to social and educational systems already posed in section 1.4. Next, the chapter will look at what a generic model of a CAS looks like; why a CAS might be a good lens through which to view a Trinidadian Caribbean science classroom; and why a CAS might be a good model of curriculum integration to incorporate the native-indigenous science of the First peoples into mainstream Trinidadian science classrooms which are bastions of western modern science. Finally, and as a precursor to the 'methodology' of chapter four, this chapter proposes the use of a CAS as a methodological framework.

3.3 What is a Complex Adaptive System?

This section introduces complex adaptive systems (CAS) by looking at why systems thinking might be important, and then giving a generic definition of a CAS. Later on in the chapter these understandings of complex adaptive systems are applied to explain why a CAS might be a useful theory of Caribbeanness and so help to promote the primary aims of the chapter: justification of a CAS as a curriculum integrating framework (sections 3.5 and 3.6); and as a methodological framework (section 3.7) within this study.

In section 1.4 the thesis mentioned the advent of complexity and its increasing use and focus in the social sciences, including education. An understanding of complex adaptive systems (complexity thinking) is recommended within both the content of educational arenas, and for the study of those arenas themselves. Within content domains complexity thinking might help students to better observe and resolve real life problems which are embedded within connected and interacting social, cultural, political, and economic systems. Of course the larger education arena itself is also part of this socio-cultural-politico-economic network and so its investigation is also suited to a complexity lens (New England Complex Systems Institute, 2001).

I mentioned in section 1.4 that complexity thinking "has roots in such fields as chaos (Doll, 1993; Fleener, 2008), cybernetics, systems theory, the natural sciences (such as evolutionary biology), and information science (Davis & Sumara, 2006; Alhadeff-Jones, 2008)" (p. 36 of this document). It is important to understand that

"complexity thinking does not *rise ove*r, but *arises among*" (Davis & Sumara, 2006, p. 8) these discourses. Complexity studies is itself emerging, reflexive, and co-participatory (Davis & Sumara, 2006). All of these approaches named here have in common that they look at how *systems* behave, and how a system's behaviour changes over time as it relates and adapts to itself and the environment (Fleener, 2008). That is, cybernetics, chaos, evolutionary studies, and information science are all contributing to the study of complexity (which drives complex adaptive systems). All of these things are concerned with how systems behave. This movement is part of postmodern new science thought that searches for alternative methods to the rigid empiricism and hypodeduction of the physical sciences to better document the vastness of the human experience (Fleener, 2002, 2008). Indeed

> It could even be said we are in need of a new cosmology-using this word to indicate not only our deepest metaphysical and spiritual beliefs about our origins but also to indicate the methods of ritual, story, and myth whereby we express and develop these beliefs. The new [complexity] paradigm we are seeing emerge from the insights of chaos theory requires of us nothing less than a brand new start in the description of nature-a start which will affect our metaphysics as well as our physics, our cosmology as well as our logic. (Doll, 1993, pp. 90-91)

So far systems thinking has contributed to insights in quantum physics, evolutionary biology, and psychology (Fleener, 2002).

In marked contrast to a systems perspective, more historical models such as Newtonian systems look at how the *members* of a system behave (e.g. students are members in the system of a classroom). A Newtonian model of a classroom would suggest that the behaviour of the classroom system would be the sum total of the behaviour of individual members/students of the classroom. These older, Newtonian models do not take into consideration that students within the classroom are also interacting with each other; that these interactions are also contributing to the overall nature of the classroom/system; and that interactions also affect how students behave in the first place. This is to say that a Newtonian model of a classroom suggests that individual student behaviour is independent of the

interactions and dynamics within the classroom. Conversely, systems thinking models look at *systems* as opposed to *members* only, and believe that student behaviour cannot be independent of the interactions and dynamics of the classroom system, and is in indeed shaped in many ways by these interactions and dynamics.

Why though does systems thinking focus on systems as opposed to members? One interesting natural science experiment from chaos theory that contributed to complexity and a study of systems has been described by Doll (1993). A pendulum was swung first between two magnets- a and b- in a plane. In a second experiment the pendulum was then swung between three magnets- a, b, and c- set up in the same plane with the magnets equidistant from each other in an equilateral triangle. When the pendulum was swung between only two magnets it did so in a rigid and repetitive pattern from a then to b, then to a, then to b, and so on. The behaviour of the magnet when it is swung between the three magnets is more dramatic. When the magnet is swung with a low momentum (speed x weight) in the plane with the three magnets it swings between two of the magnets and ignores the third. If the magnet is pushed hard so that the momentum is increased, the pendulum alternates between pairs of magnets and swings say first between a-b, then between, b-c, then between a-c. If the pendulum is given an even harder push, at first it alternates between pairs, but at some point it begins to move haphazardly between all three magnets and at this time its behaviour becomes chaotic. The behaviour of the pendulum movement between the magnets during the chaotic period could be represented graphically in two ways. The first would plot the behaviour of the pendulum alone over time on a regular x-axis, y-axis Cartesian grid (see ‘Figure 1’ below). An inconsistent, chaotic pattern is evident here.

Figure 1: Cartesian Graph of a System in Chaos (Doll, 1993, p. 93)

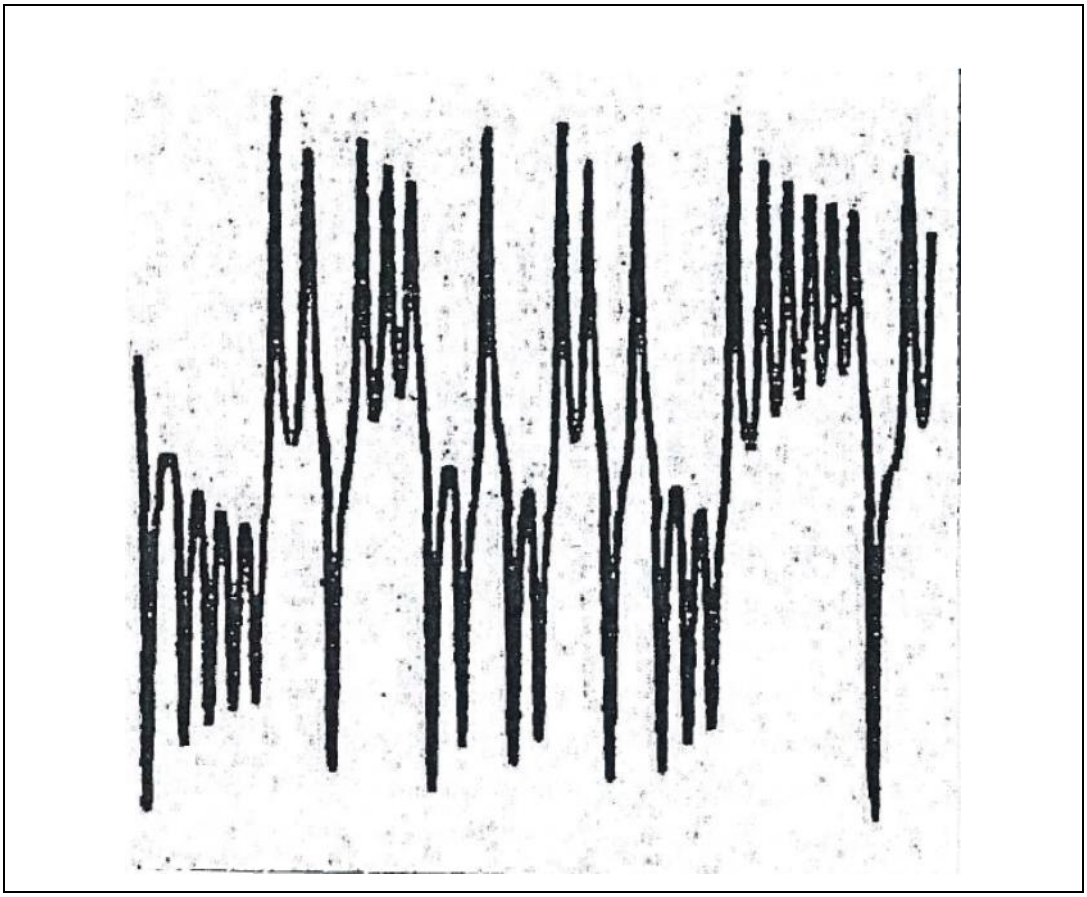


Figure 1: Here only two variables are represented- how the pendulum moves and the time in which it does so- with one on each representative axis. An inconsistent, chaotic pattern is evident here.

The second plot would be a phase space graph which would then look at the co-ordination between the different variables of the pendulum's behaviour and how they related to each other as a system over time (see 'Figure 2' below also known as Lorenz's 'owl's eyes').

Figure 2: Phase Space Graph of a System in Chaos

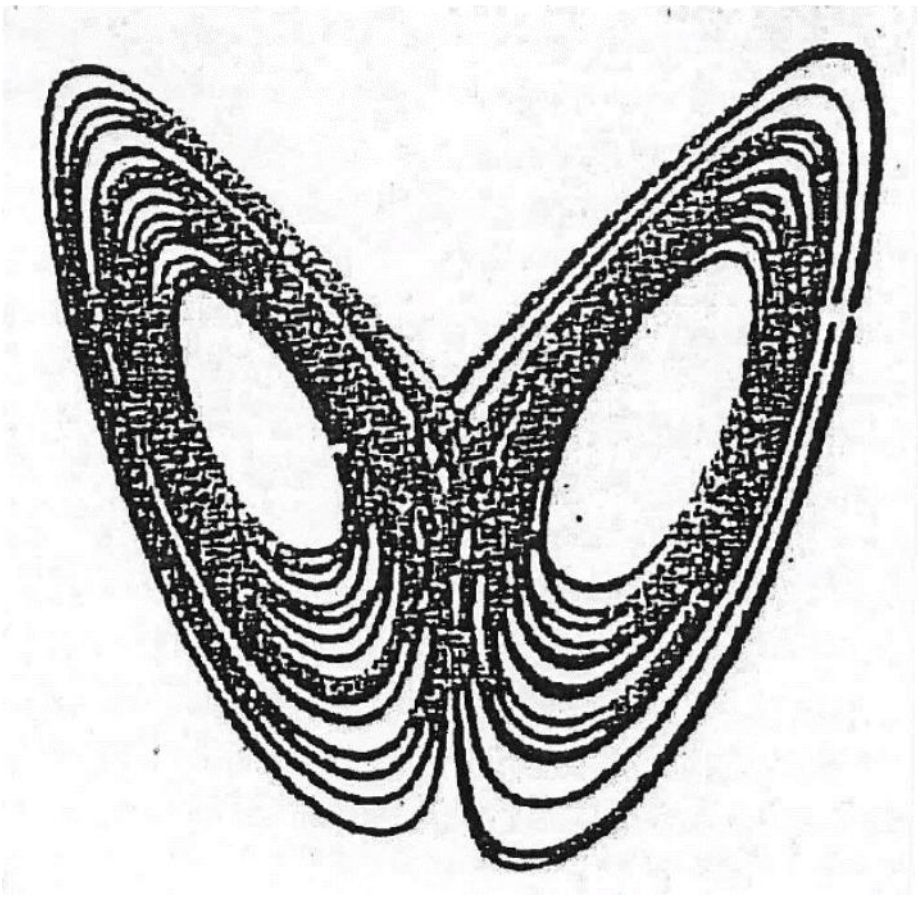


Figure 2: Variables about the system are coordinated as one point on the graph so the shape of the graph represents how the system as a whole changes over time. Unlike the Cartesian graph in 'Figure 1' of a system in chaos, time is not on any axis but shifts along the line of the graph itself. The shape of this figure is known as Lorenz's owl's eyes (Doll, 1993, p. 92)

By looking at the behaviour of the system ('Figure 2'), as opposed to the behaviour of its members, the magnets ('Figure 1'), we can see that within a chaotic system there is an ordered pattern of behaviour as the behaviour of the system itself is bound to a certain pathway over time- that of Lorenz's owl's eyes in this example. Here we can see that chaos tends to order and is bound to a certain pathway. These pathways are suggested to be universal regardless as to whether the subject is pendulums or students (Hayles, 1990).

> The fundamental assumption of chaos theory, by contrast [to the Newtonian paradigm] is that the individual unit does not matter. What does matter are recursive symmetries between different levels of the system.…The regularities of the system emerge not from knowing about individual units but from understanding correspondence across scales. (Hayles, 1990, p. 170)

"Translated into curriculum terms, this quotation says it is not the individual as an isolated entity which is important but the person within the communal, experiential, and environmental frame" (Doll, 1993, p. 92). This is to say that curriculum is relational in its philosophy. Studies like these contributed to the discussion of systems thinking and hence to complexity.

The paper has just looked at why complexity thinking might be important and moves on now to generically define what a complex adaptive system is. The application of complex adaptive systems (CAS), chaos theory, and a systems perspective in general to social systems and education is relatively new (see section 1.4). I am suggesting within this chapter that a CAS is a useful curriculum integrating framework for this study and Doll (1993) has provided a useful model. The chapter is also proposing a new way in which a CAS can be used as a methodological framework but I do not have scope within this work to fine-tune the exact dimensions of that proposition. Indeed, the intrinsic adaptive nature of a CAS does not allow any complex system to be exhaustively defined and the paper goes on now to generically define what a CAS is. It will later turn to look at how this definition can be applied as an integrating and a methodological framework within the study.

A complex adaptive system (CAS) can be visualised as a network (see 'Figure 3') and is made up of members (represented by the spheres) who are connected, and who interact via simple rules. An example of a CAS is a classroom with the students being members, or an organisation with employees being the members.

Figure 3: A Complex Adaptive System

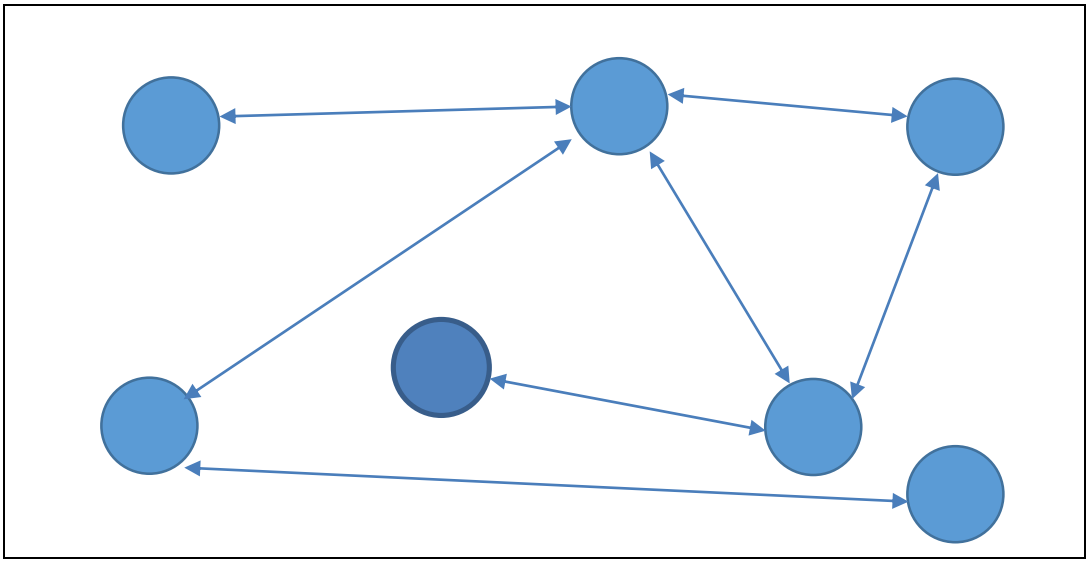


Figure 3: A simple schematic depicting members (spheres) within a complex adaptive system, and their potential interactions (double-sided arrows).

The boundaries between the members are porous so that they can pass information between them as they interact (Chaffee & Mc Neill, 2007; N. Johnson, 2012). Hence, individual elements/members are not always discrete or easily defined. Within a CAS, members are governed by simple rules and so do not require any regulating central authority (Chaffee & Mc Neill, 2007). Information exchange within a CAS tends to occur primarily between members within immediate proximity so that the integrity of the system relies on members' immediate interdependencies, "not on centralized control or top-down administration" (Davis & Sumara, 2006, p. 5). If there is a change or bifurcation in the system, members utilise the simple governing rules to decide how they will interact with each other to face the change. To adapt to change, a CAS, (through its members), self-organises and emerges new behaviours (Chaffee & Mc Neill, 2007; Davis & Sumara, 2006; N. Johnson, 2012), and possibly rules, via trial and error to yield stable, systematic, and usually increasingly complex ways of knowing, being and doing. 'Trial and error' is a feedback loop where reflections upon past actions/lessons/learnings inform future decision making (N. Johnson, 2012): that is, a CAS can adapt and is a learning system (Davis & Sumara, 2006). A healthy CAS permits creativity and

innovation, but faces extinction if it is unable to evolve in the face of change. An example of a CAS is the traffic system with cars moving along the network of roads in a given area. If there is a sudden traffic jam (a bifurcation or change to the smooth flow of cars) on the highway, drivers/members will individually self-organise by moving onto alternative pathways to escape the traffic jam perhaps guided by radio reports of clear connector roads, or by their GPS. In this way the system adapts and emerges a new pattern of ordered, overall traffic flow without direction from any central authority. At any time though, this new order threatens to descend into the disorder of blocked traffic flow somewhere in the overall system of roads. That is, complex systems simultaneously display ordered and disordered behaviour and move between order and disorder through their own doing: so that a traffic jam can spring up suddenly for no foreseen reason (N. Johnson, 2012). Complex systems hence exist far from a state of equilibrium and small bifurcations to the system can lead to extreme responses/emergents (Davis & Sumara, 2006; Fleener, 2002; N. Johnson, 2012). The ways in which a CAS will adapt to a bifurcation are unpredictable (Chaffee & Mc Neill, 2007) as both the members and the relations between them are able to change in order to adjust and survive. Moreover, these interactions are uncoordinated and hence do not tend to occur in any linear (Chaffee & Mc Neill, 2007) sort of way.

The emergent, macroscopic properties of a CAS are an amalgam of both the characteristics of individual members, and the outcome of the relationships between them. Unlike a Newtonian system then, a CAS cannot be reduced to the sum of its parts: a traffic pattern is more than the sum of how well or poorly individuals drive, but is also a function of how those drivers inter-relate as they occupy the highways/roads together. A CAS is hence non-reductionist: the sum of the microscopic properties of individual members do not account for the total elements of the system, with the interactions between members adding further texture (Davis & Sumara, 2006). A CAS is also dissipative: an open system with fuzzy boundaries that exchanges matter, energy, and information with all around them (Davis & Sumara, 2006). A CAS is therefore problematic as a ‘scientific’ system in the western modern sense, as these are closed and endure only one manipulated variable at a time so as to determine causal effects (N. Johnson, 2012). Even as CASs are systemically open, they are organisationally closed – “inherently stable –

that is, their behavioral patterns or internal organizations endure, even while they exchange energy and matter with their dynamic contexts (so judgments about their edges are usually based on perceptible and sufficiently stable coherences)" (Davis & Sumara, 2006, p. 6).

This section has so far discussed complex systems thinking, and defined what a CAS is. The essay now applies these understandings to explain why a CAS might be a useful theory of Caribbeanness and so help to achieve the primary aims of the chapter: justification of a CAS as a curriculum integrating framework (sections 3.5 and 3.6); and as a methodological framework (section 3.7) within this study.

3.4 The Role of a Complex Adaptive System as a Theory for Caribbeanness and the Trinidadian experience

Even if unrealised or undeclared, practitioners approach research with ideas influenced by their experiences about how the world works. By suggesting how the world works these ideas by extension suggest too how it should be investigated, and how any challenges therein may be addressed and solved. These testable ideas or suppositions are theories, and choosing one to guide a research endeavour may be tricky as it requires an understanding of the epistemological mores of participants and their world (Fetterman, 1998). Hence, it is important to build any research upon a theoretical foundation that supports and aligns with the philosophical mores of a study. I am suggesting that a complex adaptive system can do just that for a study of science within the Trinidadian, Caribbean experience.

There is a paucity of research about the relatively new independent nations of the Caribbean. In my experience as a Caribbean person, teacher, student, and researcher I have found that most widely accepted educational theories have been extrapolated from realities dissimilar, and often times dichotomous, to the everyday experiences of these underrepresented populations. Mainstream educational theory, as a simplified approximation of reality (Maxwell, 2011b), may be an even more obscure model of the life of minorities. The spurious application of theory to contexts outside of those in which the theory has been formulated risks the formation of metanarratives. For this study, localised in the postcolonial Caribbean,

the application of theory generalised or concluded from peoples with dissimilar cultures risks warnings of practice that is not practical (Thomas, 2007), and admonition that "we cannot occupy a position outside practice" (Carr, 2006, p. 137). Plantation economic theory, even though outside of the education arena of this study, contains parallels that can help illustrate:

> The theory of plantation economy asserted the specificity of the Caribbean experience. It was one of the earliest attempts to understand the Caribbean economy within its own terms, rather than within the framework of a preordained paradigm of metropolitan provenance. It is heterodox rather than orthodox, eclectic rather than ideological, and Caribbean-centred rather than Eurocentric. And it provides an historical perspective…that is highly relevant to the present. (Norman Girvan in Foreword to Best & Levitt, 2009, p. xvii)

Indeed it has been said that "the master's tools will never dismantle the master's house. They may allow us to temporarily beat him at his own game, but they will never enable us to bring genuine change" (Lorde, 1984, p. 112). As practical example, I want this research to be indigenist research that rests upon Trinidadian ontology as opposed to western research done by an indigenous Trinidadian (Martin & Mirraboopa, 2003). My identity issues have not allowed me to comfortably decide if I am a western researcher carrying out research on a native, indigenous population or if I am indeed carrying out an indigenous research. As a Creole I identify more times with the first because I feel unworthy in many ways of being called an Indigenous Trinidadian as I have previously explained (see section 1.6). Western ways of knowing, being, and doing are only part of who we are as Trinidadians. Maybe I too am a porous dot as illustrated in 'Figure 3': a member in the CAS of Trinidadian science through whom indigenous science and western science pass, co-mingle, adapt, and emerge a new creolised Trinidadian science. To make this study indigenist research I attempt to "apply ontologically, epistemologically and axiologically appropriate methodologies" (Botha, 2011, p. 315) in defining all constructs. In section 3.7 I go on to propose how a CAS can be used as an appropriate methodology as it can house a variety of theories appropriate to the system under study. In the continuation of this immediate section I go on to discuss why a complex adaptive framework is appropriate to study science within

Trinidad, Caribbean. I have simultaneously aligned the study with protocols that guide western research so that this indigenist study is recognised (Martin & Mirraboopa, 2003).

There is arguably a need for a retrieval of 'space' for indigenist research (Tuhiwai Smith, 2012) within Trinidad. Successful, though extra-regional, examples of such initiatives include Kaupapa Maori research protocol. Kaupapa Maori is located within Maori philosophy and principles, and holds implicit the validity and legitimacy of Maori, its language, and its culture (Smith, 1990, as cited in Tuhiwai Smith, 2012).

Still, caution is advised when formulating theory within, and for the margins of disenfranchisement. For instance, consider postcolonial theory which has risen

> against the meta-narrative of European colonialism…as a set of perspectives through which the contemporary world is re-interrogated, re-interpreted and re-positioned discursively through practices and policies *of* and *for* social justice. If research is constructed as a dominant story told about a particular moment in which a particular group responded to social, economic, political and historical forces, the postcolonial research offers the possibility of a new story, a different story, and a contested story. It addresses not only the illusion of colonialism as a universal perspective but interrogates itself as one which is framed within the systems it functions to disrupt (Bristol, 2012, p. 21).

However, just as postcolonial theory challenges subjugation, it has potential to become a colonial metanarrative if it is not practical to the circumstances from which it emanates. "A theory of postcolonialism which suppresses differences…is ultimately flawed as an ethical and political intervention into conditions of power and inequality" (Gandhi, 1998, p. 170).

Indigeneity within a postcolonial Caribbean space is multifaceted, complexed, and manifests within the sociocultural relations of the region. Trying to understand what 'Caribbean' means by interrogating its individual parts, may be futile as the whole is more than the sum of its parts. Studies of the sociocultural relations within the

Caribbean may be best suited to a composite or metalens that is premodern, modern, and postmodern (Benitez-Rojo, 1996).

A single theoretical lens that allows this research to investigate how participants of this study make and do science within a western framework might literally render invisible the relational ways, such as metaphysics, through which native-indigenous science proceeds and constructs knowledge. The converse also holds, that a relational lens of native-indigenous science can render western science components within the study invisible. The question arises for Caribbean spaces of

> how shall we consistently articulate the magical alongside the scientific, the metaphysical with the epistemological, the mythological with the historiographical, [the African gods] Oshun or Shango with Karl Marx, Mackandal [a Haitian Maroon leader] and Michel Foucault? In pursuit of the answer to this question, I conduct my own investigation according to the nonlinear approach offered by Chaos [theory and complexity theory]; that is, I look at the Caribbean as a paradoxical machine of machines, as a turbulent system under whose disorder there are regularities that repeat themselves. I should make it clear that these repetitive patterns tell us very little about when, where, or how Caribbeanness originated. Nevertheless, they tell us how the system functions, what its critical points are, which of its dynamics are resistant to change. (Benitez-Rojo, 1996, p. 296)

I am suggesting a complex adaptive system as most suited to help me resolve the tension of the research questions (Fetterman, 1998) as *firstly*, it is representative of the Caribbean context in which the study is located. That is, a CAS might be a useful theory of Caribbeanness and so help to achieve the primary aims of the chapter: justification of a CAS as a curriculum integrating framework (sections 3.5 and 3.6); and as a methodological framework (section 3.7). As has been discussed in chapter one, the Trinidadian experience is a creolised one. Pioneering works such as Laurette Bristol's Plantation Pedagogy (2012), and Lloyd Best's Plantation Economy (Best, 1968; Best & Levitt, 1969) on which Bristol's (2012) work is based, have been critically acclaimed as groundbreaking. They offer theoretical lenses that consider the continued impact of the colonial plantation on Trinidadian pedagogy, and economy respectively. Even so, neither work speaks specifically to creolisation within the Caribbean. Creolisation is not widely considered within the

contemporary literature as a form of indigeneity modelled by practical theory, and so possibly enable it to function as decolonising methodology regionally. I suggest here that a CAS can recognise creolisation and so act as a decolonising and indigenous methodology as it can hold all of the different disparate bits and their interactions that form a creole (as is the scientific system under study as proposed in the next paragraph).

Secondly, a CAS is a useful *methodological framework* (explained further in section 3.7) because it can accommodate the philosophy of a Trinidadian science, and by acting as a lens that lends greater visibility to the particulars of the Caribbean condition. I suggest a complex adaptive framework as appropriate to study science within Trinidad as it can contain the philosophies of western science (which has a predominantly positivist philosophy); native-indigenous science (which has a relational, interpretivist philosophy); and an emergent creolised science formed from the interaction between them (and which possibly has a creole philosophy that is a mix of relationality, interpretivism, and positivism; this is discussed further in section 3.7).

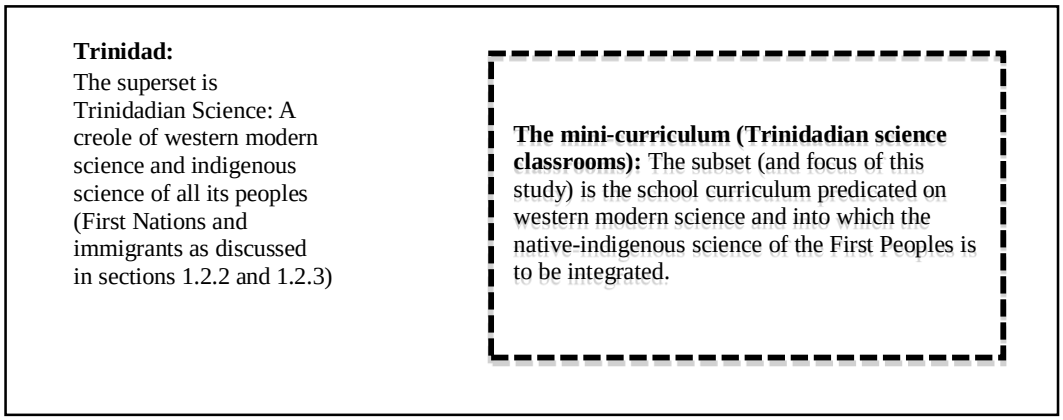
Thirdly, a complex adaptive system can be used as an *integrating curriculum framework* (explained further in sections 3.5 and 3.6) to accommodate both western science, native-indigenous science, and their integration into a course of studies.

The thesis goes next to discuss why it proposes a CAS as an integrating curriculum framework and how it will be used as such. The last section (3.7) of this chapter looks at how a CAS functions as a methodological framework in the study. It is done at the end of this chapter to form a bridge into the 'methodology' in chapter four.

3.5 Why a Complex Adaptive System Might be a Useful Curriculum Framework

This study is about the nature of the science of the First Nations peoples of Trinidad (a native-indigenous science), and its integration with western science (WMS) in a mini-curriculum (see 'Figure 4').

Figure 4: Science of the Mini-curriculum (note the porous border)



Section 3.5 justifies why a CAS might be a useful curriculum framework and section 3.6 goes on to justify how a CAS acts as such a curriculum framework to help to integrate native-indigenous science into a western science curriculum. There is academic work indicating that the superset of Trinidadian science has been studied within Trinidad (e.g. Coard, 2013; Herbert, 2003). Moreover, as a teacher-educator in Trinidad, our student-teachers were routinely encouraged to accommodate the Trinidadian IS practices that their students brought from home into their lesson planning and enactment. This accommodation was not primarily aimed at an explanation of the IS practice unless it fell into category one of George's (1986, as cited in George, 1999) taxonomy (see section 1.2.3.2). It was more so a consideration of the students' pre-knowledge to better chart the course of their border-crossing into the WMS of school science. The interviews with Trinidadian science experts in chapter one of this study indicate that they too practice the Trinidadian science described in 'Figure 4': a form of science that is an integration of IS and WMS. This is in spite of their scientific mastery as evidenced by their academic qualifications assumingly indicating their embrace of WMS epistemology. These scenarios indicate that within Trinidadian science, firstly, that an IS-WMS integration is already occurring practically in the way science is used in Trinidadian homes or everyday life. Even so, reliable, duplicable, curricular methods/models that provide a road map for such integration are not prolific, and need to be articulated. Secondly, within a practical, everyday reality participants utilise the facets and content that they know of WMS and/or IS as it suits the needs

of their everyday lives without a conscious intent to integrate the two types of science (this is an example of autonomous acculturation). This indicates routine border-crossing back and forth between WMS and IS and suggests that the border between WMS and IS is *porous*. That is, WMS and IS are each a dot with porous borders (see 'Figure 3') which permit them to interact, share information and adapt within a complex adaptive system. (Do note, though, that this research is not aimed at determining the degree of porosity of the border). This border-crossing also occurs in no fixed or linear way, dictated only by the demands of the circumstances requiring scientific intervention. This crossing is done at will with no central, governing mandates, and occurs via simple rules which appear culturally derived and of which participants of the culture are knowledgeable. That is, participants of the culture know when to use science content of IS or of WMS to support and justify their daily living simply by being practitioners of the culture. Furthermore, the epistemological bits and pieces transported by migrants as they crisscross the WMS-IS border, and how these elements are used to adapt the epistemological terrain on either side of the border, may be able to be mapped from the nature of the new (creole) science that emerges. This emergent new science is a result of collateral learning (Jegede, 1995) and is hence an interscience. It seems too that as users pass back and forth that the epistemological structures of IS and WMS naturally self-organise to yield the features or nature of this new creole, interscience. This new science is non-reductionist as it cannot simply be separated into its WMS and IS attributes which seem to be relating within a wider tapestry as indicated by George's (1986, as cited in George, 1999) taxonomy for Trinidadian science (see chapter one). Hence, Trinidadian science is suggested here as a complex adaptive system (CAS) of western and indigenous science (of which the native science of this study is a part).

A CAS was hence thought useful to the integration of an indigenous native science into school (western) science within the proposed mini-curriculum/unit of work for two primary reasons. Firstly, Trinidadian students in Trinidadian science classrooms are learning WMS off of the official school curriculum. However, a classroom is a subset of wider Trinidadian society and students within our society are practicing (and bring these understandings with them to class) Trinidadian science in their everyday lives. A CAS then is a useful representative of Trinidadian

science which is the context within which the study is collecting and analysing data. Secondly, a CAS can hold the relational, interpretivist elements of a native-indigenous science as well as the positivist elements of WMS (this is discussed more in section 3.7) that are being integrated in this study to respond to research question two. As such, a 4R curriculum model (Doll, 1993) that is inherently a CAS is used as a curriculum integration instrument and is discussed next.

3.6 The Model of the Proposed Unit of Work

3.6.1 The Unit's Audience

The unit of work was originally to be utilised within a school classroom. The Native peoples who are allowing me to participate in their story run a small museum which they are in the midst of converting into a cultural village. During data collection I became aware that it is of greater utility to them to have a unit of work that can contribute to their presentations and work at their museum and village, which includes camps for school-aged children. The unit has hence been geared directly for this use but is still user-friendly as an addendum within any western science curriculum to the topics that my unit of work addresses.

3.6.2 The Unit's Complex Adaptive Model/Frame

This section discusses what a unit of work that is a complex adaptive system looks like. The unit of work utilises the 4R model (richness, recursion, relations, and rigor) for a complex adaptive curriculum (Doll, 1993). Curriculum in this model is: non-algorithmic; emergent, determined and discovered along the way; post-modernist (and hence postpositivist); self-actualising; and transformative to all members concerned (teacher and student), as well as the community in which they are embedded (Doll, 1993).

A rich curriculum optimises "*indeterminacy, anomaly, inefficiency, chaos, disequilibrium, dissipation, lived experience*….to be provocatively generative without losing form or shape" (Doll, 1993, p. 176). Richness introduces *bifurcations* as myriad new stimuli, dissonant to the students' held knowledge. This

gives students opportunity for adaptation and *self-organisation* of their knowledge constructions to *emerge* new learnings. This essay interprets 'richness' as problem-based, exploratory, contextual, and relevant to the life world of users.

Recursion is a *trial and error feedback loop*. It deals with "having thoughts loop back on themselves….Such looping, thoughts on thoughts, distinguishes human consciousness; it is the way we make meaning" (Doll, 1993, p. 177). Recursion utilises reflection differently to repetition. Repetition would have us repeat the same circumstances multiply – and possibly mindlessly – until we achieve some set of closed a priori aims. In recursion, reflection is more reflexive; as thoughts loop back onto themselves there is opportunity for reflection and decision making that can lead to adaptation and transformation. That is, *the system is an open one*. The power of recursion is seen in Bruner's (1960) spiral curriculum (Doll, 1993). A spiral curriculum allows any concept to be taught in an intellectually honest form to any age of children and their understandings 'spiraled upwards' as they mature cognitively. Unlike repetition, in recursion things do not

> just go back to the beginning; it creates a new world where the initial conditions are different from the previous world and where some evaluation occurs or a decision is made. As the recursive process continues, new worlds are created each time (in the middle of one world) new possibilities are created. (Fleener, 2002, p. 169).

Recursion is infused in this work as assessment that is dialogic and reflective. Hence, it utilises self, peer, and teacher assessment as part of a reflective dialog (Doll, 1993).

Relations are both pedagogic and cultural. Pedagogic relations assume a non-uniform universe; one that is not constant throughout time. If uniformitarianism is true, then as time passes we have increasing opportunity to view/discover more of the universe. If the universe is expanding, "in a universe of and in process", time is transformative as it permits development to occur (Doll, 1993, p. 179). Hence, the curriculum frame at the start of a course is unavoidably different from its shape at the end – most importantly the difference should have led to positive change or transformation. Pedagogic relations permit curriculum to be student-directed in

some measure; are time-oriented as they choose activities that are built/completed iteratively over time; and focus heavily on classroom discussion and interactions between people, ideas, and resources (Doll, 1993). The curriculum is hence not a priori but *emerges* over time as members (people, ideas, and resources) of the system *interact*. Cultural relations are described in this curriculum model as hermeneutic, and incorporate both narration and dialogue. In being narrational the model resists metanarratives and embraces the local and historic. In being dialogic the curriculum maintains a global and international perspective, and the place of the local and historic in this wider scenario. The curriculum is hence non-anthropocentric and is instead cosmological (Doll, 1993). Hence, this curriculum unit utilises 'relations' within cognitive mentorship and social constructivism.

Rigor helps the 4R model to escape "rampant relativism…sentimental solipsism….anti-measurement or non-measurement" (Doll, 1993, p. 181). Rigor includes a purposeful search for, and development of "different alternatives, relations, connections" (Doll, 1993, pp. 182-183). At first glance this search may resemble Popperian falsification but inspection reveals its embrace of alternate pathways of experiencing the world and an encouragement of imagination and creativity. Rigor utilises inquiry based learning geared towards "examining assumptions, challenging traditions, and encouraging creative solutions" (Fleener, 2002, p. 173). The unit of work adds rigor through the use of inquiry learning, creativity, and imagination.

3.6.3 How the Unit was Integrated

Fogarty (1991) posited three methods of within-discipline integration (connected, fragmented, and nested); five methods to integrate across-disciplines (sequenced, webbed, shared, threaded, and integrated); and two methods of integration that occur within-and-across-learners (immersed and networked integration). The infusion of indigenous native science into a western science curriculum was achieved via a connected model.

Native *science* is being integrated within a western modern *science* curriculum so a within-disciple model was chosen. Moreover, from the three types of within-

discipline integration, (connected, fragmented, and nested), a connected model was chosen. Fragmented integration keeps individual disciplines separate, as they are traditionally for example on a school's timetable. Within a nested curriculum a teacher will integrate specific skills (e.g. a thinking skill and/or a social skill) with the content skills. Within a connected curriculum linkages between skills, concepts, and/or content are made explicit to the student (Fogarty, 1991) through experiences surrounding common personal and social problems (Wraga, 2009). Within science a connected curriculum can develop links between algorithmic and conceptual understandings across native and western sciences. These algorithmic and conceptual links may include: the relationships between concepts, the physical/experiential/experimental, and the mathematical/symbolic (Levy & Wilensky, 2009). Understanding how skills, concepts, and content interact would also permit for autonomous acculturation.

3.7 A Complex Adaptive System (CAS) as the Theoretical Methodological Framework

As a reminder of section 3.1, this chapter discusses the use of complex adaptive systems within the study: that is, as an integrating curriculum framework (section 3.6) and secondly as a methodological framework (in this section). The chapter after this one is chapter four, the 'methodology'. However, since this chapter deals with all-things-CAS in this study it moves now, as a precursor to chapter four, to justify why a CAS was used as a methodological framework.

This study compares, and attempts to integrate, conceptions of science predicated on a fixed view of reality (empiricist, hypo-deductive, often quantitative, western modern science), with those predicated on a constructed view of reality (relational, metaphysical, interpretivist, often qualitative, native-indigenous science). That is, the study is undergirded by ideologies often cited as antagonistic and non-complementary. I was challenged then in finding a bifocal methodological lens able to view and discuss western and native-indigenous science on equal terms.

Mixed Methods Research (MMR) at first glance seemed able to provide a suitable bifocal lens for the study. The academic literature indicates three major research

paradigms: quantitative, qualitative, and mixed methods. Generally speaking, quantitative research is built on a positivist philosophy; qualitative research is built on an interpretivist philosophy; and mixed methods research is arguably built on both. Mixed methods research (MMR) advocates for the use of *both* quantitative *and* qualitative methodologies within a *singular* study. Utilising a variety of theories, as MMR does, about how the world works can permit "what Greene…has called a dialectical approach, one that combines divergent mental models [like theories] to expand and deepen, rather than simply confirm, one's understanding" (Maxwell, 2011b, p. 43). The field of MMR is still grappling, and arguing on many fronts, about how both qualitative and quantitative elements, which stand on dissonant philosophies some think, might be incorporated into the same study. It is still being debated whether mixing of the quantitative and the qualitative within MMR functions only at the practical methods level, or at both the practical methodical and philosophical levels (i.e. methodologically) (Tashakkori & Creswell, 2007). Even amongst researchers who view MMR as a third paradigm there is still avid contest about what mix means (Creswell, 2009); what is being mixed (Moran-Ellis et al., 2006; Sandelowski, Voils, & Knafl, 2009); and about the benefits of mixing, and how that mixing should be done (Denzin, 2012). This study's position is that MMR is a methodological paradigm (Creswell & Plano-Clark, 2007; Denzin & Lincoln, 2011; Greene, 2008; Tashakkori & Teddlie, 2003) with supporting philosophy, and not simply a mix of a variety of methods. Moreover, I utilise the term 'mixed methods research', abbreviated to MMR, to distinguish it from qualitative genres in which multiple qualitative methods might have been employed (e.g. bricolage, triangulation, and multigenre crystallisation) (Denzin, 2012).

To integrate a relational, interpretivist native-indigenous science into a positivist, western modern science school curriculum requires a framework that can house both kinds of philosophies and their accompanying methods. Mixed methods research (MMR) has already been indicated by the academic literature, as discussed in the previous paragraph, as being able to do so. I am suggesting that a CAS is a superior alternative to a MMR methodological framework within this study. To make this suggestion I forward a new proposition as to how a CAS might be used as a methodological framework.

I am proposing that a CAS, like MMR, can house diametric philosophies. Again, this is necessary because this study integrates native-indigenous science which is relational and interpretivist, and western modern science which is positivist. Exactly though, how will a CAS be able to function as a diametric methodological lens which is made up of a variety of theories? I am suggesting that to do so requires assigning a theoretical designation or representation to members within a CAS. So that the members (dots in 'Figure 3') might be positivist or opposingly relational and interpretivist, and so create a composite methodological lens that is diametric. As a closer theoretical approximation of the world around us, a composite lens may help to alleviate anxieties (as those suggested in Carr, 2006; Thomas, 2007) about the application of theory to contexts unrepresentative of the practical bounds from which they emerged. Indeed, a collection of theories may better approximate the reality on which it attempts to report given the vulnerability of a singular theory at representing the labyrinthine nature of reality (Maxwell, 2011a).

Moreover, unlike MMR, a CAS is not only capable of holding contradictory theories to represent western and native-indigenous science, but I am suggesting that it could also represent the interaction between them that seems to be occurring practically within a Trinidadian scientific system. In a similar way to MMR, a CAS encourages a "dialectic between opposing ideas [that] can contribute to new insights and new understandings" (Greene & Carecelli, 1997, as cited in Creswell, 2009, p. 102). Whilst MMR can hold opposing theories it does not suggest that these theories can interact. Certainly, the cogency of a MMR research design is strongly influenced by how well it blends the strengths and weaknesses which exist within purely qualitative or quantitative genres (e.g. the issue of validity and transferability) (Onwuegbuzie & Johnson, 2006). Moreover, "according to the *fundamental principle of mixed research*, it should often involve the combining of quantitative and qualitative methods, approaches, and concepts that have complementary strengths and non-overlapping weaknesses" (Brewer & Hunter, 1989, and Johnson & Turner, 2003, as cited in Onwuegbuzie & Johnson, 2006, p. 51). Even so, component theories within MMR are usually held as discrete things and their interaction is not routinely addressed in the scholarly literature. As a reminder, both the reported definitions of science by Trinidadian experts (in chapter one), and analysis of George's (1986, as cited in George, 1999) taxonomy indicate

some sort of interaction between western science (with a positivist philosophy) and indigenous science (with an interpretivist philosophy) occurring within Trinidadian science. I am suspicious too after investigating George's taxonomy (1986, as cited in George, 1999) that this interaction might be able to be described theoretically but this paper does not have the scope to do so.

So far I have proposed a CAS as a superior methodological framework over MMR for this study because it can not only hold diametric philosophies, but also because it might be able to facilitate the interaction between them. I am also proposing that since a CAS is inherently adaptive that this feature can also make it superior to MMR in this scenario. I suggest that this adaptability allows the methodological framework to be adaptive within the course of the research as opposed to a MMR methodological frame which is static. Why did I think that a flexible methodological frame was important? Well the ontology and epistemology of First Nations peoples in general has been well-articulated but this articulation lacks clarity specifically for the First peoples of the Caribbean. Moreover, the ontological and epistemological mores of Trinidad where the study is occurring have not been expatiated in the literature. Exploration within this study may reveal new dimensions unaccounted for in the initial theoretical frame. *Adapting* the methodological lens on information gleaned as the data is collected and analysed can enable a new lens to *emerge* which is a stronger and more adequate window through which to collect information about the research space, and so allow me to better answer the research questions (Fetterman, 1998). Adaptation permits the research to breathe, shed, or grow as it tries to uncover and explain goings-on that are already there and that are revealed through data analysis. A static methodological frame, set at the start of the research, assumes we are aware of the ontological breadth of the material we are trying to uncover, and does not make accommodation for the revelation of new philosophical realities. Indeed, the interaction between western modern and indigenous science provides opportunity to investigate how dissonant ontological boundaries may be interacting and growing within the practical use of science. I am suggesting that adaptation can emerge a variety of theories all of which might be quantitative, all qualitative, or a mixture of quantitative and qualitative.

Comparatively (and in summary), a MMR framework would only permit a mix of quantitative and qualitative theories; does not allow for emergence and adaptation; and would also not permit an interaction between the component theories of a methodological lens as a CAS can. Hence, a CAS can further the cause of this research as indigenist as it tries "to re-establish the experiences and ways of knowing that have been silenced by dominant western knowledge communities" (Botha, 2011, p. 314).

3.8 Chapter Summary

The chapter discussed what a complex adaptive system (CAS) is, and proposed its applicability as both a curriculum, and a methodological framework.

As a methodological framework, a CAS was thought useful because of my proposition that it has the ability to house the diametric relational, interpretivist, and positivist philosophies of the native-indigenous and western modern sciences respectively that are being integrated in the curriculum. A CAS was also proposed as a suitable methodological frame because Trinidadian science (the backdrop against which the study is occurring) seems to indicate some kind of interaction between indigenous and western sciences as indicated by George's (1986 as cited in George, 1999) taxonomy, and the practice of local science experts (see chapter one). My proposal suggests that a CAS can accommodate the interaction between these two types of sciences. Finally, a CAS when used as a methodological framework was also proposed to be able to allow adaptations to the methodological framework to accommodate any new constructs revealed during exploration of the relatively unknown native-indigenous sciences of Trinidad that had not been accommodated in the framework set at the beginning of the study.

The methods of performing the curriculum integration of native-indigenous science into western modern school science also utilised a complex adaptive model. As a curriculum framework the study utilised Doll's (1993) complex adaptive 4R model of curriculum intergration, and Fogarty's (1991) within-discipline connected model of integration.

3.9 The Next Chapter

Chapter four is the ‘Methodology’ and discusses the set-up and execution of the study.

CHAPTER 4

METHODOLOGY

4.1 Introduction to, and Aims of, the Chapter

The chapter discusses the research as an ethnographic, exploratory case study and considers methods of data collection, issues surrounding the implementation of the research, and ethical considerations. The specific data collection instruments and methods of analysis used to extract information to resolve the research questions are discussed in chapter five.

4.2 Design and Methods

The science of the Aboriginal peoples of Trinidad is relatively under-researched, and because they are an oral people, largely undocumented. I utilise an ethnographic, exploratory case study to uncover the scientific practices of the community under study. My study is mixed at the level of its philosophy (see section 3.7) but unmixed at the level of methods, and comprises qualitative means only. This study then adds to the MMR debate and suggests that mixing of 'quantitative' and 'qualitative' on a philosophical level may not articulate through to the methodical level.

4.2.1 The Research as Ethnography

An ethnography can be identified by its heavy reliance on: fieldwork and participant observation; its reflexivity about fieldwork engagements often through a deep analysis of fieldwork memos and notes; and its primary search for deeper cultural understanding, and universalities and idiosyncrasies of the human condition (Kendall & Thangaraj, 2013).

> Ethnography combines research design, fieldwork, and various methods of inquiry to produce historically, politically, and personally situated accounts, descriptions, interpretations and representations of human lives. As an inscription practice**,** ethnography is a continuation of fieldwork rather than a transparent record of past experiences in the field. The ongoing nature of fieldwork connects important personal experiences with an area of knowledge; as a result, it is located between the interiority of autobiography and the exteriority of cultural analysis. (Tedlock, 2000, p. 455)

The study has elements of autobiographic, and analytic ethnography.

The study incorporates autoethnography as "research, writing, story, and method that connect the autobiographical to the cultural, social, and political" (Ellis, 2004, p. xix, as cited in Ellingson & Ellis, 2008, p. 448). Autoethnography is a personal account of one's part in a story, and is told in the first person using 'I' in both the research process and its inscription or write-up. It is simultaneously self-analytical as it studies the 'I' as other (Ellis, 2004 and Goodall, 2000, both as cited in Ellingson & Ellis, 2008, p. 448).

As analytic autoethnography the study focuses on generating "theoretical explanations of broader social phenomena" (Ellingson & Ellis, 2008, p. 445). In 1995 Lofland proposed the analytic class as a new categorisation within ethnography. Judged against Lofland's (1995) initial descriptors the study has analytic ethnographic features such that:

- it makes generic propositions in its research question of what is the nature of the science of the First Nations peoples of Trinidad.
- it is an early attempt to document this science and so presents new content, and
- through emergent, inductive analysis suggests a mini-curriculum that incorporates the features of the First Nations science of Trinidad with western science.

4.2.2 The Research as Exploratory Case Study

Within case study, research findings are believed to be constructed in situ through social interaction (Chadderton & Torrance, 2011), so that the boundary between the phenomenon under study and the sociocultural milieu(x) in which it sits, is fuzzy (Yin, 2003). The phenomenon is the native-indigenous science of Trinidad. The case is bounded by, and hence delimited to, the science practices of the Santa Rosa First Nations Peoples Community in Arima, Trinidad who are the knowledge keepers of this science. As an exploratory case study the research adds to the sparse documentation to broaden the description of this indigenous science, and how it can be taught within a mini science curriculum. It hence contributes to the foundation for wider and deeper enquiry (Yin, 2003).

The study uses a reflexive researcher's diary to supplement its primary data collection method of semi-structured interview. Participant observation and document analysis helped me to gain entry, and together with email interviews of scientific experts (see chapter 1), develop a conceptual understanding of the field.

4.2.3 Participant Observation

Within the observation of participation "ethnographers both experience and observe their own and others' co-participation within the ethnographic encounter" (Tedlock, 1992, p. 69). The researcher participates in the everyday lives of the people/community under research; s/he seeks to be empathetic enough with their participants' lives to understand their story well enough to tell it, but dispassionate enough to do so in ways that are considered 'objective and scientific'.

The First Nations peoples of Trinidad do not all live in a specific geographic space where they utilise their native ways of being, knowing, and doing. Hence, participant observation of their everyday scientific practices was not possible. The study utilised participant observation of special events during their heritage celebrations held annually during the first week of October.

These observations were chiefly part of gaining entry (see section 4.3.1), and helped me to develop greater contextual understandings.

4.2.4 Document Analysis

As a representation of science (Hacking, 1983) I analysed data of how the First Nations peoples of Trinidad did science within their everyday activities from exhibits at their museum including artefacts, displays, and their textual descriptions (Appendix B). I also harnessed a recent publication for uses of their herbs (Balkaransingh, 2014). Finally, promotional flyers and brochures and displays at their museum (Appendix A) were used to gain a historical background (see section 1.3).

The museum exhibits gave insight into cultural and technical features of the groups' science practices; the other documents were unobtrusively collected, and provided a wide coverage of events across time in many settings – neither source of documents were produced primarily for the case (Yin, 2009). Hence, both of these sources share the concomitant disadvantage of their inability to respond directly to the research questions and were in some areas superfluous, and in others restricted. However, as has been noted, like participant observation, document analysis was used primarily to gain entry, and a contextual understanding of the field.

4.2.5 Reflexive Researcher's Diary

The use of a researcher's diary promoted this study as autoethnographic and helped me to be reflexive about my "cultural assumptions, standpoints and biases" (Martin & Mirraboopa, 2003, p. 212) to the knowledge that is being shared with me, and how my stance to those sharing, (and how that sets up their stance to me), might taint my representations of their lives (Botha, 2011). Analysis of my diary helped me to interrogate the positionality through which I collected and distilled data, and represented participants' lived experiences (Botha, 2011). Hence, my reflexive researcher's diary as an indigenist research method protects the ignoring or perpetuation of power imbalances between the researcher and researched that can

foster methodological erasure (Martin & Mirraboopa, 2003). Moreover, reflexivity as reflective feedback promotes adaptation and the emergence of new researcher behaviour in alignment with a complex adaptive methodological framework.

My researcher's diary was composed and stored in free cloud storage that was portable and capable of housing data in multiple modalities. My researcher's diary was multi-purposed and contained *data* as audiotape, video, photographs, and text from interviews and observations; *additional 'found items'* such as the photograph of events from my travels that impacted upon my ethical stance towards the dissertation (see section 4.4.1); *contextual information* regarding the methods and nature of the data that was collected; *ideas, examples, and plans for ongoing research*; and finally my *reflections* on research methods (Holly & Altrichter, 2011), design, and execution. The entries are of three types – memos, descriptive sequences, and interpretative sequences. The latter two are often embedded in memos which are the recollection of events and experiences that have happened during some chronological period (Holly & Altrichter, 2011). Memos were captured as text, and through audio and visual means. These memos contained descriptions of events, and of the context in which they occurred. Many times I also undertook an interpretation of those events, including of my own prejudices. The diary was never meant to be publicly disclosed and I have presented select portions at various places of the thesis as substantiation, and triangulation within the study.

4.2.6 Interviewing, and Instruments to Measure the Nature of Science

I have discussed that what science is, is a complicated issue. Within western modern science, explanations aimed at unravelling this complication have indicated a dissonance between how scientific knowledge is actually created by experts of western science, and how lay-people/lay-scientists believe that western scientific knowledge is created.

Within post-positivism there are myriad ways to experience the world, do science, and hence describe what science is and how it is done (that is, the nature of science, NOS). However, discussions in the academic literature about NOS usually refer to

the nature of western modern science and it is here on which my discussion will build.

Measuring what lay-scientists believe western modern science (WMS) to be, that is, their NOS profile, is an indication of the gap between their beliefs about WMS and what WMS really is (or at least held to be by the scientific community). The size of the gap is indirectly proportional to the scientific literacy of the individual. Furthermore, knowledge about the gap's size can help teachers, as example, to plan relevant instruction to minimise it. Indeed, textbooks, science classrooms, and representations (Hacking, 1983) in the general public such as print and electronic media, bombard lay-people/lay-scientists with opinions of what WMS is. Closing the gap can increase the scientific literacy of the citizenry thus making them more proficient at navigating and directing the western scientific enterprise within their communities.

Measurements require standards to validate them and are hence empiricist, and non-relational. 'Measuring' may be viewed then as anti-indigenous, has the power (even if unwittingly so) to establish an hierarchical structure between things that are measured, and in so doing may relegate western or indigenous science one to the other. An instrument to measure what indigenous science practitioners (lay or expert) think science is, hence seems oxymoronic and this may help to explain the paucity of such instruments in the academic literature. The thesis also does not attempt such measurement. Instead, within a complex adaptive frame I hold personal conceptions of the NOS (whether western or indigenous) as a snapshot in space and time; a precursor to an emerging conception of what science is, grown as the individual matures in scientific experience and understanding. Hence, in discussing what persons believe science to be, this document does not differentiate between the variety of terms used in the literature – for example views, beliefs, understanding or a profile – of NOS, and supports that either one gives a portrait of what or how a participant defines and describes science at a particular spatial-temporal time point.

The discussion moves now towards a justification of the interview protocol that was developed to extract a portrait of what participants think indigenous science is. As such, I will next discuss instruments popular in the scholarly literature that have been used to reveal a participant's nature of science (NOS) understandings. The instruments considered NOS from a range of angles (albeit western science due to the paucity of instruments in the indigenous literature) including: broad categories of NOS (Lederman et al., 2002; Nott & Wellington, 1993; Pomeroy, 1993); NOS within specific concentrations such as Physics (Adams et al., 2006); and NOS focused on more general views such as science, technology, society (Aikenhead & Ryan, 1992), and public perceptions of science (Cobern, 2000b).

4.2.6.1 The Nott and Wellington Instrument

The Nott and Wellington (1993) instrument encourages a science teacher to consider what they understand science to be. The instrument "does *not* purport to be a 'valid measurement' of an individual's position or 'philosophy'" (p. 112). Instead, it promotes reflection by science teachers on their personal views of science. A science teacher rates their beliefs about science across 24 statements. Each statement ascertains the degree of a participant's support or position on one of the four continua (predetermined a priori through the authors' expertise) of relativism/positivism, inductivism/deductivism, contextualism/decontextualism, and instrumentalism/realism. The sum of responses across the 24 questions represent a "profile of your views of the Nature of Science" (p. 111).

The instrument was developed for use specifically by science-teachers and its questions therefore rely on experiences/familiarity with WMS to ascertain (Nott & Wellington, 1993)

- what participants believe about scientific knowledge (e.g. statement 20: "scientific knowledge is different from other kinds of knowledge in that it has a higher status" (p. 109)); and
- the ways by which that knowledge is created (e.g. statement 13: "human emotion plays no part in the creation of scientific knowledge" (p. 109)).

4.2.6.2 The Pomeroy Instrument

Pomeroy (1993) utilised her instrument to test and compare what scientists, and secondary and elementary school teachers working in Alaska understood science to be. The survey sought responses under three categories predetermined a priori by the author from her expertise: traditional views of science; traditional views of science education; and non-traditional views of science education. There are 50 statements across the three categories to which participants register the intensity of their agreement on a five point Likert scale. Even though the 'non-traditional' aspect of Pomeroy's instrument entertained that constructivism may be considered as a valid method of knowledge creation within western modern science (WMS), it made no specific reference to indigenous sciences or to the nature of indigenous sciences.

Like the Nott and Wellington (1993) instrument, Pomeroy's (1993) instrument had not at its development been tested for its validity or reliability and it (Pomeroy, 1993) too requires participants to be experienced with WMS in order to ascertain what they *believe* about:

- scientific-knowledge (e.g. statement 9: "science is the ideal of knowledge in that it is a set of statements which are objective; i.e. their substance is determined entirely from observation" (p. 274)).
- the ways in which that scientific-knowledge is created (e.g. statement 27: "non-sequential thinking, i.e. taking conceptual leaps, is characteristic of many scientists" (p. 275)).
- science education: more so how it should be done – which arguably indicates what science education is to some extent (e.g. statement 50: " the biggest key to increasing scientific literacy is increasing students' ability to read science texts and articles" (p. 277).

4.2.6.3 The VNOS (Views of Nature of Science) Instrument

Lederman et al. (2002) revised and expanded Lederman and O'Malley's (1990) VNOS instrument (hence called VNOS-A). Their revised final version (VNOS-C)

asks participants to first respond in writing to 10 open ended questions, and subsequently engages them in a follow up interview to explain and justify their original answers (Lederman et al., 2002). The instrument considers the participants' views on (Lederman et al., 2002, pp. 499-502):

- the empirical nature of scientific knowledge;
- scientific theories and laws;
- the creative and imaginative nature of scientific knowledge;
- the theory-laden nature of scientific knowledge;
- the social and cultural embeddedness of scientific knowledge;
- the existence of the scientific method; and
- the tentative nature of scientific knowledge.

The instrument has been used with college undergraduates and graduates, and pre-service teachers by Abd-El-Khalick (1998, as cited in Lederman et al., 2002, p. 510), and requires a good knowledge on the workings of WMS. For example consider question 5: "Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example" (Lederman et al., 2002, p. 509).

4.2.6.4 The CLASS (Colorado Learning Attitudes about Science Survey) Instrument.

The CLASS instrument (Adams et al., 2006) was developed to test students' beliefs about physics, and about learning physics. The instrument has proved to be reliable and valid (face, construct, predictive, and concurrent) by Adams' team. It consists of 42 items to which participants score their level of agreement on a five point Likert scale.

Questions from the Maryland Physics Expectations Survey (MPEX) (Maryland Physics Education Research Group, 1997) and the Views about Science Survey (VASS) (Halloun, 1997) were adapted in the initial developmental phase of the CLASS (Adams et al., 2006). The categories of the CLASS were then determined a

posteriori through statistical manipulation of the empirical data from interviews to reveal which students' responses yielded a reasonable degree of coherence. Each final category constitutes a group of statistically correlated student responses, and hence demonstrates a particular aspect of thinking that can be identified upon investigation. The categories are (Adams et al., 2006, p. 3):

- real world connection;
- personal interest;
- sense making/effort;
- conceptual connections;
- applied conceptual understanding;
- problem solving general;
- problem solving confidence; and
- problem solving sophistication.

The questionnaire targets candidates in physics university courses in the United States and its questions therefore rely on experiences/familiarity with the physics of WMS to ascertain what participants believe (Adams et al., 2006):

- about physics (e.g. statement 3: "I think about the physics I experience in everyday life" (p. 12));
- and about learning physics (e.g. statement 1: "A significant problem in learning physics is being able to memorize all the information I need to know" (p. 12)).

4.2.6.5 The VOST (Views on Science-Technology-Society) Instrument

The 114 multiple choice questionnaire, developed by Aikenhead and Ryan (1992), ascertains high school students' views on a wide range of science-technology-society (STS) topics. Given the target age group and the topic, the ideas in the questionnaire do not require sophisticated scientific experiences or knowledge to access the content. Though the complete questionnaire is long, any one respondent is expected to address only 12-18 items. Still, specific questions are also very long. For example, item 20311 of the questionnaire requires students to choose from

amongst 10 responses (Aikenhead, Ryan, & Fleming, 1989) about their views on the statement that: "In North America, most scientific and technological research is done for the military and industry. Only a small amount is done for health, agriculture and for the sole pleasure of discovering more about nature".

The VOST tool does not emphasise students' affect, but rather their cognition or thinking on (Aikenhead & Ryan, 1992, pp. 480-482):

- definitions of science and technology;
- the external sociology of science (i.e. the impact of science/technology on society and vice versa, and the influence of school science on society);
- the internal sociology of science (i.e. science as a social system); and
- epistemology (i.e. the nature of scientific knowledge).

Developers of the VOST believed that researchers such as themselves used language differently to the population targeted by the questionnaire. To ensure greater usability of the instrument they considered how the target participants utilise language. Hence, the multiple choice responses were empirically determined from the writing of, and interviews held with Canadian students from grades 11-12 (16-18 year olds) who piloted the questionnaire to ensure its user-friendliness amongst a similar cohort (Aikenhead & Ryan, 1992).

4.2.6.6 The Thinking about Science Survey Instrument (TSSI)

This instrument targets the public, and elementary school teachers. The developer, Cobern (2000b), of the TSSI holds that there is public alienation with science in general. Elementary teachers as members of this public, were also resistant and disconnected, and hence likely to teach science only when mandated by school-authorities as opposed to through personal choice (Cobern, 2000b). Elementary level teachers might have been included as public lay-scientists possibly because, unlike secondary school teachers, they usually pursue fewer science disciplined courses in their academic training. Interestingly enough (to me at least), Pomeroy (1993) found that elementary school teachers are more open to non-traditional

views of science, such as the role of sociocultural influences on the creation of scientific knowledge, than either secondary school teachers or scientists.

Sociocultural influences on the generation of scientific knowledge have been considered within the scientific community as they seek definitions of science (NOS). Conversely, the TSSI (Cobern, 2000b) is set to investigate sociocultural influences on what science is from a vantage point external to science. Hence, it focuses on "the public place of science with respect to society and culture" (p. 7); "intends to illuminate the balance and valuations people hold about science in the context of several other culturally and socially – but not scientific per se – important issues" (p. 49) ; and to these ends uses a 60-item Likert scaled instrument to assess sociocultural resistance or support for science across five gradations.

The questions on the TSSI (Cobern, 2000b) are accessible by anyone with only an everyday experience of science (e.g. item 16: "Science helps develop our natural resources such as coal, gas, oil, and solar energy" (p. 55); item 32: "Religious knowledge contributes more to the well-being of a person's life than does science" (p. 56)). Responses are sought across nine categories: epistemology; science and the economy; science and the environment; public policy and science; science and public health; science, religion and morality; science, emotions and aesthetics; science, race and gender; and science for all. These categories were developed a priori through literature review and are not suggested to be an "authoritative scientific worldview, but a scientific worldview version commonly found in both the popular media and the literatures of science and science education" (p. 9).

4.2.6.7 Why Develop a New Interview Instrument?

The instruments used to discover participants' nature of science profile that have been discussed (sections 4.2.6.1 to 4.2.6.6) represent a popular fraction of the plethora of similar instruments available. Whether the instruments employ close-ended, forced choice items (e.g. Cobern, 2000b; Nott & Wellington, 1993; Pomeroy, 1993), or open-ended interview questions (e.g. Lederman et al., 2002); whether the construct that their questions seek to understand are empirically derived (Adams et al., 2006; Aikenhead & Ryan, 1992) or designated a priori by researchers

(e.g. Cobern, 2000b; Lederman et al., 2002; Nott & Wellington, 1993; Pomeroy, 1993): all of these questionnaires reveal a pattern of reliance upon an objective western modern science (WMS) worldview.

Certainly, these instruments have been developed for participants with some understanding of WMS, and the ways through which WMS creates knowledge. Amongst them there is some visible representation of postpositivism which considers that scientific knowledge might be a construction (e.g. Aikenhead & Ryan, 1992; Nott & Wellington, 1993), and that there can be a sociocultural impact on science and/or science education (Aikenhead & Ryan, 1992; Lederman et al., 2002; Pomeroy, 1993). However, the impact/role of relationality and metaphysics on the making of scientific knowledge – factors important to knowledge creation within native sciences – are not considered by these mainstream instruments.

Moreover, indigenous science (IS) is a form of indigenous knowledge and helps its participants to navigate their world space. An IS is developed from the relationality between a people and the space that they inhabit. Hence, there may exist a plethora of indigenous sciences, and even though they have been found to share similar features, it may be impossible for one person to be aware of, far less to consider, the natures and characteristics of such a variety of scientific practices. Any IS (e.g. the native sciences of Trinidad) in particular, can be argued to be a tight specialist field applicable to a very narrow population within a certain geographic locale. Even so, postmodernity and claims towards social justice validate thrusts to explain and understand native sciences – especially given that these practices emanate from peoples who have been colonised, almost decimated, and robbed for centuries of the right to practice their ways of being, knowing, and doing. Since indigenous science is geographically influenced, relational, complex adaptive, and user-specific, it can be difficult to model and represent as a set of theoretical questions upon which participants are expected to expound on its nature. So all of this contributes to the lack of availability of tested tools focused on describing the nature of IS profiles of its practitioners which could have been adapted for use by this study, and hence necessitated the development of an appropriate instrument. However, though any IS has geographic and contextual delimiters, it also holds characteristics (e.g. relationality) similar to other indigenous sciences. There is widespread

documentation on the nature of the native sciences of North America (Aikenhead & Ogawa, 2007; Colorado, 1988; Dei et al., 2000; Moreton-Robinson & Walter, 2009; Snively & Corsiglia, 2001) but such prevalent research does not exist for the nature of the native sciences of Trinidad or the Caribbean region which is also part of the Americas. The development of such an instrument may therefore also have utility in other research spaces.

4.2.6.8 Developing the Interview Protocol

Science students' and teachers' understandings of the nature of science (NOS) may improve more through personalised direct instruction and individual classroom intervention than through large scale, standardised tests utilising forced-choice, Likert type items aimed at describing or evaluating test takers understanding of science (Lederman et al., 2002). Extrapolating, the aims or use to which a NOS profile is to be put is an important determinant as to the shape of the instrument that seeks its determination. In doing so for Aboriginal people who practise science relationally led me to two major considerations – what would be the instrument's *structure*, and what would be its *content*. These are discussed next.

4.2.6.9 Justifying the Structure of the Semi-structured Interview

A closed interview structure was not used as generalisations across populations is not an aim of this study: a semi-structured interview left room to follow unexpected paths revealed by respondents, and so glean unanticipated information and foresight (Barbour & Schostak, 2011). It also provided participants chance to portray their personal constructions of the world whilst still guiding them towards responses to resolve the research questions. Other benefits that the semi-structured interviews brought to the research included their ability to develop a rapport between the interviewer and the interviewee through its use of a guided interview protocol of open-ended questions (Harrison, 2009). Conversely, an unstructured, open interview relies on the researcher's skill and agenda to ensure focus on the topics of interest; and whilst it would have permitted respondents' maximum flexibility in their answers, it would have provided too much room for variation between

interviewees (Harrison, 2009), too many chances to stray away from the research questions, and hence less opportunity for data triangulation between respondents.

The First Nations community is so fractured that daily life of descendants proceed predominantly via Trinidadian culture. What does exist, is a handful of First Nations descendant Elder experts with knowledge of the indigenous ways. Hence, a Likert style questionnaire administered over a broad range of members of the wider First Nations community was not thought to be efficient. Instead, semi-structured interview of the Elders or knowledge keepers was undertaken. Moreover, Likert type items have been found to be the most ambiguous at ascertaining students' views regarding the nature of science, standing second to empirically derived multiple choice items, and third to semi-structured interviews (Aikenhead, 1988). Additionally, whilst Likert scales have been used to measure the gap of indigenous participants' beliefs from a model of WMS, it did not account for that gap; indeed, such an explanation is best generated through interview (Sutherland & Dennick, 2002).

Aboriginal Trinidadian culture is an oral one. Semi-structured interview in which interviewer and participant socially co-construct knowledge as they relate was hence considered a valid method of data collection (Sutherland & Dennick, 2002), that could also help to put participants at ease and make them more willing to share.

The interview protocol was designed to be openly accessible and used non-specialist language that does not require a knowledge of western science (WMS) for participation. Another hurdle was that everyday people, even populations who practice it, may be unaware that indigenous sciences exist and are demarked from WMS (to which most people are accustomed). This backdrop challenges questioning native practitioners about their science because they may not consider many of their everyday activities as science. The interview protocol respects Aboriginal science as a knowledge in its own right and understands the need for wording that avoids direct comparison between conceptions of WMS and of Aboriginal indigenous science (Sutherland & Dennick, 2002). However, against the possible naivety of participants about how their own practices would count as science, there was some comparison to WMS as a launch pad and bridge to help

participants begin to expatiate on their indigenous science (see items 4 and 5 of the interview-protocol, Appendix C).

Finally, the open-endedness of a semi-structured interview protocol permits participants to articulate their nature of science (NOS) understandings without necessarily having a cogent, coherent, unfractured NOS framework within their profile. Indeed, an incoherent and fractured scientific belief frame has been demonstrated even by participants with a formal western science background. As example, Lederman et al. when utilizing the VNOS instrument (2002), and Adams et al. during the administration of the CLASS questionnaire (2006).

4.2.6.10 The Content of the Interview Protocol

Even though the First Nations science of Trinidad is unique, the literature (Aikenhead & Ogawa, 2007; Colorado, 1988; Dei et al., 2000; Moreton-Robinson & Walter, 2009; Snively & Corsiglia, 2001) reveals that native sciences share similar constructs defined around beliefs about what is real; about valid ways of coming to know; and about what type of knowledge and means of knowing are worthwhile. These constructs of native sciences (NS) have been extracted from definitions, recorded epistemologies, and practices worldwide that appear in the scholarly literature, and so reflect consensus on the nature of NS from independent philosophers (Sutherland & Dennick, 2002). These constructs (see the 'justifications' under section 5.2) act as a guide within the interview protocol and whilst not exhaustive, the semi-structured nature of the interview protocol permits expansion (or truncation) based on participants' responses. Participants' responses are not forced into fixed lanes, expatiation is allowed on any question, and the semi-structured interview is hence non-reductionist. Given that the nature of science of the First Nations peoples of Trinidad is largely unexplored, even though interview questions were determined a priori with support from the literature, they were open-ended enough to allow participants to present complex responses that depict the holism of reality that First Nations peoples support.

4.3 Carrying Out the Research: Pilot-testing, Gaining access, and Administration of the Interview Protocol

4.3.1 Pilot-testing and Gaining Access

Pilot-testing helps to ensure that a final questionnaire is user-friendly enough to maximise participant response, and to increase the confidence that the instrument is reliable and valid (Lewin, 2011). Given its tremendous impact on the quality of the final tool, pilot-testing should involve everything about the instrument including the content, structuring, and ordering of the questions; and the structure of the questionnaire as well as its administration (Oppenheim, 2005):

> In principle, anything about a social survey can and should be piloted, from the detailed method of drawing the sample to the type of paper on which the interviewers will have to write (is it too absorbent or too rough?), for almost anything that can go wrong, will go wrong! It is dangerous to assume that we know in advance how respondents or fieldworkers will react. (Oppenheim, 2005, p. 48)

A pilot-test is sometimes thought of as simply a trial interview but actually has a much broader scope. Pilot-testing of interview questionnaires helps us to validate them, that is, to be "certain that they can do the job for which they are needed" (Oppenheim, 2005, p. 47).When trial interviews are included within pilot-testing a small group of individuals similar to the participants of the research are asked to respond to the interview protocol to help ensure that the questions target the construct under scrutiny, and that they can be fairly replicated across participants (i.e. that the protocol is valid and reliable). The aim of trial interviews is the eradication of potential pitfalls that the architect may have unintentionally embedded in the questionnaire and its design (Lewin, 2011). The concepts of validity and reliability have long been assumed to be positivist tools that can help assure the rigor or confidence with which a research's findings and conclusions are held. In a qualitative frame, interpretivism holds that individuals construct their personal understandings of reality. Individuals also change almost daily as they reflect upon their experiences. Hence, it may be difficult to isolate which construct exactly is to be measured (as validity attempts to do), or to assume that personal

constructions remain stable long enough to be repeatedly measured (as reliability attempts to do). Even so, there is still potential worth to pilot-testing within qualitative work (Janesick, 2013; Sampson, 2004; Turner, 2010).

Pilot-testing can also bolster confidence in the conduct and design of research as it provides opportunity for: researcher reflection; the pre-check of interview questions through observation; trial interviews; and the interrogation of initial themes, categories and codes (Janesick, 2013). Pilot-testing also plays a role in refining the research questions (Turner, 2010) and minimising researcher bias. Pilot-testing helps to establish the validity and reliability of the questionnaire by allowing the researcher to revise statements that may be unclear or ambiguous; biased and lead interviewees towards a certain position; or unintentionally prejudiced in terms of gender, race, sexual orientation, age, disability, or ethnicity as examples (Tomal, 2010). Moreover, pilot-testing can help establish positive field relationships; provide preliminary data that can highlight gaps in the research design; establish possible risks to the researcher; and promote reflection on validity, ethics and representation (Sampson, 2004).

The interview protocol was pilot-tested first through review with professional peers knowledgeable in the topic area who inspected the protocol for validity, reliability, and coverage.

The first interview was with IS Expert-Elder 4, the Gatekeeper as she set up all of the interviews with the other participants. The Chief of the First Nations peoples (Mr. Ricardo Bharath) here in Trinidad, as a distant relative, was my entry point. My grandmother used to take me to his house when I was a child. I had not returned in many years but he and my father are second cousins and remain close. My father took me to his home, reintroduced me, and asked him if he would facilitate my research. The Chief then directed me to the Gatekeeper because of her extensive knowledge regarding First Nations communities in Trinidad and throughout the region, but mainly because she coordinated their activities and was expected to manage my interaction with the group.

Within this study the first interview acted as the trial interview and helped to refine questions that were ambiguous. It also helped to address the use of western modern science (WMS) terminology and concepts found unfriendly or hostile to the study of indigenous science, of which I might have been unaware given that I am a science educator trained in, and practising WMS in my everyday job. A full scale trial interview was impossible because of the small group of people who hold knowledge of the test material.

Many benefits to pilot-testing have been discussed above; particular to this study though, as a pseudo pilot-test, this first interview allowed me to refine the interview-protocol by adjusting research questions as example (see examples in Appendix C2).

The pseudo pilot-testing also allowed me to expand the interview protocol in some conceptual areas including the history of the Nepuyo First Nation (e.g. question 1); the differences between science and technology (e.g. question 10); the importance of the cardinal points or gateways, and the sacred symbols of the ocelot and mountain rose (e.g. question 3 (bullet 3), and logo in Appendix D). I was unaware of these issues when I first developed the interview protocol but it was open enough to reveal them, and the complex adaptive research design was reflexive and emergent enough to permit. The pseudo pilot-test also allowed me to discern if the order in which I had chosen to interview participants would allow me to maximise the amount of data that I could access to answer the research questions (Sampson, 2004). After the pseudo pilot-test, IS Expert-Elder 3 (ISEE3), IS Expert-Elder 1 (ISEE1), and IS Expert-Elder 2 (ISEE2) were to be interviewed in that specific order. However, on meeting and having opportunity to observe the ISEE3 and ISEE2 within official events of the First Nations peoples I decided to interview ISEE3 after ISEE2 as his/her role within the community was more of a social and cultural holder, a wise Elder that helped to direct his/her people. ISEE1 and ISEE2 though seemed to be the ones that held the deep scientific knowledge of the community.

In the end, interviews occurred at the convenience of my participants. ISEE1's and ISEE2's schedules within the community are hectic socially and politically. Hence, ISEE4, ISEE3, ISEE2, and ISEE1 were interviewed in that order.

Broader pilot-testing outside of the trial interviews, also helped me not to enter the research blind. It can be argued that being an insider-outsider gave me the privilege of a clearer lens to view the research problem. Though I am a descendant of the First Nations, I am not a member of their everyday community. My research connects me to them, helps me to feel like an insider, and begins to resolve my discomfort with my identity. I felt early on in the study, and still do in some ways, that they viewed me as an outsider. So I might be an insider-outsider.

Admittedly, there are advantages to going in 'blind', without a pilot. Going in 'blind' can allow researchers to approach the work with a curiosity and receptivity to new information that allows them to accept and record facts at face value instead of using their experience or cynicism as a filter. Moreover, when a researcher goes in blind the non-threatening nature of their lack of experience can help to facilitate acceptance and ease of access by their participants (Sampson, 2004). However, I found that First Nations peoples approach the world with a certain degree of caution; unsurprisingly so given their history and the continued alienation and ridicule of their knowledge and lifestyle by many in society. I felt so alienated by what I felt was their extreme wariness of me (and by my feelings that I did not belong) that I wrote in my researcher's diary on 8th October, 2014:

> I went to the Santa Rosa community today to give them the information sheets and consent forms after having received ethical clearance just this week. I did not think that I needed to start this journal before my first interview but every time I go to the First Nation's [sic] community I feel very uneasy so I thought it wise to journal. Like I am unwelcomed. Like I do not belong. Possibly just my own misgivings given that I had hoped that this research would help me find my ethnic roots - or at least quiet some of the demons. Yet when I go there I feel so much like a fraud and I feel like all of the people there know it. That I'm a pretend descendant who is only here for rape research because really, where was I in the First Nation history of my island? I've never participated in any of their activities that they had through

> time. Or went to visit their museum; nothing before now. Why does this research suddenly interest me?

Before I began collecting data I decided then to spend some time acclimating by visiting their compound and attending some of their public events.

The first activity that I undertook was to tour the museum with a group of my Trinidadian friends visiting from their residence in Canada. My children, and some other friends resident on the island, also attended. The visit made me aware of the upcoming activities of the group and of their history. I was able to ask our guide questions about knowledge making and how the Chief was elected. There was a hesitancy in the responses. I suspected because a lot of the answers that I required included the spiritual creation of knowledge. I also began to guess that knowledge was not freely shared unless the seeker was deemed fit in some way to receive it. This pilot experience allowed me to begin to reflect upon the act of my research, and how I needed to adjust the wording of my questions to be more welcoming, and less sterile and objective.

I attended two more activities before I began to collect data. The yearly First Nations week was held from 10th –18th October in 2014 (see flyer Appendix E) during which I took the opportunity to attend their River Festival, and to hike to the Caurita petroglyph. First Nations tribes from Belize, Guatemala, Dominica, Honduras, Suriname, Guyana, and Trinidad were represented at these activities.

At the River Festival we honoured the ancestors. I ensured that I stood downstream of the ritual so that I could experience the energies as they flowed past in the water. I asked the Chief if I too could be blessed by the Guatemalan medicine man and he said yes. I did not get my personal blessing but standing in that river was so spiritual for me. I felt so clean and happy when I left (Appendix F1 and F2).

The Caurita petroglyph stands on the land of a non-First Nations friend of mine. We are friends because our children are school mates, and because we both hold similar metaphysical beliefs. She has always talked to me about the petroglyph and on the day of the hike I drove to her usually well landscaped acreage expecting simply to

walk for a half hour or so. When I arrived I found out that my sandals were not appropriate for the journey; luckily I had a pair of old sneakers in the car. I had no water or supplies for the hike which took us deep into the rainforest, through rivers, and up hills so vertical and steep in some parts that a rope had to be tied to trees so that we could hoist ourselves up and down again. I came down much of that hill on my arse because it was just easier to slide down. I fell many times along our walk even after a narrow tree was cut to provide me with a supportive walking stick. The hike took five hours – two hours each way and one hour at the top for our group to squash ourselves onto the narrow plateau that housed the petroglyph. Many of the First Nations visitors hiked in slippers, make-up, jewelry, and in bare feet; one lady even carried a handbag as if on a trip to the mall! They explained their ease with the terrain – it was very similar to their villages where they lived in their countries.

On the hike up to the petroglyph I was always just about two people behind the IS Expert-Elder 2 who was pointing out various plants and their usages – from incense, to abortions, to biological warfare. The First Nations peoples from the visiting nations listened and shared their knowledge for the uses of various plants that we came across as well, and I was able to obtain the contact information of those more knowledgeable about the plant life. As part of my pilot, this hike allowed me to identify potential research collaborators (Sampson, 2004).

In what I thought was over preparation, I had walked with my camera cellular telephone which took photographs, audio, and video, as well as a digital tape recorder. I intended to audiotape the entire hike and take photographs and video recordings as corroborating evidence. IS Expert-Elder 2's explanations went by so quickly as I simultaneously tried to mind the treacherous pathway which we had already been warned was often set with trap guns by hunters. On one section of the path IS Expert-Elder 2 and our other guides became aware of a poisonous snake: these folk who repeatedly indicated through smell that such-and-such animal had recently passed, and who identified markings as footprints that looked like nothing more than squished up mud to me. We all crouched to the side of the path as we slipped past the snake. My new friend Eagle (because he does the Eagle dance) happily asked IS Expert-Elder 2 if he wanted him to catch the venomous creature, but IS Expert-Elder 2 declined.

Given the circumstances of the rainforest, and my inability to keep pace with IS Expert-Elder 2's explanations, my friend on whose land the petroglyph stood remarked that I should have collected samples of leaves about which he spoke, stuck them in a notebook, and made notations against them. I replied in my country's creole, "How I so chupid?" At which everyone laughed and I began to feel more welcomed within the group. Creating such a thorough scrapbook would have required IS Expert-Elder 2 and me alone on a personal hike collecting data. This hike as pilot helped me to determine the degree of resources needed to realistically execute this type of work (Sampson, 2004). The course was too rough and the pace too fast for proper data collection. Instead, what I did end up with were many photographs disconnected from tape recordings which I tried with some success to match up. The hike acted as a pilot by helping me to better understand the nature of the activities that my research questions required, as well as the potential risks involved (Sampson, 2004; Sampson & Thomas, 2003).

On reflection, a 'go-pro' video camera that active sportspeople hook to their heads to tape their real time participation in extreme sports seems a relevant solution to collecting data under the circumstances described. I have hiked through the rainforest many times before on excursions that lasted for days but this path was one of the toughest that I have ever done. I have torn ligaments in my right knee and falling so many times as I hiked the uneven path required a trip to the chiropractor and medication for many days afterward to alleviate swelling.

At the petroglyph we used the chalk that we had brought to colour in the markings. My friend Eagle traced the indentations with both his hands and I followed him. I felt such a rush of energy. Touching the rock was magical for me. (see Appendix F3 and F4)

On various parts of the walk IS Expert-Elder 2 talked about how the First Nations peoples had shared their knowledge of the plants with other groups who then, in a public arena, insulted the Spirit of the plants as superstition. He talked about how the petroglyph had been desecrated. He talked about how explaining this knowledge in full to just about anyone was like "putting a machine gun in the hands of a child". I asked then how was the knowledge to be saved? He replied that it was deliberately

passed to knowledge keepers indicated by Spirit as opposed to those within a genetic lineage. . Here too I felt the hesitancy to share that I had sensed on my visit to the museum.

The last event that I attended before beginning my interviews was the closing ceremony of the weeklong festival. By the end of the festival I had collected contact information to visit First Nations communities in other islands, and had volunteered to help with the launching of the festival in October 2015 (unfortunately, I migrated in February 2015 and was unable to do so). For the first time the Gatekeeper, smiled at me in what I thought was an unguarded way. In June 2014, on first meeting her, I had given her my cherished personal copy of Linda Tuhiwai Smith's 'Decolonizing Methodologies' (Tuhiwai Smith, 2012), at the time unavailable in bookstores on our island. I had also gifted her a film 'Garifuna in Peril' (Reyes & Allie, 2013) purchased on my trip to Belize in July 2014. She was always grateful but I felt, continued to keep me at arm's length; this first time smile then made me feel like I did belong in some small way. Piloting does not always bring us gains in only the areas that we anticipate (Sampson, 2004). For this study, piloting and gaining access seem inextricable and I think helped both them and me to feel at home enough with each other so that they could better tell, and I could better hear, their story.

I unexpectedly returned to Trinidad in July 2015 after my migration in February as my father had fallen ill. I took the opportunity to visit the Santa Rosa Community. I was happily greeted by IS Expert-Elder 4 (the Gatekeeper) and IS Expert-Elder 3 who were in the midst of summer camp activities with about 40 youngsters ranging through childhood, preteen, and teenagers. I was introduced as a special guest and asked to teach the campers for a few minutes. I felt that I had become a member of the community. I felt such a deep love for IS Expert-Elder 4 and told her so. She replied, "We love you too".

Outside of the First Nations community data was collected through interviews with experts to explore definitions of science (see section 1.2.1). I am well acquainted with all of the experts as members of my science education team at my job; I have known some of the contributors before that, for as long as 14 years. In contrast to

my lack of familiarity with participants at the Santa Rosa Community, I did not want my extensive personal relationship with respondents to influence their contributions as I thought could happen through face to face interview. I hence asked for contributions from these experts through a 'paper-and-pen question/response' via email (Appendix G). The email interviews (section 1.2.1) also helped me to understand the broader, national context of the study and is considered part of the pilot phase.

Within exploratory case, exploration often occurs before the study and helps to determine and increase the rigor of its final design. Hence, researchers are cautioned against using "the data collected during the pilot phase as part of the ensuing case study" (Yin, 2003, p. 7). Generally, data from the pilot phase has not informed analysis save IS Expert-Elder 4's interview which acted as a pseudo-pilot. It was included because there are no other respondents within the community (excluding the Elders already being interviewed) who could replace her ability to comment on the research questions.

4.4 Ethics: Telling the Truth and Doing no Harm

4.4.1. Data Aren't Butterflies

Pat (Sikes) said to our class once that "data aren't butterflies". The conversation veered into another direction propelled by some student question leaving me to wonder for months now what her statement meant. I have come to my own meaning. A net that catches butterflies assumes them as discrete things: that even if they have a Spirit or are connected to the rest of All-That-Is, that the butterfly does not disseminate past the boundaries of the net, that its totality can be contained therein. A thinking that the net, in the first place has the right, or power even, to catch the butterfly. Butterflies themselves are slippery things; you can leave your hand open for one to sit upon your palm so that you can gaze at it, measure it. If you close your fingers in though it will fly away quickly – or if you manage to touch its diaphanous wings they disintegrate into nothingness. This is of course why we use nets – they give us a better gaze so that we can begin to tell the truth of what a butterfly is – just as much and as well as we can to be honest about what we know

about butterflies and so that we do no harm to the butterfly. Maybe it might be better to say that we tell the story of the butterfly than the truth of it since 'truth' is difficult to know, and to tell (Tuhiwai Smith, 2008).

A complex adaptive methodological framework is necessarily reflexive and utilises such feedback to adapt and emerge the methods and conduct of the study as it proceeds. As I have pursued the research what 'telling the truth' and 'doing no harm' mean have matured and I have illustrated below from my researcher's diary.

> 14th December, 2014
> The Gatekeeper called today and asked how the research was going. Firstly, I was miffed. What right did she have to ask about my research? Did she understand the pressure that I was under with a full time job and house to run? After reflecting I realised that I have inadvertently become a rape researcher! I have realised that not only do I have an obligation to my participants, I am also accountable to them for this research- it is as much theirs as it is mine. This thing is a co-construction of ours within which they and I have become inextricably combined. I must not only finish, but am obligated to do so within a reasonable time frame. I have begun to feel something else too. A deep sense of protection for these people who have been marginalised and ostracised for so long, to tell their story and to tell it well. I don't only get to tell their story but have become implicated in the responsibility to protect this historical legacy. And I tell you, I can feel the weight of it.

Reflexive postscript: Issues of power between the researcher and participant became evident to me. That I had the power to say when this research would begin and when, if at all it would be over, and to determine the nature of its contents, and how I would use the information of their lives (their lives now!) and squish it into the frame of my research questions. I had never realised myself to be so bold or so discriminatory.

> 05th August, 2015.
> I am on holiday in Sri Lanka. I ride around on my bicycle and take photographs. Today I asked a few Indigenous people if I could snap their pictures in their traditional wear, performing traditional tasks, and they said yes. I have become sensitive enough to understand that I do not have the right to take anyone's photograph even if they are 'some random person' at

> the back of my frame. My research has caused me to develop a growing concern with the ethics of such activity, especially when it surrounds Indigenous peoples or marginalised people or people who know nothing about the power of a [sic] photography. They have no control over what I do with their picture nor how much benefit I would gain from it (Anderson, Griew, & McAullay, 2003). Nor do in many circumstances have the experience to ask or demand (Tuhiwai Smith, 2008). Who protects these vulnerables? I showed them my photograph after I took it because I had read on the tourist website that many Sri Lankans have never seen their recorded image. They were very happy to view their photos. The experience has left me pondering, more and more about the ethics of my own research.

Reflexive postscript: I have been left more aware of the tremendous responsibility that one has to protect vulnerable populations such as my participants who have been generous enough to submit to the poking and prodding of my research. I have not reproduced the 'Sri Lankan' images in this final document as I hold no permission from them to do so. However, I did do so in my electronic portfolio because I view that as a personal document between my supervisors and me that is not to be publicly disseminated. Even so, I do not think that I would want someone else to hold a picture of me in their scrapbook and speak about me in the third person. They may have the right to do so but it would still feel uncomfortable to me. Even if I tell my story, once I have implicated another person in it then somehow it becomes theirs also because the memory commingles us; now one from the other cannot be separated. Memory then is also an ethical concern (Margalit, 2002).

> 15th August, 2015.
> Whilst travelling through Sri Lanka I was invited to the home of a prominent educator for dinner. He asked me to borrow 3 knives, 3 spoons, 3 forks...just enough for my family. The continual social researcher in me thought that this man could be so poor that he only has cutlery for the exact members of his family. I had forgotten that of course Sri Lankans eat with their hands (which we did at his home too) so why would he ever need cutlery? I had of course imposed my own view of the world upon his circumstances. I began to consider how difficult it is to analyse data (as I had done) so that it tells the 'truth' of a person's story; even an emic perspective is not enough (but may be as close as we may ever get though at the time risking going native). We are always searching for that lens that shows us the story of the other as they themselves see it. This is why ethics

> are such a crucial piece of research because collecting data are not like catching butterflies - one net does not work for every circumstance because the 'truth' is such a hard thing to tell.

4.4.2. Data Butterflies and Methodical Nets: Securing Ethical Practice

'Table 2' below summarises the methods used to secure trustworthiness in the study. It utilises both quantitative (positivist) and qualitative

Table 2: Methods Used to Secure Trustworthiness in the Study

Trustworthy Criteria	**Method(s) of Security**	**Additional Methods**
(Guba, 1981, p. 80)		
Dependability (consistency or reliability)	Triangulation; reflexive journal	
Confirmability (neutrality or objectivity)	Triangulation; reflexive journal	Use of language respectful to both western and indigenous sciences
Credibility (truth value or internal validity)	Triangulation; peer debriefing, member checks; reflexive journal	• Participants' identities are revealed. • Choice of methodology • Institutional compliance
Transferability (applicability or external validity/generalisability)	Use of rich, thick descriptions; reflexive journal	

(interpretivist/relational/post-positivist) constructs/terminology in its attempts to secure trustworthiness of the findings as a reflection of the study's accommodation for the methods of both western and indigenous science.

A reflexive researcher's diary has already been discussed (see section 4.2.5). Additionally, in choosing how I decoded the data and translated it to the reader, I

have considered how my transcript reshapes the original incident, and shapes how interlocutors interpret my re-presentations (Mavers, August 2012). This includes the use of rich, thick descriptions as I analyse data and present findings in the upcoming chapter. All of the other methods listed in 'Table 2' are discussed below.

4.4.2.1 Adhering to Regulations and Institutional Compliance

Firstly, institutional compliance at the University of Sheffield required ethical clearance. Thereafter, respondents were issued an approved consent form on which they indicated their acceptance of invitation to participate, and an information sheet regarding what the study entailed (Appendix H). Participants were alerted of their right to report me to my supervisor at the University of Sheffield for ethical breaches and to withdraw at any time. Ethical clearance also required a synopsis of the study and detailed responses on how data was to be used, stored, and disposed.

The respondents were the chief knowledge keepers and Elders of the First Nations community. This helps to dispel fears about the participation of individual members of Indigenous communities within research.

> One concern of indigenous communities about the *informed consent* principle is about the bleeding of knowledge away from collective protection through individual participation in research, with knowledge moving to scientists and organizations in the world at large. This process weakens indigenous collectively shared knowledge and is especially risky in an era of knowledge hunting and gathering. (Tuhiwai Smith, 2008, p. 131)

4.4.2.2 Triangulation

Within my research design data triangulation between interviewees was primary, and methodological triangulation through the inclusion of different qualitative methods secondary, to the trustworthiness of the findings (Guion, Diehl, & Mc Donald, 2011). Methodological triangulation occurred between the semi-structured interviews, participant observation, document analysis, and the use of my researcher's diary throughout the study. Participant observation and document

analysis were primarily part of the pilot and gaining access, and did not form part of the data pool for analysis (Yin, 2003). Even so, they did inform my understandings and have impacted upon my analysis of the data, and my trust in my findings.

4.4.2.3 Peer Review and Member Checking

I also used peer review (via my supervisors) to minimise (or help me to become more aware of my) bias and aid conceptual development (Morse, 2015). Member checking occurred on the first completed draft of the document to ensure that my findings were trustworthy. It also permitted the respondents to comment on the structure of the curriculum and its usefulness for their museum's outreach services. One of my science experts cited in chapter one (WMS-Expert 2) died during the write-up of this study and was unable to contribute to the member check. Her contribution was retained in the document as she did give signed permission at the start of the study.

Findings/analytic outcomes are woven from multiple data sources of which any one participant may be unaware, and whose member check may hence incorrectly pronounce them as invalid. The researcher is then left in an ethical conundrum as to if, and how, to adjust the final document to win participants' approval whilst still telling their story. In such cases it is opined that "the researcher's background in theory and research methods must outrank the participant as a judge of the analysis" (Morse, 2015, p. 1215). Even though indigenous ways of being, of knowing, and of doing do not necessarily align with institutionalised ethical and methodological research practices, they have proven themselves valid and reliable to the sustenance and triumph of their peoples over millennia, through colonisation, decimation, and near extinction (Tuhiwai Smith, 2008). There may also be an ethical responsibility of the research community to seek out and preserve epistemologies and other cultural artefacts threatened by assimilation and erasure within modern society (Tuhiwai Smith, 2008). Moreover, Indigenous peoples have alternative ways of existing in, and experiencing the world, that can expand the methodologies of contemporary research if studies in which they are involved are breathable and emergent enough to permit them to do so. I have therefore tried through member checking and dialogue with my participants to present research findings that have

been approved by both their needs, and those of the research project. This was not a simple thing to do as I have illustrated via excerpts from my research diary below.

> 10th May, 2016
> Even though I had been careful to present clarification where the Creole was thick (see section 5.4), on member checking my participants found that I had presented their interview data verbatim in the Creole of our Trinidadian people, and are concerned that non-Creole speakers will misunderstand what they are trying to say. They have hence asked me then to present their interview data in the 'standard' English. 'Standard' to whom now? I view this as a sanitisation, a whitewash, and my heart is broken. I wanted this to be a respectful piece of decolonising, indigenous research and I feel like the participants are asking me to do just the opposite. Why don't they rage against all of those who would look down on how we speak because we do not sound how they think we should? Rage against those who say that to be legitimate, we must be like them? Rage!
>
> I feel that! Like I have a right to determine for them [my participants] how they should be presented to the world! That I could know really who they are and represent them- I assumed that my picture of them, that snapshot of 0.0000001% or less maybe of their lives that I was privileged to see, was more correct than who they knew themselves to be. Sharing one's research with your participants is a very difficult thing and has led me to a deep reflection about who really owns any piece of research. I cannot say at this point that I have the answer.
>
> 18th May, 2016
> I tried to solve it by giving them the following options via email:
>
> > 1. Would you be willing for me to include the original interviews in the appendix and put the 'standard' English one in the body of the essay?
> > 2. Would you prefer if I just included the 'standard' English version in the body of the essay only?
> > 3. Should I leave the interviews in verbatim Creole and include a paragraph on your concerns?
> > 4. Leave the interviews as they stand in the thesis in the verbatim Creole?
>
> They have chosen option two and my heart has shattered into a million more pieces. Moreover, this means a major edit to my thesis at a time when I am almost past my world limit and when I was literally ready to submit. I have worked so hard to tell what I think is their story – and I don't feel like I have

> the time now to sort through my feelings. I don't even know what I feel about this yet to be able to articulate it. I have been talking myself out of crying for the last hour. When you're sitting in a lecture hall learning about member checking it is so clean, so uncomplicated. I have never heard anyone talk about how member checking feels either for participants or for researchers. I have heard laudable speeches about 'honouring' the voice of participants but was never told how that might include relinquishing part of my own voice as them and I shared the research space – and how difficult that could be. No one spoke to me as a student of how member checking slows the completion of research and how that poses an ethical conundrum as researchers battle with deadlines and budgets. I feel like I am in the middle of an ethical s**t storm; the only thing I know for sure right now is that in the end the only way to tell the 'truth' is to let my participants decide what that sounds like for them. I guess that the decision of how I shall represent them has been made – I shall let them represent themselves (as far as that is possible anyways given that it is all in the end, as qualitative research, through my lens – coloured, foggy, and scratched in various parts).
>
> 20th May, 2016
> Well my supervisors have sent word to say I of course have to do what my participants ask. I'm wading listlessly through it - my desire to be done with this thesis exceeds my desire to be revolutionary (and who knows, in a month I might look back on this and wonder why I over-reacted so). My emotions are so sensitive to this issue that I am finding it difficult to come to a clear position. The only way to be fair at this point (I think) – to them and to me – is to do as they have asked, and to explain how that impacted upon me by presenting these excerpts of my diary as I continue to be open about my research process (Becker, 1983, 1984, 2008). Even so, I will not 'over write to it' in response because no matter how I feel about this, wallowing would disenfranchise my participants' story given that my position is antithesis to theirs. My job now is to continue to tell their story without the creole so that it still comes alive and is not "antiseptic, so devoid of anything that brings a people to life" (Read, 1965, p. ix), just as I had promised to do before (see section 5.4).

4.4.2.4 Anonymity

The study considers how participants do and make science in their activities and does not seek personal details about their lives. There is also a dearth of knowledge-keepers and the respondents' (IS-Experts') identities are all well-known and respected publicly so that their public contribution to the study could admittedly

help to increase the trustworthiness of the findings. This holds true too for the identities of the WMS-Experts who contributed to the definition of science in chapter one. However, the study was ethically approved by the University of Sheffield with respectful anonymity of the participants (see Appendices G & H).

4.4.2.5 Methodological Considerations

I hope too to ensure trust through a theoretical lens and methods of data collection and analysis that have respected and supported participants' lived experiences, and the scientific milieu in which the study is occurring. I hope that I have achieved this in the use of a complex adaptive theoretical frame so that the indigenous knowledge presented is preserved and juxtaposed against western science as opposed to lost or assimilated (Tuhiwai Smith, 2008).

4.5 Chapter Summary

This chapter justified the study as an ethnographic, exploratory case within a complex adaptive methodological framework. It discussed semi-structured interviews as the primary method of data collection, and the derivation of the interview protocol. A reflexive researcher's diary augmented the interviews. Participant observation, document analysis, and email interviews were discussed as tools of gaining access and pilot-testing. Ethics and measures to ensure the trustworthiness of the findings were also considered.

4.6 The Next Chapter

The upcoming three chapters form the series 'Resolving the Research Questions'. The first chapter in this series, chapter five, considers how the study generated answers to the research questions. Chapters six and seven then respond directly to research questions one and two respectively.

CHAPTER 5

RESOLVING THE RESEARCH QUESTIONS 1: GENERATING ANSWERS TO THE RESEARCH QUESTIONS, AND EXTRACTING AND ANALYSING DATA

5.1 Aims of the Chapter

The main aim of this chapter is to discuss how data were gathered, and the methods by which they were extracted to respond to the research questions.

5.2 Generating Answers to the Research Questions: Justifying the Semi-structured Interview Protocol.

The interview was the main data gathering instrument and this section justifies the value of each question on the interview protocol to the resolution of the research questions, and to a deeper understanding of the context. Data gained from participant observation, and document analysis during the pilot were used mainly to explore the context and have been discussed in chapter four.

Questions 1 and 2:

- Can you tell me about your First Nations ancestry?
- What is the name that your people call themselves?

Justification: First Peoples introduce themselves by stating their First Nations genealogy as it distinguishes their connection to the land and cultural traditions (Kesler, 2009; Moreton-Robinson & Walter, 2009).

Question 3:

- Which are the most important roles in your society?
- What are the roles of the chief, the queen, the pyai in your society? What is their hierarchy?
- Can you tell me about your emblem? (Appendix D)

- Can you tell me which Nations were represented at the First Nations Week of celebrations for this calendar year?

Justification: To develop my contextual understandings of the research site.

Question 4:

- What is your background in western modern science (school science)?
- What do you think is western science/school science (just in general terms)?

Justification: Western modern science (WMS) may be better understood by participants if referred to as school science, hence the phrasing of the question.

Question 5:

It is said that science is the study of the natural world around us and how it works. What is the closest word for 'science' in your language and what does it mean?

- What is science in First Nations terms?
- What does your First Nations heritage say of that?
- What does your First Nations heritage say about this 'world around us' and where it is?
- How does your First Nations heritage say that one can learn about that world?

Justification: I am trying to ascertain what science is in First Nations terms, and how does it agree with definitions of western science (WMS). Inside of that I am also trying to find out if the world or space (i.e. inner vs outer space) that indigenous science is trying to know is the same for First Nations peoples as it is for WMS.

> In the Aboriginal mind, therefore, an immanence is present that gives meaning to existence and forms the starting point for Aboriginal epistemology. It is a mysterious force that connects the totality of existence - the forms, energies, or concepts that constitute the outer and inner worlds....Couture [1991, p.208, as cited in Ermine, 1995, p. 104] has described this immanence as 'the pervasive, encompassing reality of the life force, manifest in laws – the laws of nature, the laws of energy, or the laws of light'....With this 'force' knowing becomes possible. (Ermine, 1995, pp. 103-104)

Question 6:

In Chichen Itza, the Mayan city in Mexico, the astronomers stood in a room all day and night looking through a slit in the roof observing the heavens. This is how they came up with the Mayan calendar which has proven itself to be an extremely accurate way of measuring time. So in Chichen Itza there were people who did different jobs (e.g. the astronomer). Do you know if there were amongst your First Nations peoples, special classes of scientific knowledge (e.g. Math, etc.). Can you tell me what these were?

- Were there special people responsible for gathering certain kinds of knowledge in your community?
- Can you tell me of any particular methods, and generally too, about how your people studied the world around them?
- How do your people 'measure' the world?
- How do your people come to know about how nature and the world around them work?

Justification: I am trying to look at the tendency of WMS towards atomism and reduction as compared to indigenous sciences tendency towards holism and complex adaptation.

> Native science does not view living systems reductively, but rather grants them full integrity and ontological standing. Such integrity and standing is likewise granted to the rest of the universe, in which everything is viewed as animate and having spirit. (The Native American Academy, n.d.)

> The intellectual tendency in Western science is the acquisition and synthesis of total human knowledge within a world-view that seeks to understand the outer space objectively. In the process, Western science, the flagship of the Western world, sought answers to the greatest questions concerning our existence and our place in the universe by keeping everything separate from ourselves. In viewing the world objectively, Western science has habitually fragmented and measured the external space in an attempt to understand it in all of its complexity. (Ermine, 1995, pp. 102-103)

Question 7:

- Can you identify the names of the most important folk tales of your people that talk about your science/ how the world works?

- Do any of these folk tales talk about how the world was formed or how the world works? If yes, can you tell/relate that/those particular folktale(s) to me?
- How did young people learn
    a. folk tales?
    b. how to make the canoe, cassava, medicines?
- How were these recorded?
- How have story, song and ceremony been used to depict the world around you?
- What is your favourite word, story, saying or song (from the First Nations) that describes
    a) the world and how it works?
    b) humankind's place in the functioning/working of the world?
- Tell me about how and why your people go (get information from) inside (or inner space) in order to understand the world around them?
- Would you be willing to share one of your sacred prayers that talks about how the world works and man's place in it?

Justification: I want to find out how visions, dreams, prayer, folk tales and observations/lived experience have been/are used by these people to describe the world around them.

> "Indigenous languages have a tendency to reinforce the use of analogy or metaphor; thus many objects are referred to through action-based phrases" (Sutherland & Dennick, 2002, p. 4).

> "Our Aboriginal languages and culture contain the accumulated knowledge of our ancestors, and it is critical that we examine the inherent concepts in our lexicons to develop understandings of the self in relation to existence" (Ermine, 1995, p. 104).

> Reality is not limited to a state of awakeness. Dream reality is part of the overall reality and lived experience. Knowledge can come from dreams in the same way knowledge can come from experiences in a state of awakeness – both are subject to validation, which is done through testing conducted in a state of awakeness to ascertain the uses and values contained in the knowledge. (The Native American Academy, n.d.)

> "Prayer is a medicine where all life begins, exists within, without and between us and our relationships. It is an actual place and state of being that marks the endpoint/beginning of our science" (Colorado, 1988, p. 54)

Question 8:

- Where do your people believe that knowledge comes from?
- Can you finish this sentence for me? "Everything in the world is about…….science is about……?"

Justification: Grade 7 Cree students were found to possess "an all encompassing view of science. Traditional knowledge is not something distinct from science" (Sutherland & Dennick, 2002, p. 19).

Question 9:

- How does one become an expert about how the world works, say like your pyai or chief?
- Within First Nation communities, who is/was responsible for
    a. collecting
    b. taking care of
    c. and passing on to the less experienced members of the community knowledge about how the world works (i.e. scientific knowledge)?
- How was the other knowledge of the community taught to members earlier in history, and now?
- How are the chief, the queen and the pyai chosen?
- What are the roles of the chief, the queen, the pyai
    a. in knowledge making, knowledge preservation and knowledge dissemination to the community?

Justification: Who keeps their knowledge (notice not who makes their knowledge)? I want to know who was responsible for teaching science/how was science taught recorded in these communities (e.g. are they mentored by an elder from young? Are they sent to a special school? Is it about observing and experiencing life?)

> "knowledge *holders* [italics added] must be ethical elders and leaders" (The Native American Academy, n.d.).

> Ermine (1995) talks about Aboriginal "Old Ones and the keepers of the earth among our people…" (p. 106).

Even though knowledge keepers were a special group within indigenous societies, knowledge makers are everyday individuals who are able to get knowledge from the inner space and enact it as a subjective worldview within the external world (Ermine, 1995). The scientific knowledge gained by individuals is then contributed to the community and used to develop technologies to suit both the needs of the society, and to protect the environment (The Native American Academy, n.d.). Within an indigenous framework then, the individual has the power to create communal knowledge, using individual means within exploration and introspection of inner space.

> Aboriginal epistemology is grounded in the Self, the Spirit, the unknown. Understanding of the universe must be grounded in the Spirit. Knowledge must be sought through the stream of the inner space in unison with all instruments of knowing and conditions that make individuals receptive to knowing. Ultimately it was in the Self that Aboriginal people discovered great resources for coming to grips with life's mysteries. It was in the Self that the richest source of information could be found by delving into the metaphysical, and the nature and origin of knowledge (Ermine, 1995, p. 108).

Question 10:

- Tell me about how each of the following is made (please describe any sacred or everyday rituals that might accompany them):
    i. Canoe
    ii. Cassava farine and cassareep
    iii. the drums
    iv. medicine
    v. blow darts
    vi. cloth from the plant

Justification: "Ancestral explorers of the inner space encoded their findings in community praxis as a way of synthesizing knowledge derived from introspection" (Ermine, 1995, p. 104). The knowings of the ancestors have been immortalised into

everyday routines and common acts that are still performed, and which demonstrate the knowledge or science of the people: that is, what they know, and how they come to use what they know to exist with and within the world around them. I am trying to find out what is the difference between science and knowledge. Is there such a thing as science for indigenous peoples or is it just about coming to know the Immanence?

Question 11:

- How do you think the scientific ways of being, knowing, and doing of indigenous regional peoples can be/should be used within school curricula and why?

Justification: Response to this question feeds research question two. Even so, the participants' expertise does not lie in science teaching nor curriculum development; and the curriculum's structure and content were extracted from analysis of the data in questions one to ten along with theoretical support.

Question 12:

- How is indigenous scientific knowledge validated?
- What is good science and bad science for Indigenous people?

Justification: For instance, WMS considers the hypo-deductive method and falsification as epistemological routes that lead to the creation of scientific knowledge that is valid. I am trying to ascertain what epistemological conditions (routes of knowledge creation, what knowledge is created, and how this knowledge is to be used) are considered to be necessary for indigenous scientific knowledge to be considered valid or good knowledge by these peoples.

Question 13:

- Is there anything else you think that I should know?

Justification: Allows the participant to furnish extra information that they deem necessary to my understanding of the topic.

5.3 Extracting Answers to the Research Questions: Mining the Interview Transcripts

The interview protocol was derived to provide answers directly to the research questions; a few questions therein helped to develop my contextual understandings of the research site. The conceptual framework and the research questions were used as a joint lens to mine the transcripts for relevant answers. There are 13 interview questions. Questions one to 11 help to respond to research question one whilst question 12 helps to respond to research question two directly. Moreover, the responses to research question one are used to inductively inform research question two which is the mini-curriculum of work. The last and 13th question is the usual 'do you think there is anything else that I should know'. However, this is qualitative work and semi-structured interview which in the end made it very difficult to limit responses to any particular question on the interview protocol to any one/particular research question. In the end, analysis of participants responses used a priori themes about how scientific knowledge is thought to be created taken from the conceptual bounds (chapter two): metaphysics; empiricism/positivism; hypodeduction; falsification; paradigmatic shifts and scientific revolutions; representing and intervening; relationality and holism; and ways of being, knowing, and doing. The complex adaptive framework also allowed emergence of a posteriori themes (see section 6.2) revealed from multiple re-readings and analysis across the transcripts of different participants to compare and contrast their responses to similar research questions.

Moreover, The Trinidadian English Creole language has been recognised as a language in its own right and there is a small movement to begin to document its structure and content (see Chin Pang, 1981; Ferreira, 1997; Winer, 2009). Even so, it would be impossible for one to take a formal class or tutorial where one can learn Trinidadian Creole, which is very different to Tobagonian Creole. Even though Tobago is part of the Independent twin island Republic of Trinidad and Tobago, I as a Trinidadian, cannot speak and often do not understand Tobagonian Creole. Speakers of Trinidadian Creole (and Tobagonian Creole) learn it by living within, and participating in, the culture. In this way it is an indigenous knowledge. We do not study Trinidadian Creole in school as we do ‘English Language’ or ‘Spanish’;

we speak it through an informal mentorship between more experienced holders of the language and neophytes such as our children who are born into or live within our culture. The process of code switching then from our English Creole to what is considered the 'standard' version of English is something that we do instinctively and lies for the most part undocumented. Moreover, any sparse documentation about this code switching exists only in the land of linguistic academics of which ordinary speakers- who are the experts in the language- are largely unaware. My participants have specifically asked that the Creole version of their interview transcripts not be published (see section 4.4.2.3) but the final document has undergone member checking by them to ensure the consistency of my conversion of their English Creole to the Standard English. To indicate then the process of converting the Trinidadian Creole in which they spoke into 'standard' English, I present below an excerpt from Trinidadian Nobel Laureate Sir V.S. Naipaul's (1959) story 'Miguel Street' (pp. 115-116) in Trinidadian Creole and 'standard' English in *italics*. I have used the word 'conversion' as opposed to 'translation' to maintain my recognition of Trinidadian Creole as an English language, and I suppose that a similar situation exists between the different dialects within England and the 'standard' account of English.

> My Uncle Bhakcu was very nearly a mechanical genius. I cannot remember a time when he was not the owner of a motor-vehicle of some sort. I don't think he always approved of the manufacturers' designs, however, for he was always pulling engines to bits. Titus Hoyt said that this was also a habit of the Eskimos. It was something he had got out of a geography book.
>
> If I try to think of Bhakcu I never see his face. I can see only the soles of his feet as he worms his way under a car. I was worried when Bhakcu was under a car because it looked so easy for the car to slip off the jack and fall on him.
>
> One day it did.
>
> He gave a faint groan that reached the ears of only his wife.
>
> She bawled, 'Oh God!' and burst into tears right away. 'I know something wrong. Something happen to he'. [*I know that something is wrong. Something has happened to my husband*].
>
> Mrs Bhacku always used this pronoun when she spoke of her husband.
>
> She hurried to the side of the yard and heard Bhakcu groaning.
>
> 'Man,' she whispered, 'you all right?' [*Are you okay?*]

> He said, 'How the hell I all right? You mean you so blind you ain't see the whole motor-car break up my arse?' [*How can I be ok? Are you so stupid that you expect that an entire motor-car can fall on me and that I would not be hurt?*]
>
> Mrs Bhakcu, dutiful wife, began to cry afresh.
>
> She beat on the galvanized-iron fence.
>
> 'Hat,' Mrs Bhakcu called, 'Hat, come quick. A whole motor-car fall on he.' [*Mrs. Bhakcu calls to a person named 'Hat' to come in a hurry as the motor-car has fallen on her husband*]
>
> Hat was cleaning out the cow-pen. When he heard Mrs Bhakcu he laughed. 'You know what I always does say,' [*I usually say*] Hat said. 'When you play the ass you bound to catch hell. The blasted car brand-new. What the hell he was tinkering with so?' [*If you do stupid things you are bound to get yourself into trouble. What was the need for him to fix a brand new car; there could have been nothing wrong with it*].
>
> 'He say the crank-shaft wasn't working nice' [*My husband said that the crank-shaft was faulty*]
>
> 'And is there he looking for the crank-shaft?'[*Your husband is looking in the wrong place in the car for the crank shaft*]
>
> 'Hat,' Bhakcu shouted from under the car, 'the moment you get this car from off me, I going to break up your tail.' [*As soon as I am able to get out from under this car that has fallen on me I am going to beat you up*]
>
> 'Man,' Mrs Bhakcu said to her husband, 'how you so advantageous? The man come round with his good good mind to help you and now you want to beat him up?' [*You are being very unfair. Hat was kind enough to come to help. Why would you threaten to beat him up*]
>
> (Naipaul, 1959, pp. 115-116)

5.4 Framing a Response to the Research Questions: Forms of Re-presentation and Issues of Translation.

I have tried to construct a report true to the tapestry of meanings of the lived experiences being documented. Translation requires me to bring alive how the First Nations peoples of my country do and live science. My report then is the bridge between 'them' (the reader) and 'us' (the First Nations representative participants from amongst my Trinidadian people).

> Why, then, is so much anthropological writing so antiseptic, so devoid of anything that brings a people to life? There they are, pinned like butterflies in a glass case, with the difference, however, that we often cannot tell what

> color these specimens are, and we are never shown them in flight, never see them soar or die except in generalities. (Read, 1965, p. ix)

My challenge is languaging this translation to readers unfamiliar with the Trinidadian Creole and cultural practices through which the participants have revealed their experiences. Simultaneously, the report must I believe, respect the ways of speaking and expression of participants who have honoured me and my research with a brief stint in their life story. I hence utilise the cultural representations, heritage and practices (including the preferred languages) of the peoples whose lives are being re-presented, and have maintained the relations within re-search sites (Martin & Mirraboopa, 2003) by interviewing four key Elders in the community. When the Trinidadian Creole is used quotation marks do not distinguish it as I believe that this would represent the Creole as a deviation from the 'standard' account of English. If the Creole is thick, I present translation into the 'standard' account of English to promote the sharing of meanings with my reader. [*Reflexive postscript*: See section 4.4.2.3 for changes that had to be made to reporting in the Creole on the request of the participants after member checking].

The findings have been woven using text that helps to present the lives of participants both generally, and in its defining particular details (Read, 1965) so that the layers of doing and making science within the community can be articulated to the reader in a more holistic way. Hence, in responding to the research questions I utilise different levels of generality crossing (Bethel College, n.d.):

> *i. universal statements* about western and indigenous sciences in general.
> ii. *cross-cultural descriptive statements* comparing scenarios across western and indigenous sciences, and how different groups may go about either of these.
> *iii. general statements* about the society or cultural group including science in Trinidad.
> *iv. general statements* about the specific cultural scene, that is about the First Nations peoples of the region and their scientific practices.
> *v. specific statements about the cultural domain*, that is of the science of the First Nations peoples of Trinidad.

vi. specific incident statements such as directly observed scientific practices of the First Nations peoples of Trinidad.

5.5 Responding to the Research Questions: Introducing the Participants

Since the genealogy of an Indigenous (First) person establishes their connection to the land and to cultural traditions (Kesler, 2009; Moreton-Robinson & Walter, 2009), an introduction of the participants contributes to the trustworthiness of the findings by indicating their relation to the scientific system under study (that of the First Nations peoples of Trinidad). They are all Elders of the Nepuyo Nation peoples of Trinidad and are introduced here via excerpts from relevant interviews.

The Indigenous Science-Expert 1 (IS Expert-Elder 1):

> *Laila:* Can you tell me a little bit about your First Nation ancestry?
>
> *IS Expert-Elder 1:* My ancestry, native ancestry goes back to the 1700s that is far as we can go back in terms of the records and the oral tradition and all that we have. So, I will go back for now to the Mission. The establishment of the Mission in Arima. When the Mission was established in 1750s, I think 1758/57 somewhere around there. There isn't much about that but just some historical information that talks about the establishment of that Mission and that the Mission was short-lived because of financial problems the church had, and then they had some resistance from the Indigenous peoples in the surrounding areas. So they abandoned the mission for 30 years. And it was not until 1785 that an attempt was made to re-establish that Mission in Arima. So that was done and this time it was successful because it existed from that time and you have the parish of Santa Rosa existing continuously from 1785 to today. Now, to establish a Mission there would have been Indigenous peoples living in this area but not in an organised way. They might have just been living in different parts of the area; there was no organised village, there was no establishment. When the Mission was established it was established primarily for the Indians as they called them, Amerindians from three specific areas – Caura, Tacarigua, and Aruaca which we now call Arouca. The Indigenous peoples had established villages in those areas and the Spaniards wanted those particular areas because they were already developed and planted by the First Peoples who lived there. Those First Peoples were moved to Arima; the Mission of Arima was established for these Native peoples that came from these areas. It is from

there we can trace our ancestry. We trace that the patriot in the first instance of the Indians was Pascual who was followed by Francisco Lopez, and then Francisco's son, Pablo. Next was Juan Martinez Lopez who was followed by his sister, Josefa Lopez. These were the Indians that held the hierarchy of the community and the lineage from which I came; quite a lot of people in the Arima area and who belong to the Santa Rosa First Peoples today can trace their ancestry from that origin.

Laila: What Nation are you?

IS Expert-Elder 1: They are from the Nepuyos. The Nepuyo is of mixed Indigenous groups. So you would have mixtures with the Carina, the Caribs, the Arawaks, The Chaimase, maybe the Waraos. It isn't a pure group as you would have a pure Carina group, a pure Arawak group, it is a mixture of groupings of Indigenous peoples.

IS Expert-Elder 2 descends from the Carina Pogoto tribe of the Carib Nation.

Laila: Can you tell me a little bit about your First Nation ancestry?

IS Expert-Elder 2: We say First Nations now because we have realised from our studies that when the Spaniards placed Indigenous peoples from different Nations onto the encomiendas that they intermarried and became mixed culturally. Many of the words that we use are not really Carina [Carib] words but Lokono words, what you would call Arawak, words. For example, in the rural parts of Trinidad we use the Lokono word 'cocovite' for 'candlefly'. So, to be safe, or correct, we say 'First Peoples' to eliminate any discrepancy between the different peoples. My maternal grandfather was of Indigenous blood and we have traced our origins to Caura Valley and from there to Venezuela. We suspect that they were from deeper in South America and are in the process of researching that. My paternal grandmother was of Carina descent and though she was born in Trinidad we have traced her family back to the Carinas on Martinique.

IS Expert-Elder 3 is of the Lokono and Carina nations.

Laila: Can you tell me a little bit about your First Nation ancestry?

IS Expert-Elder 3: My great-great-grandmother's relatives came from Venezuela, they never told me which part of Venezuela, but they came from Venezuela and settled in Caura Valley. My maternal grandfather was Pablito Lara. And they came from the Carina, Carib line. My maternal grandmother

> was a Mulatto, half white and half black; my Carib ancestry came from the lineage of my maternal grandfather. My Lokono heritage comes from my father; though he was Barbadian by birth his grandmother and great grandparents were Lokono from Guyana.

IS Expert-Elder 4 is currently a regional administrator of First Nations Peoples in the Caribbean. She is a Black Carib of the Garifuna Nation from St. Vincent who are offspring of the Yellow Carib and Africans.

> *Laila:* Can you tell me a little bit about your First Nation ancestry?
>
> *IS Expert-Elder 4:* I identify as Black Carib or as we found out later, Garifuna. But I always identified, from the time I was sensible enough to hear from my mother, as Black Carib. Which is the offspring of African and the indigenous Yellow Carib as they are called in St. Vincent. It was always said that the children of that union took on more of the African in terms of pigmentation. I learnt that Black Caribs were more assertive in defending the country than the Yellow Caribs who were seen as quiet….My history tells me that the children of that union, First Peoples and Africans, were more assertive than the Yellow Caribs. The British then, made that distinction, that they were the Yellow Caribs. The country St. Vincent could not be settled because of that resistance. It was one of the last to be settled and to be colonised and to be brought into the production of sugar and the slave trade because of that resistance. I grew up with that pride.

5.6 Chapter Summary, and the Next Chapter

This chapter discussed how data were generated through the development of the research protocol, and then extracted from interview transcripts in response to the research questions. The upcoming chapter is the second in the 'Resolving the Research Questions' section and presents the findings that were extracted from the data to offer a response to research question one.

CHAPTER 6

RESOLVING THE RESEARCH QUESTIONS 2: RESPONDING TO RESEARCH QUESTION 1

6.1 Aims of the Chapter

This is the second instalment of the three 'Resolving the Research Questions' chapters and responds to the first research question.

Question 1:

What is the Nature of Indigenous Science of the First Nations people of Trinidad?

a. What are the elements/content of this science?
   (response is in section 6.2)
b. What are the specific methods/strategies/circumstances through which native science is developed?
   (response is in section 6.3)
c. How are the following passed from experts to neophytes within the community *(response is in section 6.4)*:
   i. the elements/content of native science demonstrated?
   ii. the methods/strategies used to develop native science?

6.2 Response to Research Question 1a

The theme represented in each subsection of 6.2 has emerged a posteriori from the data (see section 5.3).

6.2.1 Science is Individualistic and Personal

Western science gives open access to scientific knowledge and then debates if how it has been used constitutes ethical means. Contrastingly, within the native-indigenous science system under study what knowledge is allowed to which users is a selective process with distinct aims of promoting harmony, and preventing harm.

From the IS Expert-Elder 1 ’s interview:

> *IS Expert-Elder 1*: You might have a business appointment or an examination coming, whatever it might be. An ancestor may visit you the night before with the specific directions that you particularly need to obtain success within this given situation. However, if you share those directions as advice when a friend is facing the same situation, they are not guaranteed to achieve success because the remedy was not developed for their particular needs.

From the IS Expert-Elder 2’s interview:

> *Laila:* American Indians used medicine stones for healing. The ancestors would go into trance and come back and write the things that they learnt on the medicine stones. If somebody got sick they could read the medicine stones and utilise the remedies on them. However, not everybody was able to read and understand the medicine stones. In regular science in contrast, if you or I have a headache, we can each utilise the same medicine, maybe Panadol, and it would cure us. It doesn’t work that way with the stones, what was that about?
>
> *IS Expert-Elder 2:* Not everybody could read the medicine stones because you cannot put a weapon of such magnitude into each and everybody’s hands. It is not only a cure, it is a weapon. It is a powerful thing and can be used to destroy people just as it could be used to heal people.

From IS Expert-Elder 4’s interview:

> *IS Expert-Elder 4*: If either you or I have a stomachache we could buy the same medicine to treat it successfully. What I do know is that in trance you get a message that is specific to your particular needs. Yes you may use a particular herb medicine that might work but the specific message from trance may suggest something else too

> for you; not just that you need a general pain killer. So that would be part of the reason why not everybody will be able to access it because it might come as a message that is for specific use by a particular person. Moreover, if you go into rituals too you have to prepare yourself in a certain way to ensure that the medicine is effective. So I guess this is why you hear accusations about witchcraft because people might try to access bits of truth which cannot work because it has been divorced from other conditions with which it was originally revealed during trance or rituals to the medicine man.
>
> *Laila*: Ok. That's a lot to think about.
>
> *IS Expert-Elder 4*: If you and I both come here limping in pain, and we take the medicine that the doctor [western modern science] prescribes, you may recover and I might not. This seems to indicate that there is something else [something personal about each case that native science tries to capture to ensure healing].

6.2.2. There is Only One Kind of Knowledge

The following interview excerpts are responses to whether there are different kinds of knowledges for their (Native) people:

From the IS Expert-Elder 1's interview:

> *IS Expert-Elder 1*: In a broad sense it is the same thing [western and native sciences] because I interpret science as knowledge in a particular area…you will have Spirit, you will have general science, and then you have spiritual science but they all fall under science.

From the IS Expert-Elder 2's interview:

> *IS Expert-Elder 2:* For Indigenous people they are all connected. Everything is connected, there is no bigger one. Spirituality overcomes everything because our spirituality is in everything. I am going to say, if we are going to choose a leader, and choosing a leader that's politics...but we are going to go about it in a spiritual way first. We consult with the Entities to determine if this leader will be a good one.

Laila: So, everything is part of, when you see spirituality, spirituality is the big thing or everything is a part of spirituality?

IS Expert-Elder 2: Everything is a part of spirituality.

Laila: So spirituality is the whole and everything is coming into that?
IS Expert-Elder 2: Yes, yes.

Laila: Ok, I understand that.

From Ms. IS Expert-Elder 4's interview:

Laila: Is there a separation between scientific and spiritual knowledge and other kinds of knowledge?

IS Expert-Elder 4: I don't want to say separation because I talked about the connectivity. But I would say that there are different levels and different things we have to look at right…I believe that there are different levels of knowledge. That spirituality you know, that it is a power...

6.2.3. Scientific Knowledge that Protects the Community, Entities therein, and their Holism is considered to be Epistemologically Robust, Valid, or Good Knowledge

Question: How is indigenous scientific knowledge validated?
What is good science and bad science for Indigenous/Native/First peoples?

IS Expert-Elder 1: Good science, well again I will give a spiritual response. Good science is a person going into trance and getting healing, and good directions for the community. Bad science, and there are bad or dark shamans who practice bad things to harm you. They will send things into your body. They would be with you. They will have bad Spirits provoking you, causing you pain and all these things. So that is bad science. So where there is positive there is negative.

IS Expert-Elder 2: Don't say First Nations. There is good science and bad science throughout the world. And there are good things that could be turned in the negative way. We will consider people creating things like bombs. We will consider pesticides and weedicides because they do a lot of harm to the earth. If we spray weedicide to kill the grass, we kill the grass and we kill the worm that God uses to rejuvenate the earth. We kill all the little bugs. We say to ourselves that we are going to kill the ants on the mango tree because they are destroying all the mangoes. We spray the ants and we kill the birds too. We kill the manicou [Trinidadian forest animal]. We kill the porcupine.

IS Expert-Elder 4: Good science for First Peoples is anything that will help to conserve the creation because everything is interconnected. So you are not going to hunt and kill more than you need to for your meal or use. You are not going to plunder just to store it up. So for example, tractors clearing forest land of all the trees is bad science. This is bad science because, yes the First Peoples do cut down trees but they know how to do so, and when. They will not cut down trees just to store it up. Even if you are doing something useful such as building a bridge or extracting gold, that will be bad science if you do not maintain balance and kill the fishes, the birds and whatever makes up the life of the people in the forest. It deskills you too. First Nations peoples are told that activities such as logging or mining would give them a better job. But you are being deskilled because you are not hunting and lose these skills and your independence. This was part of the fight of the First Peoples who were defending their lands from the colonisers. If you use the case of Canada or wherever, the bison and the buffalo that ran through the prairies [laughs] I read a story once that said John Deere the tractor and machinery maker, that John Deere became an enemy of the First Peoples because that machinery was able to mow down the prairie.

6.2.4. Knowledge Gathering is an Egalitarian Affair and is Open to Anyone Capable of Accessing it

From the IS Expert-Elder 1's interview (whilst discussing the role of knowledge keeping Elders within the community):

IS Expert-Elder 1: A person like that with special knowledge is born and chosen for that role. Their entire life's experiences will guide

them towards acquiring that position when the time reaches. So they would have learnt most of the things, again, from an Elder before them and they would have been in the right place, put themselves in the right places so that people could share their knowledge with them and so on. Just as the Chiefs.
Laila: So who chooses them? You said born and chosen.

IS Expert-Elder 1: When I say chosen, chosen by the Great Spirit. Chosen by that Spirit so that you would find yourself in places where that knowledge will be passed on to you and you will retain it. There are some people to whom knowledge is passed and they don't retain it. So they hear it but never retain it well enough to share it and pass it on.

From the IS Expert-Elder 2's interview:

Laila: What are the gateways to?

IS Expert-Elder 2: Well, it isn't only to pyais and to shamans, but to anybody who is capable of entering the Spirit world. The gateways also have totems who are represented as Spirit guides. In our grouping here [Trinidad] the gateway of the north is the hawk, the south is the ocelot or jaguar, the east is the deer, and the west is the turtle. Now it is our belief that the system, that the whole earth, this place we live in, that there are four portals whereby our Spirit guides can enter when they need to visit us when we call on them. And we also believe that through sacrifices and through meditation when we want to consult with those, whichever Spirit guide, that we can go through those portals.

Laila: So anybody can go through?

IS Expert-Elder 2: As long as you are prepared.

Laila: And who teaches them to be prepared?

IS Expert-Elder 2: The Pyai. The spiritual people.

Laila: So I can't just, without you, as a regular person, First Nation person who probably meditates?

> *IS Expert-Elder 2:* Who am I to say you are not capable or not prepared? If it is Creator's desire for you to go through the portals then you will go.

From IS Expert-Elder 4's interview:

> *Laila*: Oh, you can have a female medicine woman?
>
> *IS Expert-Elder 4*: Yes, and one of them was here from Suriname and one of them was here from Guyana [during the First Nations annual celebrations]....So the female emerges as well as the medicine people, those are the ones that they call witches in English and Spanish coloniser language.
>
> *Laila:* I heard something in the First Nation week [celebrations] about the female Spirit being the highest Spirit or one of the highest?
>
> *IS Expert-Elder 4:* If that is how it emerges then that is how it is. There is no discrimination.
>
> *Laila:* So it is just what is best for the society, who is best?
>
> *IS Expert-Elder 4:* And what the Great Spirit sends, what the Great Spirit allows to emerge. Because it is the Great Spirit that is endowing.

6.3 Response to Research Question 1b

The themes represented in each subsection of 6.3 were determined a priori (see section 5.3) save that of 6.3.7 which is a collective a posteriori code formed from all of the a priori codes from 6.3.1 to 6.3.5. Each way of knowing elaborated in chapter two has been represented here as a theme and interview excerpts used to demonstrate how First Nations science of Trinidad demonstrates these various ways of knowing.

6.3.1 Metaphysics

Faith and intuition, including prayer and dream-work, are valid ways of knowing the world.

From the IS Expert-Elder 1's interview:

> *IS Expert-Elder 1:* When I was 8 or 9 years old we lived on Calvary Hill [a place in Arima, Trinidad]. I had a piercing pain in my mouth on the side of my jaw that was so bad that sometimes I couldn't open my mouth. My grandmother used to tell me that what I had was 'lockjaw' and that its relief would require a visit to the hospital so that the doctor could medicate me. That made me afraid. I was even afraid to touch it. This went on for a long time. One night I dreamt that I was walking up Calvary Hill and just before I got to my grandparents' house, I looked east and saw this old lady washing clothes over a tub. She called to me and asked if I had a pain in my mouth and jaw; I responded 'yes'. She took a lime and rubbed it for a long time on the spot that had been paining me. She told me to take the lime and to throw it behind me, as far as I could. I threw that lime, this was all happening in my dream, and I saw the lime roll down the hill until it was out of sight. When I got up the next morning I no longer had that mouth and jaw pain from then until now. That was a healing. A spiritual healing by an ancestor.

From the IS Expert-Elder 2 Pyai's interview:

> *Laila:* If someone has a problem or is sick, how do you know how to heal them?
>
> *IS Expert-Elder 2:* If someone goes to a modern day doctor they give them a cat scan or an x-ray; our x-ray is our energy field. This isn't magic. We are able to discern the weakness in a person's energy shield or pattern so we know where in your body the problem is located. We do a spiritual cat scan.

From the IS Expert-Elder 3's interview:

> *Laila:* How do First Nations people come to know about the world around them?
>
> *IS Expert-Elder 3:* First of all it came spiritually. They would go into the forest to seek guidance from Tamushi, God in our language…Tamushi is the Carina [Carib Nation] and Adayaliwachnachi is the Lokono [Nation] name or the Arawak for God. So you go into the forest and like everything else, you fast and cleanse yourself and the solution will be revealed to you in dreams or visions.

From IS Expert-Elder 4's interview:

> I believe that there are different levels of knowledge. That Spirituality is a power. Also there is a strong belief, instead of saying the Spirit, in the ancestors. And among the First People it is like the ancestors may visit you and talk to you. Today we may say your guardian angel. You see a lot of the things are not really different.

6.3.2 A Case for Utility - A Creole of Empiricism/Positivism, Hypo-deduction, Falsification, and Representing and Intervening

For the First Nations group, scientific practice is aimed at serving the needs of the community, primarily utilitarian, and hence necessarily technological. To achieve these aims native science utilises the observational data collection of empiricism within a hypo-deductive spiral aimed particularly at the production of tools/technologies (representations) that are useful to the community. Falsification through testing and re-testing of the utility of these representations is carried out in a real world arena; that is, how beneficial they have proven themselves to the everyday lives of the community.

From the IS Expert-Elder 1's interview:

> *IS Expert-Elder 1:* Most of the things that the indigenous people do they were taught by nature. For instance, they developed a cassava squeezer that juices the cassava [Appendix B1]. The oral traditions says it is called a matapi which is the Guyanese name. In Trinidad we call it a coulevre or culibra; it all translates to snake. The science behind it is that they observed the snake, how the snake moved, how the snake devoured its food, and so developed the coulevre. This is one example of how nature and the animals taught them and gave them knowledge, how they observed animals and nature and were able to make applications to their own life.

From the IS Expert-Elder 2's interview:

> *IS Expert-Elder 2:* Professor Seaforth is a natural product chemist with whom I collaborate; he is the scientific person. When I go to give lectures to students at the university someone usually asks how did the First Nations peoples know what medicine to take and when I respond through observation they are always disbelieving. We eat

> the deer and the meat doesn't poison us right? We eat the lappe [a Trinidadian forest animal], we eat certain fishes. Also, the First Nations people observed the deer using certain medicine. Some smarty pants might ask how the deer knew which medicine to take but they will have to ask Creator. Indigenous people observed the deer scratching his horn on a tree and licking the tree and getting healed. They observed the lappe eating the crapaud seed and being able to dive into and swim around in very cold water.
> *Laila:* Crapaud seed you said?
>
> *IS Expert-Elder 2:* Yes. The botanical name is carapa guyanesis but the local [Trinidadian] name is crapaud.
>
> *Laila:* So when you take it you don't get cold in the water?
>
> *IS Expert-Elder 2:* Well there is an entire process which I am not going to teach you. We boil it, but the lappe would eat it raw. The First Peoples did not have photography, they had to observe. They had to observe the deer scratching her horns on a tree and licking her horns off. They had to observe the identity of the tree. Perhaps they observed that the deer may have been vomiting or that they had a sick limb before and was healed. We still do it, when we shoot a deer we take their horn, we keep their horn for medicinal purposes because the horn has residues of medicines.

From IS Expert-Elder 4's interview:

> *IS Expert-Elder 4:* A man looked at the trail of footprints and he was able to tell which group of people had passed by. He was also able to tell that the horse that one person was riding was limping. People were amazed at how he could tell such a thing. I think First Nations people were very close to nature so that they were able to understand. And they looked at the ways that the birds gathered….there was technology and science as you put it….they had to observe the ways how the trees grow, how the river winds, where did it go? They had to observe what the animals did and so on.

6.3.3 Relationality and Holism

The Universe is a living, breathing, growing organism within which all Entities are considered alive, interconnected, and dependent on each other.

From the IS Expert-Elder 1's interview:

> *IS Expert-Elder 1:* Indigenous spirituality is that God is Spirit and that Spirit is neither male nor female but coming to you it will come in a form and that form could either be feminine or masculine.
>
> *Laila:* And then there are other Spirits too, like you have the Spirit of the trees, and the Spirit of the water?
> *IS Expert-Elder 1:* The water, the land, the wind, the fire.
>
> *Laila*: But they are not God?
>
> *IS Expert-Elder 1:* These are just the elements, and the Spirit of these elements are all part of the overall Spirit.
>
> *Laila:* We too?
>
> *IS Expert-Elder 1:* Yes. And that is why the Indigenous people use some of those elements in their ceremonies. They use water, they use fire because we are made up of water and fire. If we don't have that within us we don't exist. So recognising the power of those elements, we use them in the ceremonies. You need them for survival. They can also be destructive, so you pray always that the sustainable aspect of them will be with you.

From the IS Expert-Elder 2's interview:

> *Laila*: Before you go on, tell me then, what is science for First Nations?
>
> *IS Expert-Elder 2:* Science for First Nation people is living in harmony with all Entities.
>
> *Laila:* And what are all these Entities?
>
> *IS Expert-Elder 2:* The fishes, the trees, the rivers, the moon, the sun, the other planets, stars.
>
> *Laila*: Ok.
>
> *IS Expert-Elder 2:* Harmony in diversity. Respect. Like when I talk to students I tell them that respect is the most important thing. Indigenous peoples use what we call the payback system. You are taught from childhood that if you are going into the forest that you

take any seeds that you have – corn, avocado, pommerac, mammyseport. You plant these seeds in any empty spot that you come across in the forest. You do not plant with the expectation that you will eat from these trees but you met trees in the forest from which you ate and which you didn't plant. So there is continuity. Because if you have a bank account and you withdraw everyday, one day you will go and it will be empty. You have to deposit.

From IS Expert-Elder 3's interview:

Laila: So illness is not physical is what you're saying, it could be spiritual?

IS Expert-Elder 3: Yes.

Laila: Is it always spiritual and physical?

IS Expert-Elder 3: Sometimes both. So you have to be able to discern what it is you are dealing with. You have to prepare yourself by praying and fasting before you even attempt to go into that realm to deal with it because you could end up getting sick and dying. When you have a certain situation you go to a shaman who is more qualified because they went in depth into the forest to gain the knowledge, spiritually and otherwise so that they are best able to treat with certain things. [A relationality between the forest, the physical, and spiritual is demonstrated here]

From IS Expert-Elder 4's interview

IS Expert-Elder 4: Yes, how the world works. If I want to make the connection I would say that is part of why the smoke ceremony recognises the elements, the importance of the energy of fire. There is also a water ritual. Today we have many United Nations initiatives regarding water and its importance to life but the First Nations peoples recognised its importance a long time ago. They did not pollute the water because the water was the road for the canoe to get to places; the water was to drink, it wasn't pipe borne. The water was the home for fishes and other sea and marine life. The moon and the sun would indicate the seasons, the time, and when rain would fall. They recognised the elements in their everyday lives.

6.3.4 Ways of Being, Knowing, and Doing

Given the relationality of the universe, science is a process of self-actualisation; of living the fullness of one's God given purpose upon the earth plane whilst being in harmony with all other Entities. (The theme represented in section 6.2.1, "Science is individualistic and personal", also supports).

> *IS Expert-Elder 2:* Part of the vision quest is sitting in darkness. You are back in your mother's womb. You are back in that void. And from in that entombed place, in your asking questions of Tamoshoki [Indigenous word for God], the Creator and the Spirit Guides, then you would see lights and a direction. The road you are supposed to walk. What you are supposed to do. If you are to be a healer, if you are to be a teacher, though a healer is a teacher too. But you know there are people who have different roles.
>
> *IS Expert-Elder 3:* We see spirituality as a universal thing where a creature as I say is communicating with God. So you try to live in what is perceived as a good way. To do good. Or when you treat with somebody else, and interact with them, to see the good in that person or the image of God in that person.
>
> *IS Expert-Elder 4:* First Nations people believe that all things in nature are connected. We may be afraid of certain animals, and yes maybe if we are unwise we may be stung, be poisoned, or be killed by it. Even so, it has a purpose so that we must be careful how we interact with it. Yes, the fishes are there in the sea for us to eat but we have to be careful not to kill the young ones and such thinking influenced how they built their fish pots. Fish pots were built in a way that the little fishes could escape to propagate whilst the larger fish would be caught and used as food.

6.3.5 Constructivism and Other Theories of Knowledge

Scientific knowledge is a personal construction. There are various theories as to the nature of this construction and its relationship to reality (e.g. that it is a construction of a fixed reality, or a radical construct of an unknowable reality; or frozen by the measurement instrument as in quantum theory).

See interview excerpts under section 6.2.1, “Science is individualistic and personal” as examples.

6.3.6 Scientific Revolutions and Paradigm Shifts

This theme has not been revealed in the data; its absence is accounted for in section 8.2.1.

6.3.7 A Collective A Posteriori Code: Complex Adaptive Systems

This code is an amalgam of the findings within a priori codes represented in sections 6.3.1 through 6.3.5. Indeed, the presentation of native science as a complex adaptive system (CAS) is not widespread in the literature (e.g. The Native American Academy, n.d.). However, the data from this study have revealed a connectedness between Entities, and that these Entities are relating and responding to input data from each other (relationality). To achieve self-actualisation (as the highest form of scientific knowledge), these Entities are provided by Spirit with individualistic knowledge or experiences (and these act as bifurcations or changes in the system). Each Entity is given the specific knowledge or experiences needed to secure the evolution/adaptation necessary for their self-actualisation. The newly self-actualised person, as a relating member of the collective Spirit, feeds back their new wisdom into the holistic Spirit or the Universe which hence evolves and expands. The data suggest to me then that the indigenous science system under study is a complex adaptive system.

6.4 Response to Research Question 1c

6.4.1 Scientific Knowledge (Elements/Content and Methods/Strategies) can be Revealed or Acquired

Scientific knowledge is revealed via orientation with the Spirit world. It is acquired through mentorship (see section 6.4.2).

From the IS Expert-Elder 1’s interview:

Laila: Ok, thanks. So finish this sentence for me 'science is .....'

IS Expert-Elder 1: Science is knowledge revealed or acquired.

Laila: Is that First Nation science for you or everything science? That's First Nation science?

IS Expert-Elder 1: Well, for me it's everything.

Laila: Science or First Nation science is the same thing to you?

IS Expert-Elder 1: In a broad sense it is the same thing because I interpret science as knowledge in a particular area. It can also be acquired or it can be lived. Today in the world science is mostly learned by people studying science. But for First Nations People it is mostly acquired in the first instance and then some of it is also passed on, is also taught from generation to generation. What do I mean by that? The First Nations people are people of nature in the first instance so that they are very close to nature. I am talking about First Nations people mainly a little while back for Trinidad but for those in the interior on the mainland [South America], they are still very close to nature. So all that they know and they experience comes from nature so that's why it is acquired. It is acquired through their connection with nature. In other words, the nature, the forest, the elements are the computer of the First Nations people; the 'acquired' is through teaching so that I learn something. For me I acquired the knowledge of weaving the coulevre because I learnt it from somebody but it was revealed to the first person who ever wove a coulevre. It was revealed to them through the observance and knowledge that would have come either from the Great Spirit or through whatever influence it was revealed to them. And from there it was taught, it was passed on so others would have acquired it from that. So there are some things that will be given to *you [stressed]*, that will be revealed to *you [stressed]* because the Great Spirit or some ancestor of yours wants you to know that and will show it to you but not to me. For instance with bush medicines, there are some medicines that are general so that anyone can use it for a cold, as example. This cold medicine was initially revealed and then it was acquired by others from one to the next. But there are some things that are only for *you [stressed]*. And what is for you will work only for you. You will have an ailment that it will cure and another person with the same ailment will not be cured. It is not for them. And I have personal experience of this. So that you may dream of somebody you knew, your grandmother, or somebody, your mother

or father when they pass on, and they will come and give you specific advice which if you take, will yield successful results. This advice though wouldn't work for somebody else because it is not for them – it is for you. That is what I mean by revealed and acquired.

6.4.2 Scientific Knowledge (Elements/Content and Methods/Strategies) is Acquired from Knowledgeable Elders or Mentors via a Lived Experience or the Oral Tradition

From the IS Expert-Elder 1's interview:

Excerpt 1:

IS Expert-Elder 1: The birds talk to them. The wind talks to them. The animals spoke to them. I remember when I was a child, about 20 years ago, that there was a lady of First Nations heritage who lived on Calvary Hill [in Trinidad]. She would hear a bird and she would say, "Do you hear what the bird is saying?" And she would tell you. Before she said this you could only hear the whistling and singing of the bird but once she said "Hear what he is saying", and she told you what she had heard, then you began to hear it too but you couldn't do so on your own before.

Laila: ...but little people, the little ones also, they could have dreams too?

IS Expert-Elder 1: Of course!

Laila: But how could they understand those dreams because they're little people [children]?

IS Expert-Elder 1: Well, they would share it with the Elders and the Elders who are more knowledgeable would interpret it for them.

Laila: And who are the Elders. You just have to be an older person to become an Elder?

IS Expert-Elder 1: Well, yes but there are different kinds of Elders. Some people are considered to be Elders in the community because they are older. However, you also have Elders who are knowledgeable about certain things. For instance in the community

> there was always an elderly female who was very well respected because she held knowledge of traditions; was knowledgeable in medicine and in different things. You may have had an Elder who was the same age as her but not as knowledgeable. Yes, Elders are senior people but some are versed in certain areas – medicine, midwifery, delivering babies, different things.

Excerpt 2:

> *IS Expert-Elder 1:* Nature taught Indigenous people to do most of the things that they know how to do today. For instance, they developed a cassava squeezer that juices the cassava. The oral traditions say it is called a matapi.

From the IS Expert-Elder 2's interview:

> *IS Expert-Elder 2:* ...Indigenous people were taught to read, read a trail that you could tell a sign if a man has walked here and if he went two hours ago, three hours. Indigenous people can look at the bark of a tree and determine what forest animal had climbed up the tree – whether manicou [a Trinidadian forest animal] did climb up that tree, or an anteater [e.g. of lived experience].
>
> *Laila:* Who teaches them to read, to read it you say?
>
> *IS Expert-Elder 2:* Well it was handed down, taught.

From IS Expert-Elder 3's interview:

Excerpt 1:

> *IS Expert-Elder 3:* If a child was sick we would perform santiwah, the [East] Indians call it jaray. My grandfather would send me to collect the necessary materials and he would do the prayer. You use sweet broom (tree), holy water and a candle within a certain ritual. The sweet broom is used like a sprinkler similar to that used by Roman Catholic Priests. You dip it into the holy water and sprinkle it onto the child whilst his/her arms and legs are crossed in a particular position. You flip the child over and do the same thing to their back. You start at the forehead where you make a cross, you then come down to the chest, then the feet after which you flip them over and do it to their back whilst all the time saying a particular prayer

> [notice here evidence of both scientific content: the healing of illness, and scientific method: how the healing was done]
>
> *Laila:* Santiwah? Is that what I saw the medicine man do at the River Festival because I noticed when he was praying that he sprayed water [at the chakra points, indicates chakras]
>
> *IS Expert-Elder 3:* Vital spots that they use. My grandfather used to do it with children and he was widely sought after for his services.

Excerpt 2:

> *IS Expert-Elder 3:* I get visions that I can unfold because my grandparents would explain to me how to do so [evidence of the oral tradition].

From IS Expert-Elder 4's interview:

Excerpt 1:

> *Laila:* So who would teach them how to make the canoe?
>
> *IS Expert-Elder 4:* It would be handed down…. the school was the Elders and the tradition.

Excerpt 2:

> *Laila:* How do people learn of these things...like all the stuff that you know. How do we young people who are coming up, who are First Nation, learn it?
>
> *IS Expert-Elder 4:* The oral tradition is the primary method but now quite a bit has been written down. There has been quite a bit of research about the history of Santa Rosa [the First Nations community in Trinidad] and some of those brochures tell about the culture and the traditions.

6.5 Chapter Summary, and the Next Chapter

This chapter presented the findings that were extracted from the data to offer a response to research question one. The upcoming chapter is the third and final in the

‘Resolving the Research Questions’ section, and presents the findings that were extracted from the data to offer a response to research question two.

CHAPTER 7

RESOLVING THE RESEARCH QUESTIONS
PART THREE:
RESPONDING TO RESEARCH QUESTION 2

7.1 Aims of the Chapter

This is the final instalment of the three 'Resolving the Research Questions' chapters and responds to the second research question:

> How might these indigenous ways of being, knowing, and doing science in Trinidad be used to enrich current science school curricula?

A response to this question was assembled in two ways. Firstly, it was used as a direct question in the interview protocol (see responses in section 7.2). These responses were then merged with answers to research question one (see chapter 6), and used to suggest the structure and content of a mini-curriculum of work that integrates western modern and Trinidad's native-indigenous science (presented in section 7.3).

7.2 Responses to the Interview Question: "If you had to put the science of the First Nations peoples of Trinidad onto science school curricula, what would you include?"

Responses suggested that such a curriculum should use discussions about living holistically with nature and the elements to consider: native technologies (e.g. weaving of the matapi or coulevre); the development of respect for all Entities; native medicines; and native spirituality.

From the IS Expert-Elder 1's interview:

IS Expert-Elder 1: Firstly, for technology we could include weaving, and other equipment and implements that they made for their survival. Secondly, what is the spirituality of the First Peoples and its basis on nature – what is nature, the elements of nature and so on.

From the IS Expert-Elder 2's interview:

IS Expert-Elder 2: I would want to teach people, not just children, because you have to educate educators to educate children.

Laila: So that's a big one. So you would put it on teacher training programmes too?

IS Expert-Elder 2: Yes! And first of all I will teach respect. Not just respect between men and women but total respect for the environment, respecting everything around you. If we teach respect it won't even have any more littering.

Laila: That is very difficult to teach though you know.

IS Expert-Elder 2: What?

Laila: You don't think? How will you teach that?

IS Expert-Elder 2: Respect?

Laila: Yes. Give me an idea how you would do that in terms of a First Nation way. Maybe a hike through the forest?

IS Expert-Elder 2: You don't have to take them anywhere. You can write and disseminate material on the behavioural patterns of the First People [one reason that I have used folktales in the curriculum] as many people are interested in this.

From the IS Expert-Elder 3's interview:

IS Expert-Elder 3: I would say traditional medicine to give people choices to western medicine. There are many cases where western medicine uses the same herbs but in different proportions and dosages.

Laila: Don't many of your medicines have a spiritual component to it?

IS Expert-Elder 3: Umm hmm. You have to pray.

Laila: So how would you teach that in schools?

IS Expert-Elder 3: Some things that are done with prayer may not be applicable to the school curriculum.

Laila: Give me one or two medicines that you think they should know about that you would want to be, that doesn't need the prayer then, and that you could use on the school curriculum.

IS Expert-Elder 3: There are antidotes for snakebites that the Pyai prepares, medicines for headaches and childbirth, and herbs that are used instead of penicillin and other mainstream drugs.

From IS Expert-Elder 4's interview:

IS Expert-Elder 4: The environment. Even from the level of the UN there is encouragement towards indigenous practices. Practices that hold a worldview that all things are connected.

7.3 The Curriculum: Integrating the First Nations Science of Trinidad with Western Science

This section describes the mini-curriculum. Its foundational aspects are discussed in 'Table 3' and are simultaneously presented as subsections to 7.3. That is, its philosophy (7.3.1), misconceptions (7.3.2), pedagogic creed (7.3.3), aims (7.3.4 and 7.3.5), and goals (7.3.6); and how the curriculum secures the complex adaptive 4R model (Doll, 1993), and facilitates connected integration (Fogarty, 1991), autonomous acculturation and collateral learning (7.3.7). The four component lessons are subsequently presented in sections 7.3.8 to 7.3.11 contained in Tables 4 through 7.

Table 3: Foundational Aspects of The Curriculum

7.3.1 Philosophy of the Curriculum	**7.3.2 Misconceptions**
Science is harmony.	An awareness of the misconceptions which participant-learners bring to the learning space can help educators to focus on debunking these. One major misconception might be that there is only one kind of science (western modern science) and its methods are the only valid way of knowing the world.
7.3.3 The Pedagogic Creed of the Curriculum	
i. Science is spirituality and spirituality is balance (derived from the IS Expert-Elder 2 's interview): *IS Expert-Elder 2:* To Indigenous People everything in the world is about balance. We believe that if we were to remove certain things or to interfere with certain things the balance would be disrupted. If I put a cocoa grain on one end, then the other end will go down [demonstration of a scale]. *Laila:* What do you think of this sentence – science is spirituality and spirituality is balance? *IS Expert-Elder 2:* Good. ii. In support of the 4R curriculum model: "In a reflective relationship between teacher and student, the teacher does not ask the student to accept the teacher's authority; rather, the teacher asks the student *to suspend disbelief in that authority*, to join with the teacher in inquiry, into that which the student is experiencing. The teacher agrees to help the student understand the meaning of the advice given, to be readily confrontable by the student, and to work with the student in reflecting on the tacit understanding each has." (Doll, 1993, p. 160)	

Table 3: Foundational Aspects of The Curriculum (continued)

7.3.4 Aims Chosen to Govern the Curriculum at the International Level	
1. From the United Nations declaration on the rights of Indigenous peoples Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions. (Article 31.1, United Nations, 2008, p. 11)	2. From the United Nations' Educational, Scientific and Cultural Organisation's Local and Indigenous Knowledge Systems (LINKS) (UNESCO, 2015): • to secure an active and equitable role for local communities in resource management; • to strengthen knowledge transmission across and within generations; • to explore pathways to balance community-based knowledge with global knowledge in formal and non-formal education.

Table 3: Foundational Aspects of The Curriculum (continued)

7.3.5 Aims Chosen to Govern the Curriculum at the National Level	**7.3.6 Goals Created to Govern the Curriculum at the Local Level (The First Nations Museum of Trinidad)**
3. From the Education Policy Paper (1993-2003) that presently governs education in Trinidad and Tobago (p. xvii): That the educational system of Trinidad and Tobago must endeavour to develop a spiritually, morally, physically, intellectually and emotionally sound individual. That ethical and moral concerns are central to human development and survival. Fundamental constructs such as 'decency', 'justice', 'respect', 'kindness', 'equality', 'love', 'honesty', 'and [sic]'sensitivity', are major determinants of the survival of our multicultural society. That the educational system must provide curricular arrangements and choices that ensure that cultural, ethnic, class and gender needs are appropriately addressed. That we must be alert to new research and development in all fields of human learning and to the implications of these developments for more effective teaching and school improvement. 4. From the 'Vision Statement' of the Trinidad and Tobago Secondary School Science Curriculum: The science curriculum will: stimulate students' curiosity and creativity; develop competence in the use of the knowledge and methods of science; [and] develop students' critical awareness of the role of science in everyday living (Trinidad and Tobago. Ministry of Education, 2008, p. 21)	i. To develop an awareness of First Nations science as a valid way of coming to know how the world works. ii. To appreciate the similarities and differences between the nature of native/Aboriginal and western sciences.

Table 3: Foundational Aspects of The Curriculum (continued)

7.3.7 How the Curriculum Secures The 4Rs (richness, rigor, recursion, relations); Border Crossing; Collateral Learning; and Connected Integration.	
The pedagogic methods used to formulate a complex adaptive curriculum predicated on Doll's (1993) model have been discussed in section 3.6. The nature of indigenous science revealed in question one was used to build each 'R'. 1. Richness: Problem based, exploratory, and contextual pedagogy has been secured by allowing students to explore how Indigenous peoples developed technologies used to navigate their world space (e.g. quinine, lesson four), and how these technologies function (e.g. fish pots, the matapi for cassava production, lesson two). 2. Recursion: Dialogic and reflective strategies have been used and include storytelling, and self-reflection about humankind's relationship with trees in particular, and nature in general (lesson one). Stories have also been carefully chosen to provoke a reflective comparison between the nature of western and indigenous science (lesson four).	3. Relations: Social constructivism and cognitive mentorship see students working with a knowledgeable mentor, or in small groups for storytelling (lesson four); when developing indigenous technologies (e.g. weaving, fish pots, and medicines in lesson two and four); and to learn indigenous methods of planting (lesson one). 4. Rigor: Inquiry learning and pedagogical strategies that promote creativity and imagination have been utilised in plan and design strategies which encourage students to develop experimental models based on an indigenous worldview to investigate or solve a practical problem (e.g. the designing of fish pots in lesson two). There has also been an inquiry into the nature of indigenous science in lesson three.

Table 3: Foundational Aspects of The Curriculum (continued)

7.3.7 (continued) How the Curriculum Secures The 4Rs (richness, rigor, recursion, relations); Border Crossing; Collateral Learning; and Connected Integration.
An examination of the lessons below will reveal that indigenous science is not presented here as distinct from western science, nor are its delineating features highlighted. Instead, as a connected integration model, each lesson juxtaposes western and indigenous science and has tried to provide opportunity for a thoughtful comparison of content, skills, and links between the two. I have done so in attempts to create an ethical space: > 'ethical space' is formed when two societies, with disparate worldviews, are poised to engage each other. It is the thought about diverse societies and the space in between them that contributes to the development of a framework for dialogue between human communities. (Ermine, 2007, p. 193) Such a deliberatively, comparative space offers opportunity for border crossing, collateral learning, and autonomous acculturation. The safety and respect of ethical space hopefully encourages students to pursue them.

7.3.8 Table 4: Lesson One of the Mini-Curriculum

<table>
<tr><td>Lesson One</td><td>1. General Objective

To evaluate the role of relationality and holism in science.</td><td>2. Specific Objectives
To:
i. plant a tree using First Nations methods of holism.

ii. appraise the benefits of First Nations holism in planting.</td></tr>
<tr><td colspan="3">3. Resources:

One ‘My Tree Pack’ for each participant containing:
one paper cup; one dead fish; soil; one plastic spoon; one seedling; paper and pencil</td></tr>
<tr><td colspan="2">4. Set induction/introduction:

First Nations peoples believed that we are connected to the plants, the animals, the water, the wind, and that they are connected to us. That all of us exist as part of the whole of Life (holism), and in relationship with each other (relationality). We are going to plant a tree in honour of that belief.</td><td>5. Development:

i. Each participant is given a ‘Tree Pack”

ii. Participants are encouraged to plant the seedling in layers from the bottom of the cup upwards in the order soil-fish-seedling-soil.

iii. Candidates are asked to draw/colour their planting method in their science notebook.

iv. Each participant is then asked to design and create a label for their plant. The label contains one reason why they are thankful for trees, and ‘My Promise’ of one special thing that they are going to do for a tree to demonstrate their gratitude.</td></tr>
<tr><td colspan="3">6. Assistive Questioning Map:

i. Why do you think we put the fish at the bottom of the cup?

ii. Why do you think that we wrote why we were grateful for trees?

iii. How do you think the way in which we planted the tree, and us being grateful for trees, demonstrates First Nations belief in holism and relationality?

iv. Can anyone help us to better explain what holism and relationality mean now that we have come to the end of our activity?</td></tr>
</table>

7.3.8 Table 4: Lesson One of the Mini-Curriculum (continued)

7. Justifying the structure/content of the lesson

Learning methods foundationed on personal subjective experiences and introspection can help societies and individuals to achieve transformational holism. The transformative process would entail "skills that promote personal and social transformation; a vision of social change that leads to harmony with rather than control over the environment; and the attribution of a spiritual dimension to the environment" (Miller, Cassie and Drake, 1990, as cited in Ermine, 1995, p. 102).

Excerpts from the interviews:

> *IS Expert-Elder 4*: ...If I hear somebody worshipping a tree then I would say that you are not supposed to worship a tree. But if I understand that the tree was the source of me getting my boat for transportation. The tree is the source of me getting the right wood to make a good bow and arrow for hunting because that is what I had. I wouldn't want to call it worship, I would say that they understood the importance.
>
> *Laila*: Of the tree? And they showed gratitude?
>
> *IS Expert-Elder 4:* Yes (laughs). The First Nations people understand that it is the earth that brings forth. They don't waste because they are thankful to the earth. There is a tradition of planting something in thankfulness. There is one, I think that we have an example of it in the museum [see Appendix B3] – when you are planting put a fish, like an offering of a fish, into the earth. It might look strange but what happens? The fish becomes an organic fertiliser, as compared to the artificial fertilisers that are presently abused.

7.3.9 Table 5: Lesson Two of the Mini-Curriculum

<table>
<tr><td>Lesson Two</td><td>1. General Objective

To analyse the functioning of some indigenous technologies.</td><td>2. Specific Objectives
To:
i. relate the functioning of the matapi (coulevre) to digestion in a constrictor snake and so decipher empiricism as part of the nature of indigenous science.

ii. relate the functioning of fish pots to a sieve.

iii. weave the matapi/coulevre

iv. determine the relationship between science and technology.</td></tr>
<tr><td colspan="3">3. Resources:
a fish pot; a sieve; a mixture of sand and rice; beakers/containers; a matapi (and materials for its construction)</td></tr>
<tr><td colspan="2">4. Set induction/ introduction:

A video of an anaconda eating and swallowing some prey (warning that some people may find the content disturbing).</td><td>5. Development:
Matapi/Coulevre:
i. A discussion/video about the dynamics of how an anaconda’s body adjusts as it consumes and digests prey (Appendix I1)

ii. Weaving of a mini-matapi by participants and observation of a real matapi and how it functions (see picture Appendix B1)

iii. Students are allowed to suggest how the matapi (especially the way its weave gives it accordion like capabilities), functions similarly to a snake digesting its food.
Fish pot:
i. Students are allowed to use sieves to separate sand from beans.

ii. There is then a discussion about over-fishing, what it is, and its consequences. (materials in Appendix I2)

iii. Students are then given materials in small groups of about four to design a fish pot that prevents overfishing which they must present with explanation.

iv. Students are then shown practically, through video or the museum exhibit, how a fish pot is made and works (see Appendix I3 and B3).</td></tr>
</table>

7.3.9 Table 5: Lesson Two of the Mini-Curriculum (continued)

6. Assistive Questioning Map:

How do you think Indigenous peoples were able to design a matapi/coulevre or a fish pot? (This question hopes to ascertain that empiricism was used; that is, the observation of nature).

7. Justifying the structure/content of the lesson

From IS Expert-Elder 4's interview:

> *IS Expert-Elder 4:* The fishes are there in the sea for us to eat but we have to be careful not to decimate the stock of young ones. So that had something to do with how they built their fish pots. Fish pots were built in a way that the little fishes could escape so that there'd be more fish and the bigger ones that were more mature would be caught in the pot.

From the IS Expert-Elder 1 's interview:

> *IS Expert-Elder 1:* It all translates to snake. The science behind that is that they observed the snake, how the snake moved, how the snake devoured its food, and used this knowledge to develop the matapi. This is just one of many examples of how nature taught them to do things. They observed nature and then applied it to their own lives. I was invited to Belize a few years ago to share knowledge on indigenous technology and I wondered at that time what are they asking me to do? I don't know anything about technology [pause] can you weave? Yes, I can weave the coulevre [matapi]. Well that is technology. So I went there and I wove the coulevre and they said "Mister, that is indigenous technology". So there is a close relationship between the science and the technology.

7.3.10 Table 6: Lesson Three of the Mini-Curriculum

<table>
<tr><td>Lesson Three</td><td>1. General Objective

To understand some indigenous medicinal remedies used to treat common diseases.</td><td>2. Specific Objectives
To:
i. explain the use of soursop (graviola) and garlic as indigenous medicines.

ii. introduce local (Trinidadian) western, and indigenous scientists who study the use of indigenous medicines.</td></tr>
<tr><td colspan="3">3. Resources:

Interview with, or short film on the biography of Dr. Compton Seaforth (western natural product Chemist, Appendix I6), and Mr. Cristo Adonis (Pyai and indigenous medicine expert); introductory slideshow; explanatory video on indigenous applications of soursop and garlic and the western science explanation of their medicinal functioning.</td></tr>
<tr><td colspan="2">4. Set induction/introduction:

An interactive slide show of a variety of examples of Trinidadian ‘bush medicine’ (e.g. aloe vera, wonder of the world, soursop, garlic, ginger). Participants will be encouraged to contribute any knowledge that they have of the use of local ‘bush medicine’.</td><td>5. Development:

i. Participants will be introduced to the term/definition/concept of indigenous medicine (‘bush medicine’).

ii. Explain that many indigenous medicines have been studied at centres such as Sloan Memorial Kettering Cancer Hospital in New York.

iii. The slide show continues with some short examples of various indigenous medicines and the cure that each can obtain.

iv. The slide show ends with a longer example that explains how the indigenous medications of soursop and garlic may function (Appendices I4 and I5).

v. Lastly, participants will have an opportunity to view a film, or to interview Mr. Adonis and Dr. Seaforth about their joint work within indigenous medicines.</td></tr>
</table>

7.3.10 Table 6: Lesson Three of the Mini-Curriculum (continued)

6. Assistive Questioning Map:

i. Why should we say 'indigenous medicine' and not 'bush medicine' (the term commonly used in Trinidad)?

ii. Do you think Dr. Seaforth and Mr. Adonis are both scientists? Why/Why not?

7. Justifying the structure/content of the lesson

The lesson was developed where indigenous scientific practices are explained using western scientific principles. The lesson operates at category one of George's (1986, as cited in George, 1999) taxonomy (see section 1.2.3.2)

The content was suggested by IS Expert-Elder 3 as documented in excerpts from her interview:

> *IS Expert-Elder 3:* There are simple things, you can use fruits to decrease the bad cells that cause you to get cancer.
>
> *Laila:* Like what?
>
> *IS Expert-Elder 3:* Soursop [otherwise known as graviola]. You can eat soursop raw. Garlic too and it has also insulin potency. You can use natural medicines instead of artificial, man-made medicines.

Moreover, one of the aims of local science pedagogy has been to introduce regional people famous on the world stage for their contribution to science. Dr. Compton E. Seaforth is a natural product chemist at The University of the West Indies, St. Augustine Campus since 1963. He routinely works with indigenous scientist and Pyai, Mr. Cristo Adonis. Mr. Adonis has also worked extensively teaching indigenous medicines with Trinity College in Connecticut, USA for the past 12 years.

7.3.11 Table 7: Lesson Four of the Mini-Curriculum

<table>
<tr><td>Lesson Four</td><td>1. General Objective

To evaluate the nature of indigenous science.</td><td>2. Specific Objectives
To:
i. compare and contrast how western and indigenous science come to know through an investigation of literary artefacts.

ii. To identify falsification (from the story of quinine), observation of nature (from the story about how fire was discovered), and dreams and visions (from the story of the medicine society), as ways of knowing within indigenous science.</td></tr>
<tr><td colspan="3">3. Resources:

Literary artefacts (see Appendices I7, I8, and I9)

Story 1: Kekulé and the snake: The structure of benzene according to western science.
Story 2: The discovery of fire * (The Mohawk Nation, 1968)
Story 3: The origin of the medicine society* (The Seneca Nation, 1968)

*Artefacts from North American Indigenous Nations were used as these were unavailable for Trinidad.</td></tr>
<tr><td colspan="2">4. Set induction/introduction (continued)

Indigenous science has its own ways of coming to know the world, many are similar to those of western science. For instance, indigenous people discovered quinine, the cure for malaria.

This story is then to be told using audio visual means. It is recommended that a short movie in which the text below is acted out might be of greatest efficiency. A method of reading instruction known as ‘Reader’s Theatre’ is also plausible. It utilises members of the audience as actors and supplies them with sufficient costuming, script, and props.</td><td>5. Development:

Storytelling:
Participants are asked to actively listen for the answers to the questions on the question map as they are told each of the three stories. The question map is to be suspended on the overhead projector during reading to facilitate active listening.</td></tr>
</table>

7.3.11 Table 7: Lesson Four of the Mini-Curriculum (continued)

"Quinine comes from an infusion of the bark of a particular tree from the Amazon rain forest. How did pre-modern people ever discover that a tea made from this tree, of all the plants in the forest, would relieve the symptoms of malaria? They must have tried every tree and every plant – roots, stems, bark, leaves – tried chewing on them, mashing them up, making an infusion. This constitutes a massive set of scientific experiments continuing over generations, experiments that moreover could not be duplicated today for reasons of medical ethics. Think of how many bark infusions from other trees must have been useless, or made the patient retch or even die. In such a case, the healer chalks these potential medicines off the list, and moves on to the next. The data of ethnopharmacology may not be systematically or even consciously acquired. By trial and error, though, and carefully remembering what worked, eventually they get there – using the rich molecular riches in the plant kingdom to accumulate a pharmacopoeia that works. Absolutely essential, life-saving information can be acquired from folk medicine and in no other way". (Sagan, 1997, pp. 251-252)	**6. Assistive Questioning Map** i. Name some ways in which the story says the hero came to learn about benzene (story 1) or fire (story 2) or medicine (story 3)? ii. What are the major differences/similarities between stories one, two, and three? **7. Justifying the structure/content of the lesson** Storytelling allows the students to indirectly discuss their own views of science through indirect questioning. Stories, as opposed to real incidents, permit students to be detached observers who can relate their true feelings about the particular worldview identified without feeling like they are being judgmental. Storytelling gives space for students to compare the worldviews of western and indigenous native science, to help them to be able to separate the different ways of coming to know, and so understand each better through collateral learning (Sutherland & Dennick, 2002, pp. 19, 21-22). From the IS Expert-Elder 2's interview: *IS Expert-Elder 2:* You can write and disseminate material on the behavioural patterns of the First People as many people are interested in this.

7.4 Chapter Summary, and the Next Chapter

This chapter presented the findings that were extracted from the data to offer a response to research question two, and so suggests a model for a mini-curriculum as a unit of work that integrates indigenous and western science. The curriculum is a complex adaptive (Doll, 1993) model that uses a connected strategy to integrate (Fogarty, 1991) indigenous science with western school science. It creates an ethical space to promote autonomous acculturation as a critical border crossing through the provision of experiences that provoke secured collateral learning. The upcoming chapter is the final in the document; it summarises the responses to the research questions; discusses the findings; presents limitations based on the research design and its implementation; and finally makes recommendations for further research.

CHAPTER 8

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.

8.1 Aims of the Chapter

This final chapter summarises and discusses the findings to each research question. Though the study was performed in Trinidad, indigenous science of First Nations peoples (often called native/Aboriginal science) are very similar in their constructs(Aikenhead & Ogawa, 2007; Colorado, 1988; Dei et al., 2000; Moreton-Robinson & Walter, 2009; Snively & Corsiglia, 2001), and the work may have applicability further afield than the Caribbean. With this awareness, recommendations are made for further study based on both the limitations encountered with the research design, and on the findings. Finally, the chapter concludes the report.

8.2 Responding to Research Question One

What is the Nature of the Indigenous Science of the First Nations peoples of Trinidad:

a. What are the elements/content of this science?
b. What are the specific methods/strategies/circumstances through which native science is developed?
c. How are the following passed from experts to neophytes within the community?
    a. the elements/content of native science
    b. the methods/strategies used to develop native science

Native science is a holistic system, a whole that comprises only spiritual knowledge of which all other knowledges, including scientific knowledge, is part (Moreton-Robinson & Walter, 2009).

Native science is a relational system within which all Entities are animate, connected to each other, and sharing knowledge through their connections (Snively & Corsiglia, 2001).

Relationality means that the knowledge (content and methods) of native science can be revealed to any Entity via connections formed through intuition, dreams or spiritual means; or acquired or learnt from knowledgeable mentors or Elders via an oral or a shared lived experience (Moreton-Robinson & Walter, 2009).

The findings indicated that scientific knowledge revelation was egalitarian and bestowed by the Great Spirit according to personal and individual need to the fulfilment of one's life's mission, that is, towards self-actualisation. Self-actualisation for Indigenous people is the act of coming to know (Ermine, 1995; Sutherland & Dennick, 2002). Within the native-indigenous system under study knowledge was found to be individualistic and personal; often derived through intuition for, and within a specific context inside of which it is potent. That is, indigenous science is focused on intervening (Hacking, 1983), hence primarily technological, and helps humankind to navigate a holistic (spiritual, physical, emotional, social) world space (Dei et al., 2000; Snively & Corsiglia, 2001).

Valid or good scientific knowledge respects relationality and holism. Bad science hurts members of the community (this expands to all Entities) and disrupts the circle of holism (Ermine, 1995).

Native science honours the connectivity of everything (Lavallee, 2009). The complex adaptivity of native science (The Native American Academy, n.d.) is geared towards the self-actualisation of all Entities. The native system is complex adaptive because: it is a holistic one within which members inter-relate (relationality) towards self-actualisation; and of its continuous evolution through growth and self-actualisation by living in respect, balance, and harmony with all Entities.

In summary, native science is utilitarian towards the community and the specific needs of individuals; the system under study came to know through

- metaphysics (Colorado, 1988);
- relationality and holism (Aikenhead & Ogawa, 2007);

- empiricism/positivism and hypo-deduction (Colorado, 1988; Moreton-Robinson & Walter, 2009);
- falsification (Moreton-Robinson & Walter, 2009);
- a technological/representational focus (Dei et al., 2000; Snively & Corsiglia, 2001) (as opposed to intervening).

8.2.1 Unexpected Anomalies in the Findings to Research Question One

An amalgamation of a posteriori codes (see section 6.3.7) indicated complex adaptation as a feature of native science. Even so, the a priori code of 'paradigm shifts and scientific revolutions' as a way of knowing was not seen in the data. This was surprising to me because I believe scientific revolutions occur through complex adaptation. "Any conception of nature compatible with the growth of science by proof is compatible with the evolutionary view of science developed here [i.e. as proposed through paradigm shifts and scientific revolutions]" (Kuhn, 1970, p. 173). I am going to quote extensively from Kuhn's (1970) work in order to explain (the italics) and fortify my suggestion that scientific revolutions and paradigmatic shifts being evolutionary, are complex adaptive.

> At the start a new candidate for paradigm may have few supporters, and on occasions the supporters' motives may be suspect [*the crisis is set up – a bifurcation has entered the system*]. Nevertheless, if they are competent, they will improve it, explore its possibilities, and show what it would be like to belong to the community guided by it [*elements begin to self-organise; adaptation is spontaneous and occurs without a governing authority*]. And as that goes on, if the paradigm is one destined to win its fight, [*scientific revolutions are non-cumulative and it is unpredictable how, and what, adaptations will occur as old paradigms are argued against the new. This also makes scientific revolutions and paradigm shifts non-reductionist*] the number and strength of the persuasive arguments in its favor will increase [*as new properties of the paradigm begin to emerge*]. More scientists will then be converted, and the exploration of the new paradigm will go on. Gradually the number of experiments, instruments, articles, and books based upon the paradigm will multiply. Still more men, convinced of the new view's fruitfulness, will adopt the new mode of practicing normal science, until at last only a few elderly hold-outs remain [*the new paradigm incorporates either all or portions of the paradigm that it replaced so that the emergent paradigm/system enjoys greater order and is more complex than before*].

> Falsification rejects theory once it cannot be experimentally corroborated. In this way falsification parallels the emergent anomalous experiences within scientific practice which spark crisis and lead to the scientific revolution that prepares the way for new theory. (Kuhn, 1970, p. 159)

I propose what I call a *contextual utility* to explain why complex adaptation was visible in the data as a feature of native science whereas paradigm shifts via scientific revolution were not.

Whilst utilitarianism is arguably part of the driving philosophy behind indigenous science (IS), debatably it is not itself a philosophy. A philosophy should have an ontology or ideas about what is the nature of reality or ways of being; it should have an epistemology or ideas about the ways by which one comes to know or by which knowledge is created; finally it should have an axiology, ways of doing, or a value system. Whilst utilitarianism can say that utility is the best way of doing, that utility is the best way of coming to know – with utility here needing operational definition but arguably dealing with efficiency and greatest benefit to the masses – utilitarianism lacks the ability to suggest what reality should look like. I will say then that IS values utility as opposed to holds a philosophy of utility. IS' value for scientific utility seems to have made it more focused on representing than intervening; on useful products and technologies rather than the processes by which they were produced.

Western modern science (WMS) demonstrates a *universal utility* as opposed to indigenous science's (IS) – which includes native science's – contextual utility. In critical thinking the mind is thought to work in a clear and defensible way. Within WMS a scientific mind has been considered to be critical and searches for knowledge proven un-falsifiable under a wide variety of conditions. This results in WMS interventions that are rigorous and which hence have the power of universal utility. IS holds a different view of utility, one that is contextually applicable or specific to the needs and eventual self-actualisation of the immediate user(s). Hence, it may be unsurprising that this critical scientific mind has not yet been widely applied to mainstream analysis of the processes by which IS makes knowledge; to the interventions of IS as these are individualistic as opposed to universal. Within a critical scientific mind these interventions, processes or paradigms by which knowing

occurs, includes the determination of research questions, and methodologies through which data are collected, made sense of, and reported. A scientific revolution is argued as a necessary and iterative process to replace paradigms that have become non-functioning with ones more efficient at explaining how the world works. Indeed, IS itself seems so far unconcerned with its own interventions or the ways by which it creates knowledge; holding that contextually utilised knowledge is created by whomever needs it, to exactly meet personal needs or self-actualisation goals, often as they need it, and with the permission and aid of Spirit. Hence, the value towards contextual utility of IS may make it apparent that how IS knowledge systems change over time was not a focus of the participants' responses.

Moreover, the participants are themselves lay-scientists within both western and indigenous science. Indeed, even lay-scientists within western science are expectedly largely unaware of how science creates knowledge as highlighted in Mc Comas' (1996) myths, and I would hazard that most have never heard of Kuhn's (1970) theory regarding scientific revolutions. Perhaps then for these reasons, paradigm shifts through scientific revolutions (Kuhn, 1970) as a way of coming to know was not found as a theme in the data.

8.3 Responding to Research Question Two

> How might these indigenous ways of being, knowing, and doing science in Trinidad be used to enrich school science curricula?

A complex adaptive curriculum was used to create an ethical space (Ermine, 2007) by utilising Doll's (1993) 4R model (richness, recursion, relations, and rigor) to integrate indigenous and western science via a connected design (Fogarty, 1991). The 4Rcurriculum uses problem based learning; dialog and reflection; inquiry based learning; social constructivism and cognitive mentorship; storytelling, and the promotion of creativity and imagination. Connected integration allowed the skills, concepts, and content of western and indigenous science to be integrated (Fogarty, 1991) around common personal and social issues (Wraga, 2009), and so helps to develop a relationship between concepts (e.g. between the physical, experiential, and experimental) (Levy & Wilensky, 2009).

By designing lessons to create an ethical, connected, and integrated space within which western and indigenous science can be compared, it is hoped that students will feel safe to engage in border crossing, collateral learning, and subsequent autonomous acculturation. The lessons and their objectives are summarised in ‘Table 8’.

Table 8: A Summary of Lessons in the Mini-Curriculum

Lesson	General Objective. To:	Accompanying Specific Objectives. To:
1	evaluate the role of relationality and holism in science.	i. plant a tree using First Nations methods involving holism. ii. appraise the benefits of First Nations holism in planting.
2	analyse the functioning of some indigenous technologies.	i. relate the functioning of the matapi (coulevre) to digestion in a constrictor snake and so decipher empiricism as part of the nature of indigenous science. ii. relate the functioning of fish pots to a sieve. iii. weave the coulevre (matapi). iv. determine the relationship between science and technology.
3	understand some indigenous medicinal remedies used to treat common diseases.	i. explain the use of soursop (graviola) and garlic as indigenous medicines. ii. introduce local (Trinidadian) western and indigenous scientists who study the use of indigenous medicines.
4	evaluate the nature of indigenous science.	i. compare and contrast how western and indigenous science come to know through an investigation of literary artefacts. ii. identify falsification, observation of nature, dreams and visions as ways of knowing for indigenous science.

8.4 Emergence

As an ethical consideration I committed to keep my reader abreast of my research process (Becker, 1983, 1984, 2008). A researcher's journal, my ongoing readings, peer discussions, and a general reflexivity have created a different vantage point from where I began: in some places where I have changed my mind about things it is dissonant; it is smarter (I think); and more mature (Guba & Lincoln, 2008). At this point in the research process, I can look backwards on my writings and initial epistemological suppositions and identify how slips in my design and implementation might have impacted upon, or even threatened, my findings. In the spirit of complex adaptive systems this is a feedback loop that helps to emerge a stronger design for ongoing work. Hence, this section discusses the limitations that were met, and provides recommendations for future work.

8.4.1 Successes of, Limitations in, and Recommendations for, the Research Design

This section reflects firstly on the utility of a complex adaptive system (CAS) as a methodological framework to the study; secondly upon the form of the research questions; and lastly upon the value of the participants to development of the mini-curriculum.

Firstly, a complex adaptive (CAS) methodological framework as a non-discriminatory platform on which western and indigenous science (IS) enjoyed equal footing, and which was open enough to allow for emergence about the nature of IS (a relatively understudied phenomenon), has proven a worthwhile proposition. The CAS was open enough to allow indigenous science to be determined as having both the usual interpretivist (e.g. holistic, relational, metaphysical) characteristics as well as, perhaps surprisingly, positivistic (e.g. empiricist, hypo-deductive) ones. To strengthen the complex adaptive framework by introducing further bifurcations to enhance emergence and better cater to the needs of the participants, I should have sought their contribution to the research questions. This would have had to been done during the execution of the study itself so that my permission for ethical clearance would have indicated irresolute research questions. The institutional review board may not have

welcomed this level of indecision within my initial research design. A strong case needed to be made that such a complex adaptive framework was more "central to the needs, aspirations, or worldviews of 'marginalized and vulnerable' communities", as opposed to one-size-fit-all professional and institutional rules (Tuhiwai Smith, 2008, p. 128). A detailed audit trail may also have been a good catalogue of bifurcations, emergence, and hence overall adaptations over the course of the study.

When I started this study I was not sure what I was going to find. Whilst documentation existed on the nature of the native sciences of North America (Aikenhead & Ogawa, 2007; Colorado, 1988; Dei et al., 2000; Moreton-Robinson & Walter, 2009; Snively & Corsiglia, 2001), I had only an assumption that the nature of the native sciences of Trinidad would be similar. The findings of this thesis do help to leave me more convinced of this similarity. I did know from my own experience that Native peoples of Trinidad validated knowledge through personal, individual, Spiritual means. I thought then that their science would not rely on the same (usually quantitative) methods that WMS used to validate knowledge such as empiricism, hypodeduction, and falsification through a general process of consensual knowledge determination within a wider scientific community. Instead, the ways of knowing of native science (a kind of indigenous science) being Spiritual, relational, and holistic would lead to personal, individualistic, qualitative understandings of the world. However, knowing that Native peoples had utilised native science for millennia and that it had successfully helped them to survive, I did suspect that native science might possess methods by which their Spiritual walking in the inner worlds worked, and which were being shared through generations. Hence, these methods would have to be duplicable and generalisable within similar conditions as are quantitative means. I needed a platform then that would be flexible enough to allow whichever qualities of Trinidad native science that was found to *emerge* be they supportive of the quantitative or qualitative genres, or both. A CAS did so as it allows a system to adapt and emerge new properties (Davis & Sumara, 2006; Fleener, 2002; N. Johnson, 2012). I hence continue to suggest that a CAS makes an appropriate platform.

Additionally, after reading Aikenhead (2014) I was particularly concerned that the thesis should place both western and native science on equal footing and began to look for a framework that could do so. The issue with doing so was that WMS

favours quantitative methods and native science qualitative ones (though I suspected as explained above that native science possibly also used quantitative ones). The disposition of this study too is that a methodology has a philosophical underpinning and utilises certain methods to collect data that support this philosophy. For example, a qualitative methodology is supported by an interpretivist philosophy and utilises methods such as semi-structured interviews to determine how participants interpret the world. Hence, this thesis holds that methods and methodology are inseparable. I suggested that a CAS could act as a platform mutually respectful to western modern (WMS) and native (NS) science by allowing for both quantitative and qualitative methodologies. A mixed methods (MMR) framework also seemed suitable as it could hold philosophies that supported both quantitative (such as in WMS) and qualitative (such as in NS) activities simultaneously. However, a study is defined as MMR only if it utilises both quantitative and qualitative methods in a singular study (Greene, Kreider, & Mayer, 2011, p. 259; J. Maxwell & Loomis, 2003, p. 241)) and this research did not. This study is mixed at the level of philosophy (to accommodate the philosophies of WMS and NS) but not at the level of methods (these are qualitative only). Hence, I proposed a CAS as a suitable methodological framework over MMR.

Added to this dilemma was the Trinidadian context in which the study was occurring and within whose classrooms the final unit of work integrated both WMS and NS. The Trinidadian context itself indicated that science was practiced as a tapestry which contained both WMS and Trinidad's indigenous science interacting with each other (see George, 1986 (as cited in George, 1999). Moreover, Caribbean society itself has been proposed as a CAS (Benitez-Rojo, 1996; see section 3.4). A platform was needed that permitted the quantitative elements of WMS and the qualitative elements of NS not just to co-exist but to interact and MMR did not have this capacity. However, the members within a CAS can interact and I hence proposed a new use for a CAS in which each member could possibly be a theoretical entity of quantitative or qualitative persuasion co-existing and inter-relating.

Secondly, the research questions drove the development of the interview protocol's content, and the percentage to which it focused on any construct. The protocol did not ask many questions about how indigenous science practices could be infused in a curriculum, concerned about being unfair to the participants, who though informants

about indigenous science, are not professional educators. However, the most substantial educational outcome of data analysis has been the mini-curriculum of work, and this is not reflected in the way that the research questions were originally stated. This unit of work integrates indigenous and western science, and is predicated on the nature of the indigenous science of First Nations peoples of Trinidad gleaned in research question one. Now, at the end of the work, I believe that the below adjustment of the research questions better reflects my data analytic goals and outcomes:

Grand tour question: How might the indigenous (Aboriginal/native) ways of being, knowing, and doing science be used to enrich current science school curricula?

Question 1: What is the Nature of Indigenous Science of the First Nations peoples:

a. What elements/content of these sciences are demonstrated?

b. What are the specific methods/strategies/circumstances through which indigenous science is developed?

c. How are the following passed from experts to neophytes within the community:

i. the elements/content of indigenous science demonstrated?

ii. the methods/strategies used to develop indigenous science?

Question 2: What is the form and content of a mini science curriculum (unit of school work) based on the First Nations indigenous science?

Lastly, my experience with my participants indicates in spite of not being professional educators, that they were well able to contribute substantially to the development of the curriculum and that I should have pursued this line of questioning more determinedly.

8.4.2 Limitations in Data Collection

There was some information about native science that was not shared; I was told bluntly that I could not be told, limiting my data collection. Some information was possibly not shared with me because I might have been viewed as an outsider of the community:

> *IS Expert-Elder 2*: Well, there is a particular process which I am not going to teach you. We boil it but the lappe would eat it raw.

Other reasons for the limits in sharing their knowledge in general were given to me including:

i. a wariness of their practices being mocked as witchcraft:

> *IS Expert-Elder 1:* There is a stigma and belief that many people do not identify with our practices and that is the main reason why First Nations peoples don't openly share their knowledge.

ii. the use of the knowledge to cause harm:

> *IS Expert-Elder 2*: So you can't teach all Tom, Dick and Harry because it can be used to destroy people just as it could be used to heal people.

iii. and that even within indigenous communities knowledge is only shared with whomever's path of growth and self-actualisation is discerned to need it:

> *IS Expert-Elder 3:* My daughter is into other faith systems, which is fine. My son shows interest about learning about our rituals so I teach him.

Moreover, these private ways of doing were also likened by the IS Expert-Elders 2 and 3 to mainstream religious practices, for instance to the theological privacy/secrets

of the Roman Catholic Mass (e.g. the conversion of the host to the body and blood of Christ).

Additionally, I was unable to collect any stories or folktales, songs, poems, idioms or other literary artefacts in which scientific practices and beliefs of the First Nations peoples of Trinidad might have been embedded. Hence, my unit of work utilised American Indian stories. In seeking out these literary artefacts the IS-Experts 1, 3 and 4, all directed me to the IS Expert-Elder 2:

> *Laila:* So you don't have any folk tales, any songs, any particular words that says something about am, anything about how First Nation people think about the world or think how the world works and things like that?
>
> *IS Expert-Elder 2:* I have no folk songs as I told you.
>
> *Laila:* A tale, a word, a saying, anything?
>
> *IS Expert-Elder 2:* I have some things that are written down, but what I can say to you as crude as it may sound. The elderly people used to tell us 'Don't shit in the road where you have to pass because the worse shit to put your foot in is that one'. In other words don't mess up what you need to live. This belongs to the First Nations peoples of Trinidad.

IS Expert-Elder 2's position supports concerns about the bleeding away of indigenous knowledge from First Nations communities by researchers (Tuhiwai Smith, 2008), as well as the question as to who stands to gain most from such research activity (Anderson et al., 2003). This is particularly true for the distinct First Nations Indigenous community of Trinidad whose cultural artefacts stand largely undocumented: an exceptionally attractive lure to researchers honest and unscrupulous alike.

8.5 Recommendations for Further Study

8.5.1 Continued Investigation into the Nature of Native Science

The data of this study have revealed that mentorship plays a large role in the induction of neophytes into native science suggesting that there are given methods (ways of

doing) by which it operates, and that it is these that experts teach to novices. Indeed, tribal rituals are maps of indigenous practices (Ermine, 1995). Native science's ways of doing have not been rigorously studied, or documented just yet through clear defensible methods. I hold that if native science's methods were clear and defensible then the concept of Spirit, held with high skepticism now, could become an acceptable part of the nature of reality and of the nature of mainstream science. Moreover, the methods of native science may help to solve problems presently thought intractable. Arguably, western modern science (WMS) enjoys a reputation of having one of, if not the, most clear and defensible ways/methods of thinking and knowledge creation presently available to humankind. I am deeply aware of not only the decimation, but erasure of peoples, cultures, and ways of lives by the coloniser. I am not suggesting here that WMS be a new coloniser to which IS must succumb; to whom it must prove itself a worthy knowledge system through demonstrations of how the ways through which it be, knows, and does satisfy the clarity and defensibility of western scientific thought. Instead, what I am advocating is continued research to delineate the ways by which IS creates and utilises knowledge.

8.5.2 Development of a CAS as a Methodological Framework towards the Deciphering of the Relationship between Western and Native Science

The complex adaptive system (CAS) was proposed in this research as a methodological framework and it could be worthwhile to develop the bounds of such a proposition and its abilities as a continued platform off of which dissonant, interacting sociocultural systems may be studied.

I have discussed that the everyday practices of the First Nations community within Trinidad are embedded within a Trinidadian sociocultural context and do not overtly demonstrate native science. Hence, within this study these have been gleaned through interviews with the Elders of the community. The data have revealed that native science utilises relationality, metaphysics, as well as methods of western science (e.g. empiricism, falsification, and hypodeduction) as valid paths of knowing. Even though my findings are substantiated by interview excerpts they are introductory and further work is required to make any definitive statements about the relationship between western and native science. There is need too to collect empirical data to test

native science as a complex adaptive system; within this study it is a secondary inference and did not emerge from primary data. Continued research to satisfy these recommendations could occur through the collection of long term observational data and interviews across multiple case sites of First Nations communities across the Caribbean. Firstly, these groups are the most similar to the Trinidadian population. Secondly, in Guyana and Dominica there are communities whose day to day living occurs with more integrity to First Nations ways of being, knowing, and doing than the Trinidadian group and may help to provide greater insights. Given the similarity in their science knowledge processes and constructs, Indigenous peoples outside of the Caribbean may also be worthwhile participants.

8.5.3 Review of Ethical Procedures for Indigenous Caribbean Peoples

There is need for a review of the ethics when working with Indigenous peoples to consider human rights and social justice. As a rather under-researched entity, First Nations groups of the Caribbean region are an attractive interest. There is space at this time for the development of a community-up regional ethical code for indigenous research with full participation from First Nations peoples, and based on their particular ways of being, knowing, and doing. This could help to entrench conceptions of morality within Indigenous research, authentic to indigenous ways of doing, as opposed to generic models of morality (Tuhiwai Smith, 2008). Kaupapa Maori is a similar initiative that has been ratified by, and for, the Australian Maori Nation. Such protocols within the Caribbean would give those Indigenous peoples more power and agency as to when, and how, to be open with their knowledge so that they rightfully stand as the main beneficiaries.

8.5.4 Development of Accepted Oral Research Reporting Formats

The explosion of audio, visual, and other immersive forms of digital media provides fertile ground for the development of alternative research methodologies, methods, designs, and reporting systems which can facilitate the oral traditions of Native peoples within rigorous academic work. I use an interview excerpt to justify my recommendation.

> *IS Expert-Elder 4:* The oral tradition isn't recognised and with all due respect to you, many academics don't pay attention to the oral because you can't make quotations from it. You can only quote something if it is written first. And for them to write it they get it from me through an oral tradition so that they can write it down. And then it becomes legitimised because you can now quote from a book right? And I think that is why a lot of indigenous knowledge is lost because it is dismissed as nonsense, stories and old wives tales. But we are still learning. The oral tradition is still strong.

I am advocating the development of representational models within the academy that utilise and recognise oral traditions as valid ways of making and disseminating knowledge.

8.5.5. Developing the Interview Protocol

I would like to further pilot-test the interview protocol developed in this study towards the creation of an instrument that is more portable, broadly applicable, and easy to administer. It is hoped that such an attractive instrument will encourage researches that map the understandings of indigenous science in a variety of populations, including amongst First Nations peoples, and within multicultural populations like Trinidad whose scientific practices are a complex weave of indigenous (including native) and western science.

The face of mainstream science is changing. Populations are becoming increasingly multicultural through swelling rates and routes of migration, and complex adaptive digital and non-digital interactions that occur within a global village. Scientific practice, as a socio-cultural endeavour, is sure to be influenced. The standard account of science (presently western modern science, WMS) may itself be increasingly influenced by the content and methods of other (indigenous) sciences. A hybrid instrument capable of photographing both western and indigenous science can prove very useful within multicultural spaces. The scientific practice of Trinidad actually testifies and I suppose that many postcolonial countries may be able to delineate a model by which their people have juxtaposed their native scientific beliefs alongside WMS within an elegant tapestry. George's taxonomy (1986, as cited in George, 1999) has done so for Trinidad and I believe that it indicates a theoretic inter-relating

between WMS and indigenous science waiting to be deciphered. Within Trinidad a recognition that our science is indeed a hybrid, though there is awareness of this, has not strongly influenced our pedagogy and there is urgent need to begin to understand how our students think about science, so that we can do a better job of teaching them science. A relevant instrument has the potential to help.

8.5.6 Pilot-testing and Expansion of the Mini-Curriculum via Networked and Immersive Integration.

Pilot-testing of the lessons would provide empirical data as to their efficiency and could help to guide their improvement towards achieving their stated objectives.

Moreover, there is need to further explore the technologies of the First Nations peoples to produce lessons utilising a networked or immersive model of integrating native and western science. Within a networked curriculum, the learner directs the integration process through a conscious expansion of their experiences to grow their knowledge and understanding about a particular interest (Fogarty, 1991). For example, a long held fascination with planes might see a learner forming networks with plane historians, pilots, aeronautical engineers, mechanics, airport ground crew, and so on: anyone who can feed their knowledge and fascination with the subject. Within an immersed curriculum learners filter all new information towards their developing understanding of a held position or thesis (Fogarty, 1991). For instance, this research has encouraged me the learner, to integrate ideas from varied topics including complexity theory, philosophy, and science education, to expand my understanding and explanation of my thesis statement and research questions. Networked and immersed models of integration align well with the holism, relationality, representational-technological methods, and complex adaptive model of First Nations science, and also offer strong support to curricula integrating western and indigenous sciences.

8.6 Closing remarks

Scientific minds work in clear and defensible ways and have been argued to be responsible for astronomically advancing the cause of humankind. In many ways too

science has bound us, not just because of its indiscriminate applications. There is what I see as a far bigger threat: our scientific minds that work in clear and defensible ways seem afraid to imagine; afraid to think that our clear and defensible ways may at times need revision, and are indeed only tools for our exploration. A true scientific mind is one that questions, doubts, and imagines better solutions, better ways. A true scientist I believe, must be trained to turn his/her clear and defensible thinking *onto the thinking itself* to ensure that it remains scientific; that it always honours the essence of what science is.

Native sciences have successfully served their peoples for millennia; helped them to grow, thrive, persevere and so proven to be rigorous. It has been exciting to me to find that the scientific system of native peoples in Trinidad is similar to the nature of the science of native peoples the world over as expatiated in the academic literature. Indeed, "the various Aboriginal cultural structures that have survived attest to the conviction of our progenitors and to the depth of their explorations and understanding of the cosmology of the inner world". Furthermore, "the deliberate probing of the incorporeal by tribal groups reveals similar experiences and themes in the inner space" (Ermine, 1995, p. 105). It is also recognised that local and traditional knowledge are needed to craft contextually relevant and useful scientific advice on development policy (Dickson, 2013). Even so, just as the United Nations has made declaration on the rights of Indigenous (Aboriginal) peoples (United Nations, 2008), its Millennium Development Goals (MDG's) for equity currently

> ignore the ways of life of indigenous peoples, not only in the economic sense, but also as underpinnings for:
>
> > traditional knowledge - the cognitive understandings and interpretations that constitute their intellectual life…and
> > worldview - that which shapes the unique relationship between a people, the living world that surrounds them and the space that is their territory. (Nakashima, 2010, p. 4)

The way forward cannot be 'us' and 'them', western vs indigenous science, even if so only in veiled agendas such as these. Out of this research comes a clarion call then for us scientists to move back to the truth of science. To science that is an exploration of the world; an inquisitiveness that seeks to unravel the mysteries of how the world about us works. It is such fun!

But what does ‘scientific’ mean? At its essence it is about coming to know the world around us, and I do not know if there are any scientists amongst us who will suggest that we hold infallible knowledge as to the nature of that world. Indeed, humankind has been recognised as existing in realms beyond their five senses and have been suggested in various quarters as having physical, emotional, spiritual, time-aware, and myriad other qualities. Is it unthinkable then that the world around us might also share these qualities, or demonstrate other dimensions beyond what our present instrumentation can measure? Or that indigenous/Aboriginal sciences might have a prominent role in our access to these dimensions? Indeed,

> Resolving issues from *within* the paradigm of science requires more experience and practice with elements *within* the paradigm science. But, if there is an issue about the paradigm itself, any attempt to address the issue from within the paradigm simply begs the question….Thus we are led to the conclusion that *within paradigm efforts* alone will always be insufficient for meeting the need. Our research is about understanding the resistance and finding ways to resolve it. (Cobern, 2000b, pp. 2-3)

I agree with Cobern’s (2000b) Kuhnian perspective and I advocate then for a complex adaptive science curriculum that: promotes imagination (as art and dreamwork for example); encourages students to continuously question, and verify if our current mental models are infringing on humankind’s ability to describe the world; and that provides methods for students to welcome and traverse change. Such science curricula would be flexible enough to help students participate in the growth of scientific knowledge within a rapidly changing world that needs to be pulled back from the threshold of extinction in so many spheres. This is not only the work of researchers, or professional or western or indigenous scientists; it is work for all of us. I hope then that the curricula presented here will make contribution to new methods of exploring the world in some small measure and contribute to the formation of an ethical space (Ermine, 2007) for the integration of western, native (and other types of indigenous) sciences.

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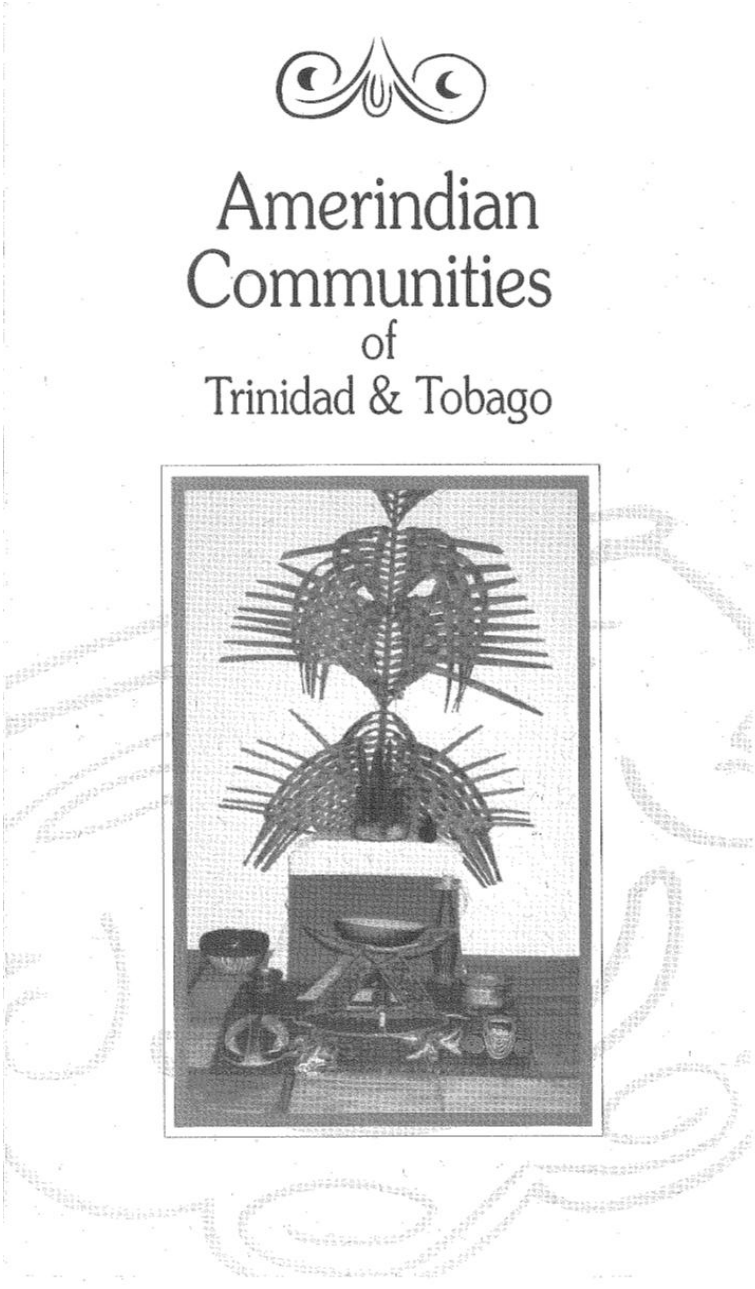
APPENDIX A

HISTORICAL INFORMATION ABOUT THE FIRST NATIONS PEOPLES OF TRINIDAD

A1: Brochure containing Historical Information about the First Peoples of Trinidad (Elie, n.d.)



The Santa Rosa Amerindian Community

Carib Queen Justa Werges
and President Ricardo Hernandez Bharath

The Santa Rosa Ameridian Community is the only organised area of Amerindian Survival in Trinidad and Tobago. They were formally recognised as representative of the Indigenous Amerindians of the twin-island state by the National Government in 1980.

Their historical continuity is remarkable. As a community they have existed since the early Spanish period, and before that archaeological and proto-historical data indicate almost 5000 years of settlement in the island. This extraordinary continuity despite the extraordinary ruptures of Spanish Conquest and Colonisation is the fundamental factor in their continuing and powerful indigenous self-identification.

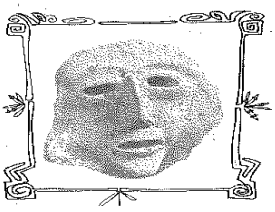
The Community consists of at least 400 members of which probably only 80 are active in its everyday life. It is urban and based in Arima. All members are identified on the basis of lineage and residence. The lineage component is the most significant marker of belonging and elders in the Community have a remarkable genealogical memory. Certain family names are associated with those of Amerindian ancestry - Boneo, Campo, Calderon, Castillo, Hernandez, Lopez, Martinez, Peña.

The Community is essentially egalitarian in its decision-making. It has always had a Council of Elders who are seen as bearers of traditional knowledge. The Council is led by the Carib Queen, presently Justa Werges, and a President, Ricardo Hernandez Bharath.

The most important event in the life of the Community is the annual celebration of the Feast of Santa Rosa de Lima, the Patronal Feast of the Parish. This event is central to the Community's sense of historical continuity and unique ethnic construction. It has been celebrated since the establishment of the mission in 1786 and in fact has the distinction of being the oldest, continuously celebrated feast in the island's history. It has its direct antecedents in the celebrations of the Patronal Feasts of the Nepuyo encomiendas which were amalgamated at the Arima Mission. These celebrations allowed indigenous spiritual and cultural elements to survive in an almost pristine form within an overtly Catholic Spanish mode. It therefore exerts a strong normative influence on the Community. The Santa Rosa Festival and the Community's central involvement in it is seen by members as the most fundamental expression of their continuing existence and survival in the face of extraordinary change. Throughout the recent history of the community it has also been the vehicle for ethnic revitalisation.

There is a body of knowledge and skill that is distinctive of the Carib Community. Their lifeways have been hispanised, but with recognisable Amerindian cultural survivals. The most important of these are the knowledge and use of indigenous flora and fauna, traditional agricultural activity, basketry, distinctive house-building skills associated with thatching and tapia, the planting and processing of cassava and to a lesser extent, maize. However, centuries of Spanish and Catholic cultural influences have also brought about cultural transformation within the Community. Consequently the Santa Rosa Caribs are also distinguished by Spanish language survival, Parang, Spanish surnames, as well as a strong and enduring Catholic belief system especially among the older generation.

Brief Historical Overview

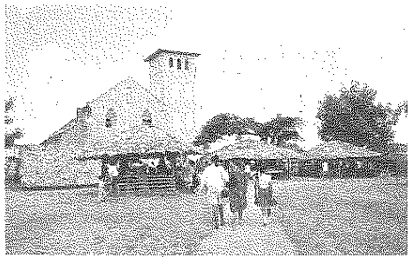


Our ancestors came to Trinidad from South America more than 7000 years ago. To them Trinidad was Caeri, meaning simply 'the Island' as distinct from the mainland which had been their original home. By the time Columbus arrived on our southern shores in 1498 there were more than 40,000 Amerindians living here. These belonged to five distinct groups: the Aruaca, Garini, Nepuyo, Shebaio and Yaio. Columbus claimed Caeri for the Spanish Crown giving it the name La Trinidad: the Trinity. This single event initiated the most violent and destructive period in our history. For almost a century Amerindians resisted the Spanish conquest of the Island. However, in 1592, the first Spanish settlement, San José de Oruña was established on the foundation of a village of the Garini chief, Goanagoanare. The cost to our ancestors of this century-long resistance was enormous: war, enslavement and migration to the safety of the South American mainland reduced the indigenous population to less than 25% of its pre-Contact levels.

The Amerindian villages in the vicinity of the new Spanish settlement were given as encomiendas to the Spanish Colonists. While the relationship between the Amerindians of the encomiendas and the Spanish encomiendaros was a very unequal one, the institution of the encomienda allowed the Amerindians to ensure their survival by preserving access to rights and resources that allowed then to maintain their ancestral way of life and social reproduction. The upheavals of the 16th century had severely and adversely affected the Amerindian economy but with the introduction of the encomiendas, the Amerindian villages entered a period of relative stability. In the late 18th century, three encomiendas still existed: the Nepuyo villages of Cuara, Arouca and Tacarigua. In 1785, the extensive and fertile ancestral lands surrounding these villages were ruthlessly taken away from the Amerindians and granted to new European immigrants. The Amerindians themselves were aggregated and relocated to Arima at the newly established Mission of Santa Rosa de Arima.

During the 64 years of the Mission's existence, the original native Amerindian population was continuously augmented by non-native Amerindians. Initially these included Caribs fleeing English persecution in the Caribbean Island of St. Vincent. These were followed by Mainland Amerindians seeking refuge from the upheavals of the Venezuelan Civil Wars. In addition, non-Amerindians were also allowed to settle in the Mission. Most of these were Spaniards both white and people of colour who owned and worked the great cacao estates surrounding the Mission. By the end of the Mission period in 1849, the original population had given rise to two closely related descendant communities. The first group, who came to be known as the Gens d'Arima, was a mixture of Amerindian, Spanish and often Negro. They continued to move away from the Amerindian core into the widening non-Amerindian population and articulated an increasingly creolised culture. However, an Amerindian core population had survived and continued to articulate an indigenous identity, supported by ongoing Amerindian immigration in the Mission period. This community had established themselves in the north of the town in what is today called Calvary. However, it was displaced when the Mission privileges were abrogated in 1849. Once again, Amerindian mission lands were lost to new settlers during the subsequent expansion of the town. The Community depended increasingly on the Mission Church which not only provided financial support, but was the only barrier against the Amerindians being evicted from their own lands. More importantly, the Church in Arima, through its annual celebration of the feast of its Patron Saint, St. Rose of Lima, provided a framework within which the Amerindian community could re-affirm its existence and its spiritual and cultural links with their indigenous ancestors.

Modern Carib Community
Development and Outreach



Part of the Carib Village erected in the Church Square Santa Rosa

The modern era of the Santa Rosa Amerindian Community began in the mid 1970s with the election of Ricardo Hernandez Bharath as President of the Council. Under his guidance the Community has aggressively pursued dual aims:-

- The preservation, revitalisation and retrieval of Amerindian traditions and the reclaiming of their history.
- The heightening of their identifiability and legitimacy as 'Amerindian' and 'Indigenous' both within the society and abroad.

Ricardo Bharath has forged a relationship with local government in Arima of which he has since become an elected member. The Community has also established ties with the state, the Catholic Church, the local and national business sector and academic institutions including the archeological centre of the University of the West Indies at St. Augustine, Trinidad. Through these ties, the Community has successfully obtained land and funding for a Community Centre. They have also established an annual programme of cultural activities with funding and support of local and national government and the business sector. At present, they are in the process of implementing plans for an Amerindian Resource and Cultural Centre.

On an international level, the Community has worked tirelessly to create links and cultural interchanges with other Amerindian groups in the Caribbean and circum-Caribbean region. They are founded members of COIP - the Caribbean Organisation of Indigenous Peoples, which also includes the indigenous organisations of Dominica, St. Vincent, Belize, Guyana and Suriname. They have also had dialogue with the First Nations of Canada, specifically the Federation of Saskatchewan Indian Nations. Subsequent to the initiation of this dialogue, a Youth Representative of the Community, Susan Campo, enjoyed a scholarship to study 'Administration and Development of Amerindian Communities' at the Federated Indian College in Regina, Saskatchewan.

From L-R Wakonax - *Member of Taino Nation*
Rose Janneire - *Former Mayor of Arima*
Ricardo Hernandez Bharath - *President of Trinidad & Tobago Carib Community*

The Community has increased its national and international exposure and has either hosted or participated at several events:-

1990 - Amerindian Heritage Week
This was a week long series of lectures exhibitions and cultural activities organised in conjunction with the Ministry of Culture and the Archaeology Centre of the University of the West Indies designed to heighten local awareness of their history and culture.

1992 - Hosted "THE FIRST GATHERING"
of indigenous people of the Caribbean at Arima which brought together participants from St. Vincent, Dominica, Guyana, Suriname with assistance and funding from the OAS.

Members of the Indigenous People

1993 - "A SECOND GATHERING" of Caribbean Indigenous Peoples was held at Arima. This gathering coincided with the bestowal on the Community by the President of the Republic of Trinidad of the Chaconia Silver Medal for its work in "Culture and Community Service".

These gatherings continued on an annual basis, but with the more specialised purpose of engaging in cultural interchanges and fostering closer personal ties.

1997 - August
With the assistance of a private organisation, Harmony in Diversity, the Santa Rosa Amerindian Community organised an inter-continental gathering of indigenous peoples at Arima. Participants came from as far afield as Australia, Puerto Rico and the United States.

Pat McLeod - *Head of Harmony in Diversity (left)*
Christo Adonis - *Member of the Carib Community (right)*

1997 - December
The Community sent a representative to the Indigenous Conference in Baracoa, Cuba, establishing links with the Amerindian Community there - Caridad de los Indios as well as re-establishing ties with the representatives of the Taino Diaspora and the Maori of New Zealand.

Other Conferences:-
Representatives (Elma Reyes) at:-

PRIMER ENCUENTRO DEL CARIBE AMERINDIO
Conference organised by the INSTITUTO INDIGENISTA INTERAMERICANO Santo Domingo, 1988.

Through these ongoing activities as well as its continued involvement in the planning and celebration of the Santa Rosa Festival at both community, church and local government level, the Santa Rosa Carib Community has highlighted and validated the Amerindian/Indigenous Cultural Sector of this Society. It has also revolutionised its image from that of an insignificant, unremarked remnant of an extinct race, to that of a major player in the cultural arena.

Arima

An Appropriate venue for Indigenous Encounter and Interchange

Arima is probably the only place in the twin island of Trinidad & Tobago that can boast of an Amerindian history that continues from Contact to the present.

HISTORICAL SURVEY

In the proto-historic period (AD 1100-1500) the entire north of the island is thought to have been occupied by the Garini or Mainland Caribs who migrated northwards from the Guiana interior. It is possible that the name Arima (or originally Hyarima) may have come into common usage at this time. In the immediate post-Contact period, the Garini occupation continues but there is considerable upheaval as Amerindian resistance to Spanish enslaving raids and attempts at settlement increases. In 1533/1534, Antonio Sedeño is at war with the combined war chief of the Garini under the cacique Bacunar. His battle is fought in the northern plains of Trinidad. Sedeño leaves the Island soon after. In the 1590s the balance of power shifts in the island. The Aruaca and Nepuyo seem to have allied with the Spanish against their traditional enemies, the Garini. The Garini are forced northwards onto the coast and hence to Tobago. Antonio de Berrio successfully establishes a settlement in St. Joseph on the site of a Garini village and takes Garini chieftains prisoner including Goanagoanare. The Nepuyo now occupy the north of Trinidad initially, with the Spanish. However many Nepuyo are still hostile to the Spanish. One of these groups inhabit the Arima valley. In 1636/1637, they are recorded as being led by the war chief Hyarima who is violently opposed to the Spanish settlement of the Island. In 1636, with the help of the Dutch in Tobago, Hyarima successfully destroys St. Joseph (the only Spanish settlement) and forces the Spaniards to abandon the Island. However, they return a couple of years later and with the help of friendly Amerindians, harass Hyarima's settlement in Arima. Many of the settlements move further north and east, while others move south of the Caroni and Aripo rivers. By 1687, the Capuchin missionaries establish San Francisco de los Arenales which may have attracted some of these northern Amerindians. In 1699, Arima is being used as a Bivouac site on the Amerindian trail from the encomiendas villages of Tacarigua and Arauca to the east coast. In 1749, there is a sufficient Amerindian presence in Arima to establish a mission, but this is short lived due to lack of funds. In 1785, the second Mission of Santa Rosa de Arima is founded with Nepuyo Amerindians of the northern encomienda whose grandparents may well have been related to Hyarima, Arima's most famous Amerindian resident. Hyarima was a runaway from one of the encomienda villages. The present-day Santa Rosa Caribs are the direct descendants of the original mission population.

Throughout the mission period, Arima attracted Amerindian immigrants from the surrounding forest and from other mission villages e.g. Sabana Grande and also from the other Caribbean Islands and the Spanish Main. Today, through the activities of the Santa Rosa Community and their President, Ricardo Hernandez Bharath, Arima has continued to be a gathering point for Amerindians from the entire circum-Caribbean region. History and tradition certainly underline its appropriateness as an indigenous meeting place.

Produced for the Santa Rosa Carib Community by The Rose Foundation

Research and Documentation - *Patrica Elie (Ethno-Historian)*
Photographs - *Patricia Elie, Ricardo Hernandez Bharath*

A2: Museum Exhibit containing Historical Information about the First Peoples of Trinidad

THE SANTA ROSA FIRST PEOPLES COMMUNITY

When Christopher Columbus arrived in Trinidad on the 31st July, 1498, our Amerindian Peoples had already lived here for six thousand (6,000) years, having already named our land 'Iere,' Land of the Hummingbird.

Our Santa Rosa First Peoples Community, formerly known as the Carib Community traces its lineage back to our first inhabitants of Trinidad. Based in Arima, our Community represents the descendants of the surviving populations of the Nepuyo encomienda villages that were amalgamated to form the Mission of Santa Rosa de Arima.

With the establishment of the Mission, land was granted to our Amerindians by the last Spanish Governor of Trinidad, Don Jose Maria Chacon, and Governor Sir Ralph Woodford. However, as the Mission gradually dissolved, these lands were seized by the State.

In May 1970, our Santa Rosa First Peoples Community was incorporated as a limited liability company. Our community set out to maintain its role in the annual Santa Rosa Festival, a celebration dedicated to Santa Rosa de Lima, the first Catholic saint canonized in the New World.

In 1991, our company changed its registration status to a Non-Governmental Organization. Today, we are a non-profit cultural and educational based organization with headquarters at 7A Paul Mitchell Street, Arima.

Today, our Community, which consists of about two hundred members, is headed by the President and Chief Ricardo Bharath Hernandez, the reigning Queen Mrs. Jennifer Cassar and Pyai Cristo Adonis. Our community is recognized by Government as the legitimate representative of Trinidad and Tobago's Indigenous people. Significant contributions have been made in championing the cause of the indigenous population.

In 1993, our community received the Chaconia Silver National Award for work in the field of culture and community service. We also lobbied successfully for the designation of October 14th 'Amerindian Day' as a day of recognition which gives special prominence to the contribution made to our nation by our ancestral people.

Today, our community continues to focus attention towards the issues of land settlement, protection of sacred rites, school curriculum revival and cultural exchanges with other indigenous people.

Our two major annual festivals are the Santa Rosa Festival and the Amerindian Heritage Day Celebrations. The Festival of Santa Rosa de Arima has special significance for both our First Peoples Community in Arima and the Catholic Church as it marks the end of hostilities between the Church and their ancestors and their acceptance of Christianity as it was taught by the Capuchin missionaries.

Started in 1786 when the new mission was formally established, the Santa Rosa Festival is the oldest continuously celebrated event in Trinidad's history, dating back to when Arima was an Amerindian Mission village. It is hailed as one of the Borough's main cultural events, one that marks Arima's special identity as an area maintaining to some degree, its Spanish, Catholic, Amerindian and Parang traditions, all intertwined.

The other major event on our community's calendar is the annual Heritage Day Celebrations which takes place during the week of October 14th. Traditionally, the activities begin with a formal launch during which all foreign and local contingents are welcomed. So far our Community has welcomed participants from Guyana, Suriname, Puerto Rico, Dominica, Venezuela, Canada, Belize and the U.S.A.

The Smoke Ceremony, deemed by many to be the most important part of the festivities, takes place on the morning of October 14th at the Hyarima Statue, a monument of the Great Nepuyo warrior chief. The ceremony is followed by a parade through the streets of Arima, a communal breakfast is shared and the high point of the festivities begins with the Amerindian Heritage Cultural Fair. This is a showcase of indigenous art and craft, games, food, interactive and cultural activities, with exhibits from various government ministries. The afternoon ends with a cultural explosion featuring our local ethnic groups and indigenous performances from visiting countries, climaxing with the ever popular live parang music.

Amerindian Heritage Day is an important historical and cultural event for the indigenous population of Trinidad and Tobago. Many aspects of our First Peoples are not known or understood and this week of events is an excellent opportunity to appreciate and recognize the contributions made by our ancestral people. The range of activities within the week of celebrations appeals to both young and mature audiences.

The twenty five acres of land in Blanchisseuse recently returned to our people also play a vital role in the preservation and survival of the cultural norms and traditional expressions of the community. Land and related resources are of fundamental importance to our indigenous peoples since they constitute the basis of our economic livelihood and are the source of our spiritual, cultural and social identity.

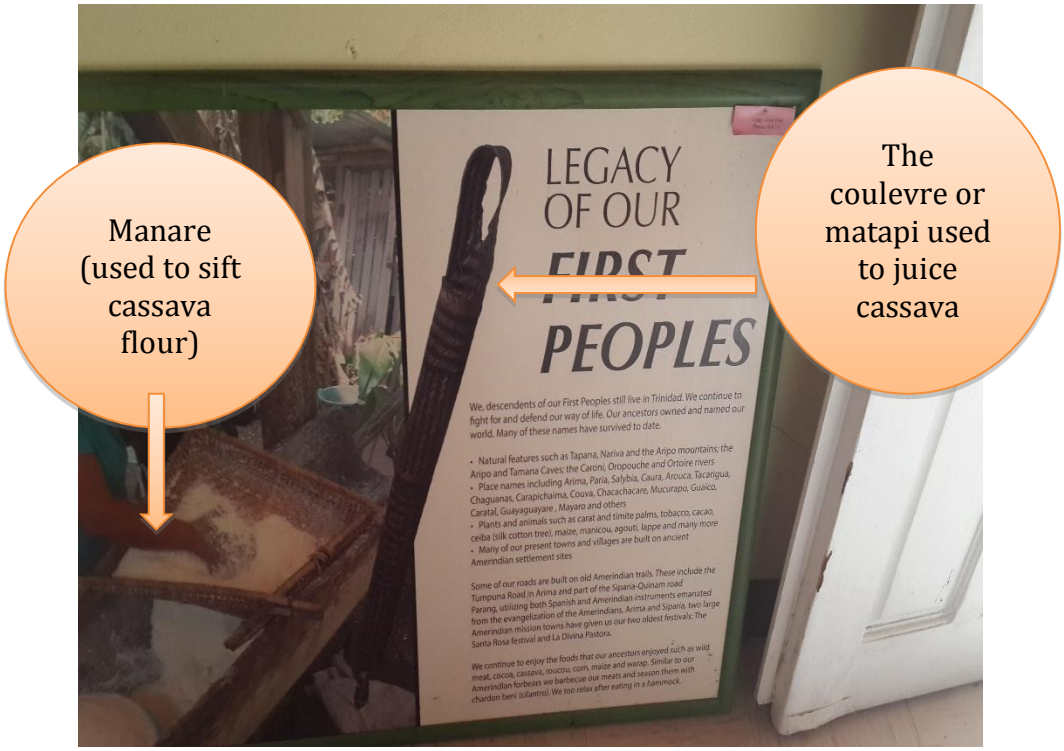
The Inter-American Court of Human Rights states that, for indigenous communities, the relationship with the land is not merely one of possession and production, but also a material and spiritual element that they should fully enjoy, as well as means through which they can preserve their cultural heritage and pass it on to future generations. Without the land and the knowledge that comes mainly from use of the land, indigenous peoples cannot survive.

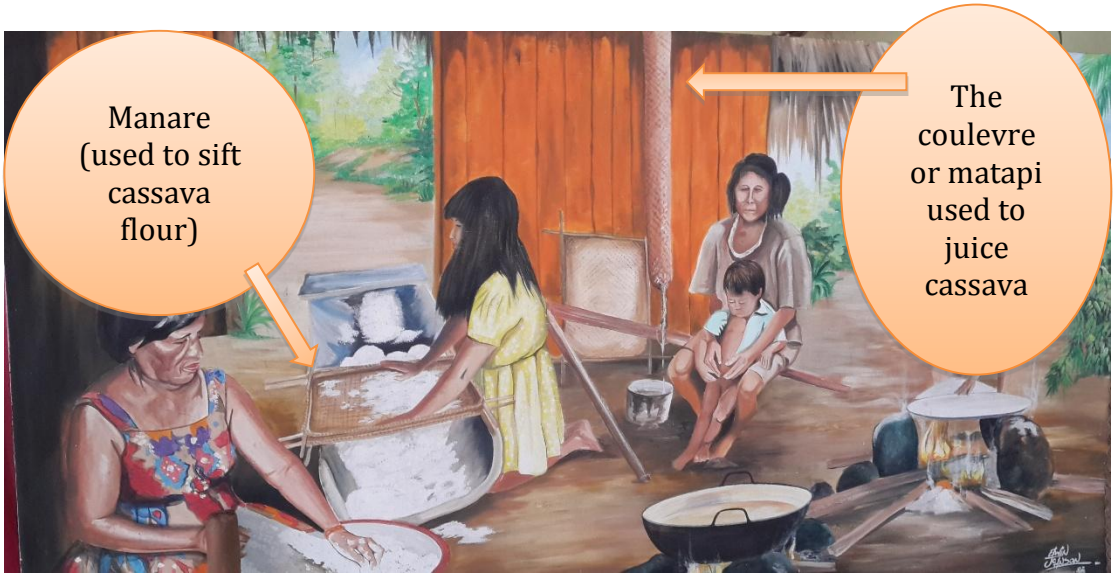
Our Santa Rosa First Peoples Community continues to intensify its efforts at promoting and supporting the recovery of our indigenous heritage by creating and disseminating in a fair environment, the cultural goods and services as well as the traditional expressions of our Amerindian People. The development of the land will further our community's goal to be a "Symbol of the Karina or Carib Way of Life."

APPENDIX B

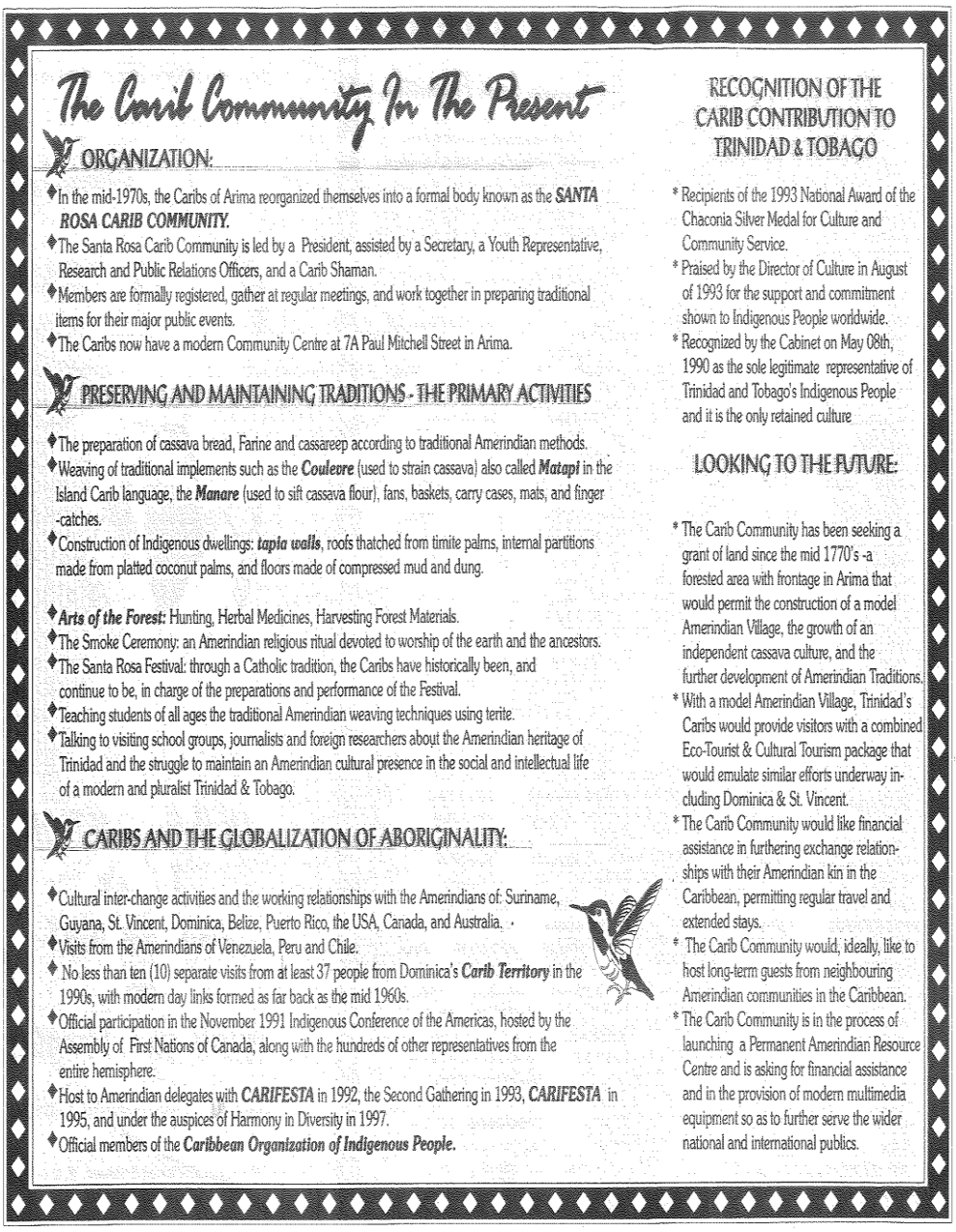
SCIENTIFIC REPRESENTATIONS/ARTEFACTS OF THE SCIENCE OF THE FIRST NATIONS PEOPLES OF TRINIDAD

B1: Pictures of the Manare and Matapi from the Museum





B2: Conversation regarding the Manare and Matapi/Coulevre from a Brochure (Auguiste, n.d.)



The Carib Community In The Present

ORGANIZATION:

- In the mid-1970s, the Caribs of Arima reorganized themselves into a formal body known as the ***SANTA ROSA CARIB COMMUNITY.***
- The Santa Rosa Carib Community is led by a President, assisted by a Secretary, a Youth Representative, Research and Public Relations Officers, and a Carib Shaman.
- Members are formally registered, gather at regular meetings, and work together in preparing traditional items for their major public events.
- The Caribs now have a modern Community Centre at 7A Paul Mitchell Street in Arima.

PRESERVING AND MAINTAINING TRADITIONS - THE PRIMARY ACTIVITIES

- The preparation of cassava bread, Farine and cassareep according to traditional Amerindian methods.
- Weaving of traditional implements such as the ***Coulevre*** (used to strain cassava) also called ***Matapi*** in the Island Carib language, the ***Manare*** (used to sift cassava flour), fans, baskets, carry cases, mats, and finger -catches.
- Construction of Indigenous dwellings: ***tapia walls***, roofs thatched from timite palms, internal partitions made from platted coconut palms, and floors made of compressed mud and dung.

- ***Arts of the Forest:*** Hunting, Herbal Medicines, Harvesting Forest Materials.
- The Smoke Ceremony: an Amerindian religious ritual devoted to worship of the earth and the ancestors.
- The Santa Rosa Festival: through a Catholic tradition, the Caribs have historically been, and continue to be, in charge of the preparations and performance of the Festival.
- Teaching students of all ages the traditional Amerindian weaving techniques using terite.
- Talking to visiting school groups, journalists and foreign researchers about the Amerindian heritage of Trinidad and the struggle to maintain an Amerindian cultural presence in the social and intellectual life of a modern and pluralist Trinidad & Tobago.

CARIBS AND THE GLOBALIZATION OF ABORIGINALITY:

- Cultural inter-change activities and the working relationships with the Amerindians of: Suriname, Guyana, St. Vincent, Dominica, Belize, Puerto Rico, the USA, Canada, and Australia.
- Visits from the Amerindians of Venezuela, Peru and Chile.
- No less than ten (10) separate visits from at least 37 people from Dominica's ***Carib Territory*** in the 1990s, with modern day links formed as far back as the mid 1960s.
- Official participation in the November 1991 Indigenous Conference of the Americas, hosted by the Assembly of First Nations of Canada, along with the hundreds of other representatives from the entire hemisphere.
- Host to Amerindian delegates with ***CARIFESTA*** in 1992, the Second Gathering in 1993, ***CARIFESTA*** in 1995, and under the auspices of Harmony in Diversity in 1997.
- Official members of the ***Caribbean Organization of Indigenous People.***

RECOGNITION OF THE CARIB CONTRIBUTION TO TRINIDAD & TOBAGO

* Recipients of the 1993 National Award of the Chaconia Silver Medal for Culture and Community Service.
* Praised by the Director of Culture in August of 1993 for the support and commitment shown to Indigenous People worldwide.
* Recognized by the Cabinet on May 08th, 1990 as the sole legitimate representative of Trinidad and Tobago's Indigenous People and it is the only retained culture

LOOKING TO THE FUTURE:

* The Carib Community has been seeking a grant of land since the mid 1770's -a forested area with frontage in Arima that would permit the construction of a model Amerindian Village, the growth of an independent cassava culture, and the further development of Amerindian Traditions.
* With a model Amerindian Village, Trinidad's Caribs would provide visitors with a combined Eco-Tourist & Cultural Tourism package that would emulate similar efforts underway including Dominica & St. Vincent.
* The Carib Community would like financial assistance in furthering exchange relationships with their Amerindian kin in the Caribbean, permitting regular travel and extended stays.
* The Carib Community would, ideally, like to host long-term guests from neighbouring Amerindian communities in the Caribbean.
* The Carib Community is in the process of launching a Permanent Amerindian Resource Centre and is asking for financial assistance and in the provision of modern multimedia equipment so as to further serve the wider national and international publics.

B3: Museum Exhibit on Sustainable Planting

(text describes how a fish is placed in the hole before the plant; and a picture of a fishpot)

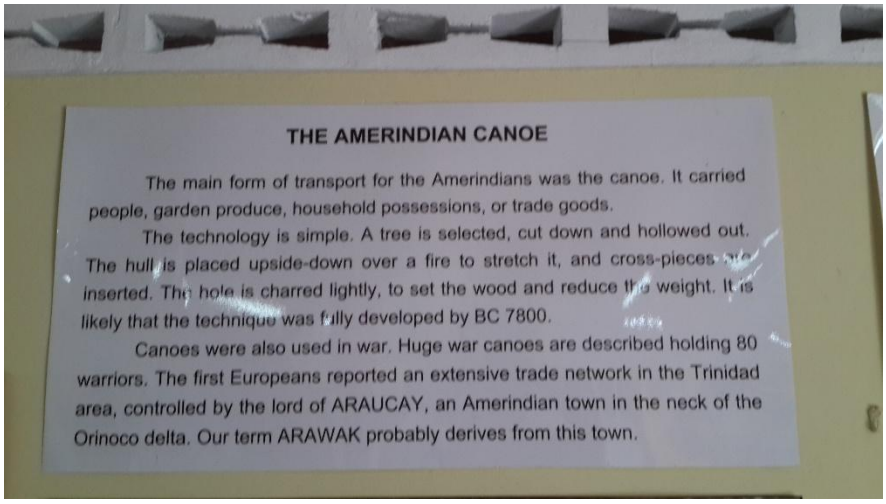
The text reads:

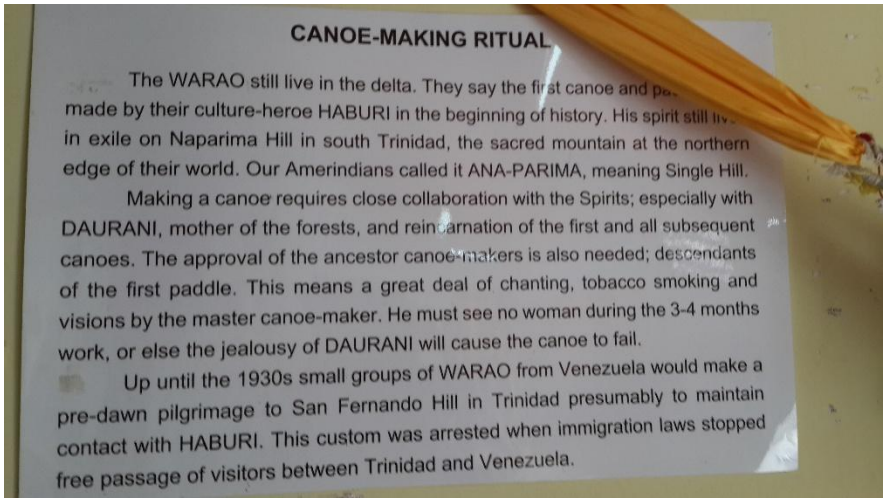
> Environmentally Sustainable Practices of Our Indigenous Peoples
>
> Our Indigenous Peoples have always co-exited with the land and all life that share in its bounty.
>
> So close was our Indigenous People's affinity to the land that there are accounts of such practices one of which was the placing of a fish into each hole dug for planting corn, beans, or watermelons. The fish was compensation to Mother Earth for having disturbed her in the necessary activity of planting the soil.

By such environmentally sustainable practices our Indigenous People ensured continuous production over the thousands of years of their life before the coming of the Europeans. As the conquistadores changed these patterns, food security became a huge issue. The sacred attachment to the land was severely challenged.

Today we, like our ancestors, have managed to maintain a harmonious relationship with the land. Ironically, modern day peoples are now consulting and working with us in the promotion of practices that will benefit the earth and its dependents in the future.

B4: Canoe Building Museum Exhibit Demonstrates Spirituality in First Nations Science





APPENDIX C

MAIN INTERVIEW PROTOCOL AND ADAPTATIONS

C1: Table Showing Final Semi-structured Interview Protocol

Question No.	Question
1 and 2	• Can you tell me about your First Nation Ancestry? • What is the name that your people call themselves?
3	• Which are the most important roles in your society? • What are the roles of the chief, the queen, the medicine man in your society? What is their hierarchy? • Can you tell me about your emblem? (see Appendix D) • Can you tell me which Nations were represented at the First Nations Week of celebrations for this calendar year?
4	• What is your background in western modern science (school science)? • What do you think is western/school science (just in general terms)?
5	It is said that science is the study of the natural world around us and how it works. What is the closest word for 'science' in your language and what does it mean? • What is science in First Nations terms? • What does your First Nations heritage say of that? • What does your First Nations heritage say about this 'world around us' and where it is? • How does your First Nations heritage say that one can learn about that world?

C1: Table Showing Final Semi-structured Interview Protocol (continued)

Question No.	Question
6	In Chichen Itza, the Mayan city in Mexico, the astronomers stood in a room all day and night looking through a slit in the roof observing the heavens. This is how they came up with the Mayan calendar which has proven itself to be an extremely accurate way of measuring time. So in Chichen Itza there were people who did different jobs (e.g., the astronomer). Do you know if there were amongst your First Nations peoples, special classes of scientific knowledge (e.g., Math etc.). Can you tell me what these were? • Were there special people responsible for gathering certain kinds of knowledge in your community? • Can you tell me of any particular methods, and generally too, about how your people studied the world around them? • How do your people 'measure' the world? • How do your people come to know about how nature and the world around them works?
7	• Can you identify the names of the most important folk tales of your people that talk about your science/ how the world works? • Do any of these folk tales talk about how the world was formed or how the world works? If yes, can you tell/relate that/those particular folktale(s) to me? • How did young people learn a. folk tales? b. how to make the canoe, cassava, medicines? • How were these recorded? • How have story, song and ceremony been used to depict the world around you? • What's your favourite word, story, saying or song (from the First Nations) that describes a) the world and how it works? b) humankind's place in the functioning/working of the world? • Tell me about how and why your people go (get information from) inside (or inner space) in order to understand the world around them? • Would you be willing to share one of your sacred prayers that talks about how the world works and man's place in it?
8	• Where do your people believe that knowledge comes from? • Can you finish this sentence for me? "Everything in the world is about…….science is about……?"

C1: Table Showing Final Semi-structured Interview Protocol (continued)

Question No.	Question
9	• How does one become an expert about how the world works, say like your pyai or chief? • Within First Nation communities, who is/was responsible for a. collecting b. taking care of c. and passing on to the less experienced members of the community knowledge about how the world works (i.e., scientific knowledge)? • How was the other knowledge of the community taught to members earlier in history, and now? • How are the chief, the queen and the medicine man chosen? • What are the roles of the chief, the queen, the medicine man a. in knowledge making, knowledge preservation and knowledge dissemination to the community?
10	• Tell me about how each of the following is made (please describe any sacred or everyday rituals that might accompany them): vii. Canoe viii. Cassava farine and cassareep ix. the drums x. medicine xi. blow darts xii. cloth from the plant
11	• How do you think the scientific ways of being, knowing, and doing of indigenous regional peoples can be/should be used within school curricula and why?
12	• How is indigenous scientific knowledge validated? • What is good science and bad science for Indigenous people?
13	• Is there anything else you think that I should know?

C2: Adaptations Made to Arrive at the Final Semi-Structured Interview Protocol

1. Re-wording question 8 so that it was less leading

> *old question*: "Do you have different types of knowledge? Like scientific knowledge; and religious knowledge?
> *revised question*: "Can you finish this sentence for me? 'Everything in the world is about……..science is about……..'"

2. Re-wording of question 4 to remove my bias surrounding the term 'science' used on its own without descriptor as representing western modern. I have also included the term 'school' to help participants to understand what western science looks like by making it relevant to their experiences.

> *old question:* "What do you think is science (just in general terms)?"
> *revised question*: "What do you think is western/school science (just in general terms?"

3. Question 13 initially read:

> "How is scientific knowledge validated?"

but during the first interview I found difficulty phrasing the question so that it would be understood by a lay-scientist. To do so I adjusted the question during interview to:

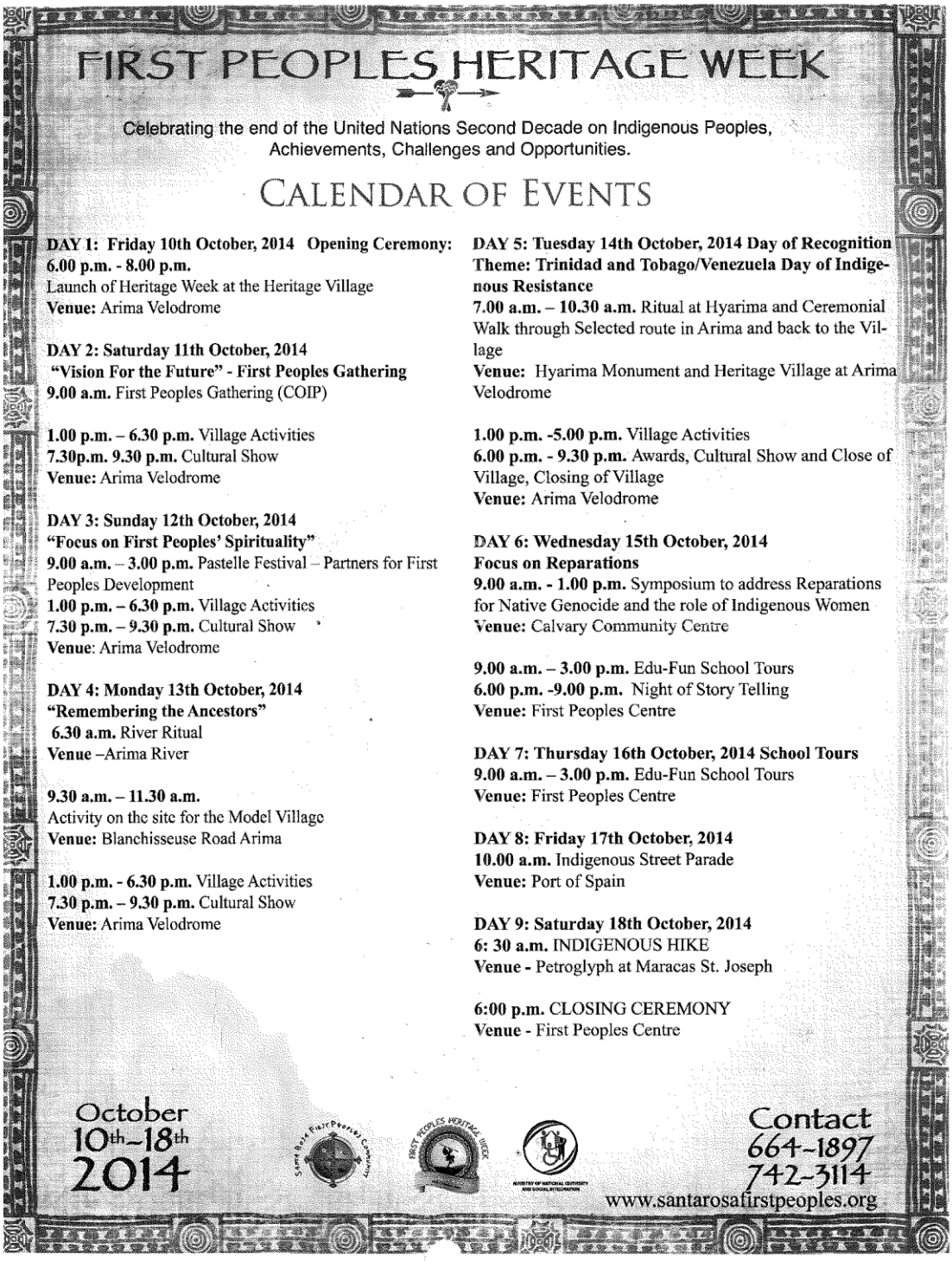
> "What is good science and bad science for Indigenous people?"

APPENDIX D

LOGO OF THE FIRST NATIONS PEOPLES OF TRINIDAD

APPENDIX E

FLYER FOR THE ANNUAL FIRST NATIONS HERITAGE WEEK 2014



FIRST PEOPLES HERITAGE WEEK

Celebrating the end of the United Nations Second Decade on Indigenous Peoples, Achievements, Challenges and Opportunities.

CALENDAR OF EVENTS

DAY 1: Friday 10th October, 2014 Opening Ceremony:
6.00 p.m. - 8.00 p.m.
Launch of Heritage Week at the Heritage Village
Venue: Arima Velodrome

DAY 2: Saturday 11th October, 2014
"Vision For the Future" - First Peoples Gathering
9.00 a.m. First Peoples Gathering (COIP)

1.00 p.m. – 6.30 p.m. Village Activities
7.30p.m. 9.30 p.m. Cultural Show
Venue: Arima Velodrome

DAY 3: Sunday 12th October, 2014
"Focus on First Peoples' Spirituality"
9.00 a.m. – 3.00 p.m. Pastelle Festival – Partners for First Peoples Development
1.00 p.m. – 6.30 p.m. Village Activities
7.30 p.m. – 9.30 p.m. Cultural Show
Venue: Arima Velodrome

DAY 4: Monday 13th October, 2014
"Remembering the Ancestors"
6.30 a.m. River Ritual
Venue –Arima River

9.30 a.m. – 11.30 a.m.
Activity on the site for the Model Village
Venue: Blanchisseuse Road Arima

1.00 p.m. - 6.30 p.m. Village Activities
7.30 p.m. – 9.30 p.m. Cultural Show
Venue: Arima Velodrome

DAY 5: Tuesday 14th October, 2014 Day of Recognition
Theme: Trinidad and Tobago/Venezuela Day of Indigenous Resistance
7.00 a.m. – 10.30 a.m. Ritual at Hyarima and Ceremonial Walk through Selected route in Arima and back to the Village
Venue: Hyarima Monument and Heritage Village at Arima Velodrome

1.00 p.m. -5.00 p.m. Village Activities
6.00 p.m. - 9.30 p.m. Awards, Cultural Show and Close of Village, Closing of Village
Venue: Arima Velodrome

DAY 6: Wednesday 15th October, 2014
Focus on Reparations
9.00 a.m. - 1.00 p.m. Symposium to address Reparations for Native Genocide and the role of Indigenous Women
Venue: Calvary Community Centre

9.00 a.m. – 3.00 p.m. Edu-Fun School Tours
6.00 p.m. -9.00 p.m. Night of Story Telling
Venue: First Peoples Centre

DAY 7: Thursday 16th October, 2014 School Tours
9.00 a.m. – 3.00 p.m. Edu-Fun School Tours
Venue: First Peoples Centre

DAY 8: Friday 17th October, 2014
10.00 a.m. Indigenous Street Parade
Venue: Port of Spain

DAY 9: Saturday 18th October, 2014
6: 30 a.m. INDIGENOUS HIKE
Venue - Petroglyph at Maracas St. Joseph

6:00 p.m. CLOSING CEREMONY
Venue - First Peoples Centre

October 10th–18th 2014

Contact
664-1897
742-3114
www.santarosafirstpeoples.org

APPENDIX F

GAINING ACCESS

F1: The River Ritual

F2: Eagle (because he does the Eagle dance) and Me at the River Ritual

F3: The Pyai Performing a Smoke Ceremony on the Caurita Petroglyph

F4: Laila (Me) at the Caurita Petroglyph

APPENDIX G

INSTRUCTION LETTER FOR RESPONDENTS INTERVIEWED VIA EMAIL

Dear Colleague,

I am using expert opinion/interview to develop the literature review of my EdD thesis and I am kindly requesting your assistance through your response to ONE question. This should take you just about 15-20 minutes and can be returned to me via email at your convenience. There is no need for us to meet.

Please find the relevant ethical approval for this study attached including the information sheet that tells you all about the study; the final approval letter; and the consent form. If you decide to participate please sign the consent form and return either a soft or hard copy with your signature to me or I can collect it at your convenience.

Presently I am developing a definition of science. I would appreciate if you can answer one question:

1. What is science?

Please also indicate your background in science and science education, including teaching experiences, held qualifications and where they were obtained (this helps to give some insight into the contextual factors that may have impacted your definition).

If you wish to recommend any extant literature to me that would be great! However, within this exercise I am looking for your PERSONAL definition of science.

If you need any clarification as to this request, whether or not you choose to participate, please contact me at will. Thanks for your consideration of this request.

APPENDIX H

LETTER OF CONSENT AND RESEARCH INFORMATION SHEET

H1: Letter of Consent

Title of the Research Project:

Blue Crab Does Run Full-Moon: An Exploration into the Science of the First Nation People of Trinidad.

Name of Researcher: Laila Nadina Boisselle

Participant Identification Number for this Project:_____

If you agree to participate in this study, please place your initial or identifying mark in each box in the rightmost column.

1.	I confirm that I have read and understand the information sheet dated……. explaining the above research project and that I have had the opportunity to ask questions about the project	
2.	I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. Contact number for the Principal researcher is: 1-868-794-7288 email is: boissellelaila@gmail.com	
3.	I understand that my responses will be anonymised before analysis. I give permission for members of the research team to have access to my anonymised responses.	
4.	I agree to take part in the above research project.	

_____	_____	_____
Name of Participant (or legal representative) **in block letters**	Date	Signature

_____	_____	_____
Lead Researcher **in block letters**	Date	Signature

To be signed and dated in presence of the participant

Copies:
Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy for the signed and dated consent form will be placed in the project's main record (e.g. a site file), and be kept in a secure location.

H2: Information Sheet

date:_____

1. Research Project Title:

Blue Crab Does Run Full-Moon: An Exploration into the Science of the First Nation People of the Caribbean.

2. Invitation

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

3. What is the project's purpose?

Very little work has been done on the scientific beliefs and practices of our First Nation people of the Caribbean. These beliefs and practices are a valuable piece of our region's heritage and of my own heritage as a First Nation descendant. This research is an exploration into how the First Nation people of the Caribbean do and make science. The study hopes to begin to map and catalogue the ways in which the First Nation people do and make science (as well as its possible applicability to science curricula of the region.) That is:

a) what is the content of their sciences?

b) how is such content developed?

c) how is this content and the ways by which it is developed shared among members within their community?

c) how can these scientific practices be applied to existing regional science curricula?

To answer these research questions I hope to analyse films and documents of the important ceremonies and practices of the First Peoples. I also intend to interview

experts on, and various members of, our First Nation community alongside experts on science education. I will be collecting data over an initial two month period. I will only need to meet with you once or twice over that period. However, if you are a key actor (for example the Chief, Queen or Medicine man of the First People), I may need to meet with you on more than one occasion. After the first two months of data collection have ended I may also have to return to ask you a few more questions if I need help to better understand some of the experiences that you have shared with me.

4. Why have I been chosen?

You have been chosen because you have specialist knowledge of the practices and beliefs of the First Nation people of the Caribbean region or of science and science education.

5. Do I have to take part?

It is your choice to take part in this study or not. If you do decide to take part then you will be required to sign a consent form and to keep this information sheet in a safe place. Even if you decide to participate and sign the consent form you can still withdraw from the study at anytime and no longer participate. You do not have to give a reason.

6. What will happen to me if I take part?

If you agree to take part you may be filmed, interviewed, and audio recorded (maybe more than once and on different days). Film or audio-recording will be used to tape any interviews. Sometimes I may be making unfilmed or unrecorded observations about the activities of the community and its members which will be noted in my diary. The experiences that you share with me will be put into my doctoral thesis. Any audio and/or video recordings of your activities made during this research will be used only for analysis and for illustration in conference presentations and lectures. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recordings. Any period for interview or filming should last about 45 minutes to 1 hour. When I am doing observations of the wider community I may be on site all day. If I need you to help me to better understand the things that you have shared with me I may ask you to

spend a little more time doing so at a later date. If this happens I will certainly ask you beforehand.

7. What are the possible benefits of taking part?

Whilst there are no immediate benefits for those people participating in the project, the science of the First Nation people of our region is an important part of our heritage. I hope that in some small way, that this project can help to preserve that heritage. Moreover, there is a marked divorce in the practice of indigenous science of the region from school science. There is also a simultaneous decline in interest in the pursuit of school science. The study also hopes then to suggest how our regional indigenous science might be married with school science curricula to make school science more relevant and possibly attractive to our students.

8. What are the possible disadvantages and risks of taking part?

There are no foreseeable discomforts, disadvantages or risks in taking part. If any of these should arise during the re-search I will bring it immediately to your attention.

9. Will my taking part in this project be kept confidential?

All of the information that I collect from you during the course of the research will be kept strictly confidential. Your identity will be represented throughout the project by your "participant identification number", no names will be used. As a participant any information that you have given to me will not be able to be identified in any reports or publications as having come from you. All of the interview data that you give will be held anonymously. The audio and/or video recordings of your activities made during this research will be used only for analysis and for illustration in conference presentations and lectures. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recordings. However, the location of the First People communities and the identity of expert key respondents will also be retained in the final report.

10. What will happen to the results of the research project?

The data will be used for my Ed. D thesis initially but might also be used for additional or subsequent research. Confidentiality of all information will be

maintained as previously described. The First Nation communities that are involved will be presented with a copy of my thesis upon its completion.

11. Who has ethically reviewed the project?

This project has been ethically approved via the University of Sheffield, School of Education's ethics review procedure. If for any reason you wish to ask questions or raise a complaint please contact me at boissellelaila@gmail.com My telephone number is 1-868-794-7288. You can also contact my supervisors Dr. Andrew Mc Lean or Professor Jeremy Wellington at any time to discuss any concerns that you have about our work together. Dr. Mc Lean is my primary supervisor and his email address is a.mclean@sheffield.ac.uk Professor Wellington is my secondary supervisor and his email address is j.wellington@sheffield.ac.uk If you feel that you need further redress you can contact the University of Sheffield's "Registrar and Secretary" at registrar@sheffield.ac.uk The current "Registrar and Secretary" is Mr. Phillip Harvey.

I want to take this opportunity to thank you for taking time to read this information sheet and for considering participation in this re-search. I also want to thank you for your assistance. If you do agree to participate you will receive a copy of the ethical clearance to do this project, a copy of this information sheet, and a copy of the consent form which you have signed

Kind regards,

……..

Laila Nadina Boisselle
University of Sheffield Reg. # 110273633
boissellelaila@gmail.com
1-868-794-7288

APPENDIX I

EXAMPLES OF TEACHING RESOURCES

I1: The mechanism by which an anaconda digests its prey
(Kiera, 2011)

I2: Overfishing and its Consequences
(reproduced from TED-ED Lessons Worth Sharing, n.d.)

Overfishing is the depletion of a stock of fish (in a body of water) by too much fishing. Many people are unaware of the scary facts behind the fish we eat. This animation creates much needed awareness about the ocean's most solvable problem while reminding us that we all have a role to play in fixing it.

Solving the overfishing problem requires governments to listen to advice from scientists. The quotas for fish stocks should be related to sustainable yields. To learn more about sustainable fisheries read
this http://en.wikipedia.org/wiki/Sustainable_fishery

Want to know more about overfishing? Check out this website http://overfishing.org/

The ocean is full of incredible creatures that have had to adapt to the changes we humans have made in their homes in order to survive. To learn more about a unique population of blue whales in a country where 66% of the population depend on fish for protein, and to learn of the problems they face due to human action, explore this website http://whalessrilanka.blogspot.com

Watch this video by eminent scientist Dr. Jeremy Jackson to learn more about the shocking state of our oceans today: http://www.ted.com/talks/jeremy_jackson.html

With fish stocks in the state they are in today, chefs around the world are faced with a big dilemma, how to keep fish on the menu without contributing to the increased decimation of current stocks. Chef Dan Barber tells the story of "an outrageously delicious fish raised using a revolutionary farming method in Spain."
http://www.ted.com/talks/lang/en/dan_barber_how_i_fell_in_love_with_a_fish.html

To learn more about how overfishing is changing the world and what we eat, watch the eye-opening documentary "The End of the Line".

Next Section »

About TED-Ed Selects

TED-Ed Selects are exceptional, user-created lessons that are carefully selected by volunteer teachers and TED-Ed staff.

Meet The Creators

Asha de Vos

Lesson Creator

OCEAN2012EU

Video Source

I3: How to Make an Amerindian Fish Pot

(Junglecrafty, 2012)

I4: Garlic as a Medicine
(reproduced from Memorial Sloan Kettering Cancer Center, 2016a)

Common Names	**Purported Uses**
• nectar of the gods • camphor of the poor • da-suan • la-suan • stinking rose	• To fight skin infections • Laboratory studies show that raw garlic has antibacterial, antiviral, antiparasitic, and antifungal activity • To prevent and treat cancer • A few clinical trials suggest that high garlic consumption may lower the risk of stomach and colorectal cancers. But a recent study did not find such benefit • To treat heart disease • Several clinical trials show that use of garlic supplements reduces cholesterol and triglyceride levels in the blood, which may reduce the risk of heart disease, but a handful of clinical trials contradict these findings. Clinical trials studying the effect of garlic on blood pressure and risk of heart disease have shown mixed results • As an antioxidant • No scientific evidence supports this use • To treat atherosclerosis • Several clinical trials show that use of garlic supplements reduces blood pressure as well as cholesterol and triglyceride blood levels, which are risk factors for developing atherosclerosis, but a handful of clinical trials contradict these findings. Clinical and laboratory studies support garlic's antiplatelet activity, which may help prevent blood clots in patients with atherosclerosis • To lower high cholesterol • Several clinical trials show that use of garlic supplements reduces cholesterol and triglyceride levels in the blood, but some clinical trials contradict these findings • To lower high blood pressure • Clinical trials studying the effects of garlic on blood pressure have shown mixed results • To treat circulatory disorders • Clinical and laboratory studies support garlic's antiplatelet activity, which may help prevent blood clots in patients with circulatory disorders
Scientific Name Allium sativum	
Patient Warnings Garlic supplements should be discontinued a week or two before undergoing surgery because of their potential for increasing bleeding time	

I4: Garlic as a Medicine (continued)
(reproduced from Memorial Sloan Kettering Cancer Center, 2016a)

Side Effects	**Do Not Take If**
• Headache • Fatigue • Altered platelet function with potential for bleeding • Offensive odor, bad breath • Stomach upset • Diarrhea • Changes in the natural bacteria found in the intestines • Sweating • Low blood sugar • Contact dermatitis (inflammation, redness of the skin) when used topically. • Following excessive use of garlic supplements, one patient experienced prolonged bleeding time, diminished platelet blood clotting activity, and spinal epidural hematoma (collection of blood in the spinal canal). • A 51-year-old man developed renal hematoma after extracorporeal shock-wave lithotripsy (SWL) that occurred due to excessive odorless garlic ingestion. He was treated with antibiotics and fluids. His hematoma went into remission after five months. • Chemical burn of oral mucosa has been reported following consumption of crushed garlic. • Two episodes of severe, near-fatal anaphylaxis were reported in a 52-year-old man following ingestion of garlic. • Topical application of garlic to treat a facial wart resulted in a burn in a 23-year-old woman. • Topical application of garlic and salt paste under occlusion caused a severe chemical burn in a 41-year-old man. His symptoms resolved after treatment and discontinuation of garlic use. • Use of an external garlic poultice for toothache resulted in significant chemical burn to the face. • An unusual garlic burn was reported on the neck of a patient, following application of crushed raw garlic to address symptoms of a sore throat.	• You are taking warfarin or other blood thinners (Garlic may increase the risk of bleeding or bruising). • You take cyclosporine (Garlic can reduce its effectiveness and potentially cause transplant rejection). • You take protease inhibitors such as saquinavir (Fortovase®, Invirase®) (Garlic can significantly reduce their levels in the blood and reduce their effectiveness). • You are taking insulin (Dose adjustments may be required because of the occasional blood sugar-lowering effect of garlic supplements. Take with caution and consult your doctor). • If you are taking drugs that are substrates of Cytochrome P450 2C9, 2C19, 3A4 (Garlic may increase the risk of side effects of these drugs). • If you are taking drugs that are substrates of P-Glycoprotein (Garlic may reduce the activity of such drugs).

I4: Garlic as a Medicine (continued)
(reproduced from Memorial Sloan Kettering Cancer Center, 2016)

How it Works	Mechanism of Action
Garlic was shown to lower blood cholesterol and triglyceride levels. It is associated with decreased risk of some cancers, but there is no evidence that it can treat cancer. Raw garlic contains compounds called alliin and allicin. In laboratory studies, these compounds and their breakdown products have been found to kill bacteria directly, reduce the number of platelets in the blood and slow clotting, and reduce the level of lipids in the blood. Compounds called ajoenes are also responsible for garlic's ability to prevent blood clots. Garlic may also reduce blood pressure. Garlic intake may protect against certain cancers possibly by decreasing tumor cell growth or stimulating the immune system. Processing can have a significant effect on the amount of active compounds in garlic: Garlic powder and garlic essential oil do not contain allicin or ajoene, compounds believed to be responsible for garlic's cholesterol-reducing and blood-thinning properties. Because garlic has blood thinning property, patients taking warfarin or other blood thinners should ask their doctor before taking garlic supplements.	The intact cells of garlic contain an odorless, sulfur-containing amino acid derivative known as alliin. When the cells are crushed, alliin comes into contact with the enzyme alliinase located in neighboring cells and is converted to allicin. Allicin is a potent antibiotic, but it is highly odoriferous and unstable. It is described as possessing antiplatelet, antibiotic, and antihyperlipidemic activities. Most authorities agree that the best measure of the total activity of garlic is its ability to produce allicin, which, in turn, results in the formation of other active constituents. In patients with hyperlipidemia, garlic might lower cholesterol levels by acting as an HMG-CoA reductase inhibitor. For atherosclerosis, garlic is believed to reduce oxidative stress and low-density lipoprotein oxidation and have antithrombotic effects. It is also thought to reduce blood pressure by causing smooth muscle relaxation and vasodilation by activating the production of endothelium-derived relaxation factor. Garlic may stimulate both humoral and cellular immunity, causing T-cell proliferation, restoring suppressed antibody responses, and stimulating macrophage cytotoxicity on tumor cells. It may increase selenium absorption with possible protection against tumorigenesis. In addition, garlic may protect against certain cancers by halting cell cycle progression and inducing apoptosis of cancer cells as well as by decreasing angiogenesis and influencing carcinogen metabolism.

I4: Garlic as a Medicine (continued)
(reproduced from Memorial Sloan Kettering Cancer Center, 2016a)

Clinical Summary

Derived from the bulb or clove of the plant, garlic is used as a spice and to treat hyperlipidemia, hypertension, atherosclerosis, cancer, and infections. Because processing can have a substantial effect on the chemical content of garlic (the volatile oil components are sensitive to heat and certain enzymes are acid-labile), the best measure of the total activity of garlic is its ability to produce allicin, which in turn, results in the formation of other active constituents. Several oral garlic formulations are available, and clinical studies have addressed a variety of the proposed claims.

Placebo-controlled trials on the cholesterol lowering effect of garlic yielded mixed results, but a systematic review showed that garlic is effective in lowering total cholesterol and LDL cholesterol levels. Studies evaluating the antithrombotic effects repeatedly show modest reduction in platelet aggregation, but varying levels of fibrinolytic activity; and mixed effects with regard to reductions in blood glucose, blood pressure, or risk of cardiovascular disease. However, according to a meta analysis, there is consistent evidence to support use of garlic in lowering cardiovascular risk factors. Garlic supplementation may also benefit patients with hepatopulmonary syndrome.

More data are needed to determine if garlic is effective against common cold and vaginal candidiasis. Whether garlic is effective in reducing the risk of mortality and cardiovascular morbidity in patients diagnosed with hypertension is inconclusive.

An analysis of several case-controlled studies in Europe suggests an inverse association between garlic consumption and risk of common cancers. High intake of garlic may be protective against gastric and colorectal cancers; however, conflicting data indicate that long-term supplementation with garlic does not significantly reduce gastric cancer incidence nor mortality. Garlic intake was inversely associated with cancer of the prostate and endometrium. In patients with advanced cancers, aged garlic extract (AGE) improved natural killer (NK) cell number and activity, but not quality of life. In patients with a history of adenomas, supplementation with AGE reduced both the number and size of subsequent colorectal adenomas. Garlic supplementation may also be associated with reduced risk of hematologic malignancies.

Because garlic is known to decrease platelet aggregation and potentially elevate International Normalized Ratio (INR) values, it should not be used with anticoagulants or in patients with platelet dysfunction.

I5: Soursop (Graviola) as a Medicine
(reproduced from Memorial Sloan Kettering Cancer Center, 2016b)

<table>
<tr>
<td>Common Names

• Guanabana
• Soursop
• Custard apple
• Brazilian paw paw</td>
<td>Purported Uses

• Cancer treatment
• Herpes
• Infections
• Parasitic infections
• Sedation</td>
</tr>
<tr>
<td>Scientific name

Annona muricata</td>
<td>Side Effects

• Movement disorders and myeloneuropathy (neuropathy that affects the myelin sheath), with symptoms similar to those of Parkinson’s disease.
• Repeated use may increase liver and kidney toxicity.</td>
</tr>
<tr>
<td>Patient Warnings

None were listed</td>
<td>Do Not Take If

• You are taking blood pressure medications: Graviola may increase their effects.
• You are taking diabetic medications: Graviola may increase their effects.
You have liver or kidney disease: Graviola can cause liver and kidney toxicity with repeated use.
• You are having nuclear imaging: Graviola can reduce tissue uptake of radiopharmaceuticals used for diagnosis or treatment.
• You have low platelet count: Graviola may reduce platelet count.</td>
</tr>
</table>

I5: Soursop (Graviola) as a Medicine (continued)

(reproduced fromMemorial Sloan Kettering Cancer Center, 2016b)

How It Works	**Mechanism of Action**
Graviola showed anticancer effects in lab studies. Human data are lacking. Extracts of graviola have been shown to be effective against a number of viruses, bacteria, and parasites in test tubes. Laboratory studies have also shown graviola to be effective against some types of cancer cells. It contains chemicals called acetogenins, which are thought to be the active ingredient. However, substances derived from graviola can damage nerve cells and cause neurological side effects similar to Parkinson's disease. Graviola may also affect nuclear imaging because it has been shown to decrease the uptake of radiopharmaceuticals used in such procedures.	Annonaceous acetogenins, phytochemicals isolated from the leaves, bark, and twigs, are thought to be the active ingredients of graviola. An ethanolic extract of *A. muricata* shows in vitro antiviral activity against the Herpes simplex virus, and antimicrobial activity against *Leishmania*. Alkaloids from graviola are detrimental to the survival of dopaminergic nerve cells in vitro. This may result in neuronal dysfunction and degeneration. Graviola-induced cell death was inhibited by glucose supplementation suggesting that cell death may have been caused by energy depletion. Graviola has also been shown to stimulate serotonin receptors. An ethanolic extract produced cell-stimulating behaviors either by increased mitochondrial turnover indicating stimulation in protein production or by preparation to leave the G1 phase, perhaps due to promitotic stimulus present within the extract which acts like a growth factor. In animal models, antidiabetic effects are due to antioxidant, hypolipidemic, and protective effects in pancreatic beta-cells, which improves glucose metabolism. Graviola extract demonstrated antiulcer effects by increasing nitric oxide and prostaglandin E2 activities. Graviola fruit extract has anti-inflammatory and analgesic actions by inhibiting cyclooxygenase (COX)-1 and COX-2 and by blocking opioid receptors. Graviola extracts were effective against adriamycin-resistant human mammary adenocarcinoma (MCF-7/Adr) by blocking access of cancer cells to ATP and by inhibiting the actions of plasma membrane glycoprotein. They also inhibited expression of HIF-1α, NF-κB, glucose transporters, and glycolytic enzymes resulting in decreased glucose uptake and ATP production in pancreatic cancer cells, and downregulated EGFR expression in breast cancer cells.

I5: Soursop (Graviola) as a Medicine (continued)

(reproduced from Memorial Sloan Kettering Cancer Center, 2016b)

Mechanism of Action (continued)	**Clinical Summary**
Phenolic compounds in graviola demonstrate free-radical scavenging potential against human breast carcinoma cells and in promyelocytic leukemia cells. Extracts of acetogenin muricins J, K, and L have antiproliferative effects against human prostate cancer cells, with the effect of muricin K being strongest. In colon and in lung cancer cell lines, the ethanolic extract of graviola caused G1 cell-cycle arrest by upregulating Bax and downregulating Bcl-2 proteins. In rodent models of hepatic cancer, although constituents of graviola led to reduced tumor growth, the acetogenin bullatacin caused liver and kidney toxicity via increasing calcium concentration, ROS production, and Bax expression and Bax/Bcl-2 ratio with repeated treatment.	Graviola is a tree prevalent in the rain forests of Africa, South America, and Southeast Asia. The fruits, also known as soursop, are consumed as food. The leaves and stems are used in traditional medicine for symptoms associated with inflammation and infection. Graviola is also available as a dietary supplement and widely promoted as an alternative treatment for cancer, although clinical evidence is lacking. Many of the health benefits from graviola are thought to be derived from its antioxidant properties. In animal studies, extracts from graviola leaves showed anti-inflammatory, analgesic, antidiabetic, antiulcer, and antiviral effects. The leaf extracts also have antimicrobial activities. Graviola extracts from the leaf, fruit, and seed have been tested in laboratories for their anticancer effects. Some studies show these extracts to be active against breast, lung, colon, prostate, pancreas, liver, and skin cancer cell lines. However, graviola products have not been studied in cancer patients. Consumption of graviola has been associated with adverse effects. Alkaloids extracted from graviola may cause neuronal dysfunction and degeneration leading to symptoms of Parkinson’s disease. Graviola may decrease the uptake of radiopharmaceuticals used in nuclear imaging and lower platelet counts.

I6: Scientists Studying Indigenous Science: Dr. Compton Seaforth (A Scientist of the Western Modern Tradition)

Brief Biography:

> He [Dr. Compton Seaforth] has spent over four decades in teaching, research and consultancies in the areas of organic and medicinal chemistry, and the economic biology of under-utilized tropical medicinal and aromatic plants. Together with his collaborators, Professor Seaforth is the author of several publications, including a 2005 “Study for a handbook of selected Caribeean herbs for industry”, and the book “Caribbean herbs and nutritional supplements” (2007). (The University of Trinidad and Tobago, 2010)

I7: Literary resource: Kekulé and the snake
(reproduced from Wayan, n.d.)

Kekulé Dreamed 1858 and 1865 by Friedrich August Kekulé von Stradonitz.

Kekulé's working-out of the structure of benzene is a well-known story. What's forgotten is that this wasn't the first time Kekulé had dreamed a breakthrough. He discovered the tetravalent nature of carbon, the foundation of structural organic chemistry; but he did not make this 1858 breakthrough by experimentation alone. He dreamed it! As he described in a speech given at the Deutsche Chemische Gesellschaft (German Chemical Society):

> "I fell into a reverie, and lo, the atoms were gamboling before my eyes! Whenever, hitherto, these diminutive beings had appeared to me, they had always been in motion; but up to that time, I had never been able to discern the nature of their motion. Now, however, I saw how, frequently, two smaller atoms united to form a pair; how a larger one embraced the two smaller ones; how still larger ones kept hold of three or even four of the smaller; whilst the whole kept whirling in a giddy dance. I saw how the larger ones formed a chain, dragging the smaller ones after them, but only at the ends of the chain. . . . The cry of the conductor: "Clapham Road," awakened me from my dreaming; but I spent part of the night in putting on paper at least sketches of these dream forms. This was the origin of the Structural Theory."

A blue Belgian stamp commemorating Kekulé's discovery of benzene's structure. Kekulé's bearded face, bordered by a schematic of the benzene ring. Seven years later, the more famous incident occurred: a dream in which he realized that the benzene molecule had a circular structure, not a linear one like other organic compounds known at the time.

> "...I was sitting writing on my textbook, but the work did not progress; my thoughts were elsewhere. I turned my chair to the fire and dozed. Again the atoms were gamboling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by the repeated visions of the kind, could now distinguish larger structures of manifold conformation; long rows sometimes more closely fitted together all twining and twisting in snake-like motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly

> before my eyes. As if by a flash of lightning I awoke; and this time also I spent the rest of the night in working out the consequences of the hypothesis."

See a useful film to accompany the story at

https://www.youtube.com/watch?v=2NRwd-JJFm4 (Ali, 2011)

I8: Literary resource: The Discovery of Fire
(Reproduced from The Mohawk Nation, 1968)

In olden times when a Mohawk boy had reached the age of fourteen winters, it was customary for him to make a journey, accompanied by his father, to some sacred place up in the mountains. There, after receiving instructions from his father, the youth would remain alone for at least four days. During these four or more days, the Mohawk boy would perform a ceremony known as the Dream Fast. This Dream Fast was very important to the Indian boy of long ago. To be successful in the Dream Fast meant that the Indian was no longer a youth but a man. During the fast, the clan s[S]pirit of the young Mohawk would appear to him in a dream and reveal to him the bird, animal, or plant that was to be his guardian throughout his life. After the fast, he must secure something from the creature of his dream and must wear it in his medicine bag as a charm.

The Mohawk Iroquois had three clans which were, the Bear clan, Turtle clan, and Wolf clan. Should the dreamer belong to the turtle clan, the s[S]pirit of the turtle would appear to him in a dream and show him his future guardian. If the clan s[S]pirit did not appear to him during the fast**,** his father who visited him daily would release him, and he departed home, a failure. He could not have two chances. The dreamer could leave his fasting place after sunset for brief periods. He could drink water to quench his thirst. He was not allowed to eat any food.

Otjiera belonged to the Bear clan and was the son of a famous leader. He had many honors to his credit. No youth of the Mohawks was fleeter on foot than he. He led in the games and was one of the best lacrosse players of his nation. He could shoot his arrow farther and straighter than any of his friends. He knew the forests and streams and would always return from the hunt loaded down with deer meat, which he always divided with the needy of his people. He could imitate the calls of the birds. They would come when he called and would sit on his shoulders. He was the pride of his people.

The time for the Dream Fast of Otjiera had come. It was in the Moon of Strawberries. Otjiera was eager to try the test of strength and endurance. High upon the mountain,

on a huge ledge of rock, he built his lodge of young saplings. He covered it with the branches of the balsam to shelter it from the rain. He removed all of his clothing save his breechclout and moccasins. Appealing to his clan s[S]pirit, he entered the crude shelter.

Four suns had passed and yet the young warrior had not been visited by the clan s[S]pirit. The fifth sun had dawned when his father appeared. He shook the lodge poles and called for Otjiera to come forth. Otjiera in a low and weak voice begged his father to give him one more day. His father left, telling Otjiera that on the morrow he must return to his village.

That night Otjiera looked down from his lodge on the mountains. In the distance he heard low rumblings of thunder. As he listened, the thunder became louder and louder. Bright flashes of lightning lit up the heavens.

"Great Thunder Man, Ra-ti-we-ras", prayed the youth, "send my clan s[S]pirit to help me". He had no sooner spoken than a blinding flash of lightning lit the sky and a rumble of thunder shook the mountain top. Otjiera looked and beheld his clan s[S]pirit. A huge bear stood beside him in his lodge. Suddenly the bear spoke, "This night, Otjiera, you shall have a magic that will not only aid you, but will also aid all of the Ongwe-Oweh, the Real People".

There was a blinding flash of lightning, and Otjiera awoke from his vision. He rubbed his eyes and looked for the clan s[S]pirit. The bear was gone. The youth wondered what his guardian helper would be. He looked out from his lodge. The storm had not yet left the mountain. Suddenly he heard a strange sound outside near the lodge. It was a dreadful screeching sound such as he had never heard before. He wondered what kind of animal or bird made such a dreadful noise. The sound had ceased. Then, almost over his head, he saw the cause of the sound. The wind was causing two balsam trees to rub their branches against each other. As the wood rubbed, the friction caused the strange, screeching sound. As Otjiera watched he saw a strange thing happen. The strong wind, rushing up the mountain, caused the trees to bend and sway more rapidly. Where the two trees rubbed against each other, a thin string of smoke appeared. As the boy watched, the wood burst into flame.

Otjiera was, at first, frightened. He started to run. None of his people had even seen fire so near, and it was feared. The boy remembered his clan s[S]pirit. “This must be what the great bear meant”, thought the boy.

That day Otjiera took two pieces of dry balsam wood. He rubbed the wood together as he had seen the storm do the night before. He soon tired and was about to throw the wood away when he noticed a thin thread of smoke coming from the wood. He rubbed harder, and soon a tiny spark appeared. By using some dry cedar bark and grass he soon had a fire.

When his father and two chiefs came that noon, they found a happy Otjiera. He had a powerful helper, a strong medicine which afterward was to help all of his people. That was how fire came to the Indian people of long ago.

I9: Literary resource: The Origin of the Medicine Society

(Reproduced from The Seneca Nation, 1968)

There was in old times a young chief who was a hunter of great cunning, but though he killed many animals he never took advantage of their positions. He never shot a swimming deer or a doe with a fawn, he never killed an animal fatigued by a long run nor took one unawares. Before the hunt he always threw tobacco and made a ceremony to ask permission to kill game. Nor was he ever ungrateful to the animals of the woods who had been his friends for so many years. The flesh that was useless he left for the wolves and birds, calling to them as he left it, "Come, my friends, I have made a feast for you". Likewise when he took honey from a tree, he left a portion for the bears, and when he had his corn harvested, he left open ears in the field for the crows, that they might not steal the corn sprouts at the next planning. He fed the fish and water animals with entrails and offal. No ruthless hunter was he but thoughtful. He threw tobacco for the animals in the woods and water, and made incense for them with the *oyenkwaonwe,* the sacred tobacco, and threw it even for the trees.

He was a well-loved chief, for he remembered his friends and gave them meat. All the animals were his friends, and all his people were loyal to him. All this was because he was good, and he was known as the "protector of the birds and the beasts". So he was called. It is supposed that his own name was His-hand-is-red.

The southwest country is a land of mysteries. There are many unknown things in the mountains there and also in the waters. The wildest people have always lived there, and some were very wise and made different things. When, many years ago, the Ongwe honwe, the Iroquois, began to make excursions to this distant country they encountered many nations that were friendly and more that were hostile. The Iroquois used to like to go to this country for there they learned new things and found new plants and new kinds of corn and beans, and when they would fight and destroy a tribe they would carry away curiously made things and some captives back to their own country.

While one of these exploring parties was in the far southwest looking for war and new things, a band of very savage people attacked them. The young chief, the friend of the

animals, was with the party, and being separated from the rest of his party, was struck down by a tomahawk blow. The enemy cut a circle around his scalp lock and tore it off. He could not fight strong because he was tired and very hungry from the long journey, so he was killed. The enemy knew him because he had been a brave fighter and killed a good many of their people in former battles, so they were glad when they killed him and prized his scalp. Now he lay dead in a thicket, and none of his warriors knew where he was, but the enemy showed them his scalp. So they knew he was dead, but they did not kill all the Iroquois.

Black night came and alone upon the red and yellow leaves the chief lay dead, and his blood was clotted upon the leaves where it had spilled. The night birds scented the blood and hovered over the body, the owl and the whippoorwill flew above it, and Oshadagea, the dew eagle, swooped down from the regions over the clouds. “He seems to be a friend”, they said. “Who can this man be?” A wolf sniffed the air and thought he smelled food. Skulking through the trees he came upon the body, dead and scalped. His nose was upon the clotted blood, and he liked blood. Then he looked into the face of the dead man and leaped back with a long yelping howl – the dead man was the friend of the wolves and the animals and birds.

His howl was a signal call and brought all the animals of the big woods, and the birds dropped down around him. All the medicine animals came – the bear, the deer, the fox, the beaver, the otter, the turtle, and the big horned deer (moose). Now the birds around him were the owl, the whippoorwill, the crow, the buzzard, the swift haw, the eagle, the snimpe, the white heron, and also the great chief of all the birds, Oshadagea, who is the eagle that flies in the world of our Creator above the clouds.

These are all the great medicine people, and they came in council about their killed friend. Then they said, “He must not be lost to us. We must restore him to life again”. Then a bird said, “He is our friend, he always fed us. We cannot allow our friend to die. We must restore him”. Then the wolf came up to the body and said, “Here is our friend, he always gave us food in time of famine. We called him our father, now we are orphans. It is our duty to give him life again. Let each one of us look in our medicine packets and take out the most potent ingredient. Then let us compound a medicine and give it”. Then the owl said, “A living man must have a scalp”.

So the animals made a wonderful medicine, and in its preparation some gave their own lives and mixed them with the medicine roots. When the medicine was made, all of it was contained in the bowl of an acorn. So they poured it down the throat of the man, and the bear, feeling over the body, found a warm spot over his heart. Then the bear hugged him close in his hairy arms and kept him warm. The crow had flown away for the scalp but could not find it. Then the white heron went, but while flying over a bean field thought herself hungry and stopped to eat and when filled was too heavy to rise again. Then the pigeon hawk, the swiftest of the birds, said that he would go and surely find it.

By this time the enemy had become aware that the animals were holding a council over their friend whom they had slain, and so they carefully guarded the scalp which they stretched upon a hoop and swung on a thong over the smoke hole of a lodge. The pigeon hawk, impatient at delay shot upward into the air and flying in wide circles discovered the scalp dangling over the fire drying in the hot smoke. Hovering over the lodge for a moment he dropped down, and snatching the scalp shot back upward into the clouds.
Faster and farther than the arrows that pursued him swift from the strong bows of the angered enemy. Back he flew, his speed undiminished by his long flight, and placed the scalp in the midst of the council. It was smoky and dried and would not fit the head of the man. Then big crow (buzzard) emptied his stomach on it to clean it of smoke and make it stick fast, and Oshadagea plucked a feather from his wing and dipped it in the pool of dew that rests in the hollow of his back and sprinkled the water upon it. The dew came down in round drops and refeshed the dry scalp as it does a withered leaf. The man had begun faintly to breathe when the animals placed the scalp back in his head, and they saw that truly he would revive. Then the man felt a warm liquid trickling down his throat, and with his eyes yet shut he began to talk the language of the birds and animals.

And they sang a wonderful song, and he listened and remembered every word of the song. This song the animals told him was the charm song of the medicine animals, and that when he wished the favor of the great medicine people, and when he felt grateful, to make a ceremony and sing the song. So also they told him that they had a dance and a dance song, and that they would teach him the dance. So they danced and

shook rattles made of the squashers (gourds), and though his eyes were closed he saw the dance and he knew all the tunes.

Then the animals told him to form a company of his friends and on certain occasions to sing and dance this ceremony, for it was a great power and called all the medicine animals together, and when the people were sick, they would devise a medicine for them. Now they said that he must not fail to perform the ceremony and throw tobacco for them. Now the name of the ceremony was *Hadidos*.

Then the chief asked the medicine people what the ingredients of the medicine were, and they promised to tell him. At a time the animals should choose they would notify him by the medicine song. Now, he could not receive the secret because he had been married. Only *hoyahdiwadoh* – virgin men – may receive the first knowledge of mysteries. Now, the chief greatly wished for the medicine, for he thought it would be a great charm and a cure for the wounds received in war. After a time the chief was lifted to his feet by the hand of the bear. Then he recoveed his full life, and when he opened his eyes he found himself alone in the midst of a circle of tracks. He made his way back to his people and related his adventure. He gathered his warriors together and in a secret place sang the medicine song of the animals, the *Hadidos*. So they sang the song, and each had a song and they danced.

After some time, the chiefs decided to send another war party against the enemy in the southwest to punish the hostile people who were attacking them. Then the friend of the birds and animals said, “It is well that we destroy them for they are not a reasonable people”, and so he went with his party.

Now after a certain number of days, the party stopped in an opening in the forest to replenish their stock of food. Now the place where they stopped was grassy and a good place for camp. Now a short distance away, a half day’s journey, was a deer lick and near it a clear spring and a brook that ran from it, and to this place all the animals came to drink. The party wanted fresh meat and so dispatched two young men, *Hoyahdiwadoh,* to the lick for game. As they approached it, they heard the sound of a distant song, and drawing near to the lick, they sat down on the bank over the spring and listened to the song. It was a most wonderful song and floated through the air to

them. At a distance away, the animals came and drank, but so entranced were the young men by the music that they killed none. Through the entire night, they sat listening to the song, and learned sections of the song.

In the morning, they returned to the camp and reported what they had heard to their chief. Then said the chief, “That song is for the good of the medicine. You must find the source of the song and discover the medicine that will make us powerful in war and cure all our ills. You must purge yourselves and go again on the morrow”. So the young men did as directed and went again to the spring and threw tobacco upon its surface. As night came on they listened, and again heard the great song. It was louder and more distinct than before. They heard a voice singing from the air and telling them the story of their lives and they marveled greatly. The song grew louder, and as they listened they discovered that it emanated from the summit of a mountain. So they returned in the morning and reported to their chief and sang to him parts of the song. Then he said, “You must cleanse yourselves again, and this time do not return until you have the medicine, the song, and the magic”.

So the young men cleansed themselves again and went to the spring. As the thick night came on, they heard the singing voices clear and loud, ringing from the mountaintop. Then said one of the young men, “Let us follow the sound to its source:, and they started in the darkness.

After a time they stumbled upon a windfall, a place where the trees had blown down in a tangled mass. It was a difficult place to pass in the darkness, for they were often entrapped in the branches, but they persevered, and it seemed that someone was leading them. Beings seemed to be all about them, yet they could not see them, for it was dark. After they had extricated themselves from the windfall, they went into a morass, where their footsteps were guided by the unseen medicine animals.

Now the journey was a very tedious one, and they could see nothing. They approached a gulf and one said, “Let us go up and down the gulf and try to cross it”, and they did and crossed one gulf. Soon they came to another, where they heard the roaring of a cataract and the rushing of waters. It was a terrifying place, and one of the young men was almost afraid. They descended the slope and came to a swift river. Its

waters were very cold, but they plunged in and would have been lost if someone unseen had not guided them. So they crossed over, and on the other side was a steep mountain which they must ascend, but could not because it was too steep. Then one of the young men said, “Let us wait here awhile and rest ourselves for we may need our strength for greater dangers”. So he said. But the other said, “I am rested, we must go onward somehow”.

When he had so spoken, a light came flying over and sang for them to follow it. So they followed the winged light and ascended the mountain, and they were helped. The winged light kept singing, “Follow me, follow me, follow me!” And they were safe when they followed and were not afraid. Now the singing, flying beacon was the whippoorwill. He led them. After a time the light disappeared, but they struggled up the mountainside unaided by its guidance. The way became very stony, and it seemed that no one was helping them now. Then they wished that their unseen friends would help them, so they made a prayer and threw sacred tobacco on the path. Then the light came again, and it was brighter; it glowed like the morning, and the way was slighted up. The singing continued all this while; they were nearing its source, and they reached the top of the mountain.

They looked about for they heard the song near at hand, but there was no one there. They saw nothing but a great stalk of corn springing from a flat rock. Its four roots stretched in the four directions, north, east, south, and west. They listened and discovered that the music emanated from the cornstalk. It was wonderful. The corn was a mystically magic plant, and life was within it. Then the winged light sang for them to cut the root and take a piece for medicine. So they made a tobacco offering and cut the root. Red blood like human blood flowed out from the cut, and then the wound immediately healed. Then the unseen speaker said, “This root is a great medicine, and now we will reveal the secret of the medicine”. So the voices told them the composition of the medicine that had healed the chief and instructed them how to use it. They taught the young men the *Ganota*, the medicine song that would make the medicine strong and preserve it. They said that, unless the song was sun, the medicine would become weak and the animals would become angry because of the neglect of the ceremonies that honored their medicine. Therefore, the holders of the medicine must sing the all-night song for it. And they told them all the laws of the medicine,

and the singing light guided them back to the spring, and it was morning then. The young men returned to their chief and told him the full story of their experiences, and he was glad for he said, “The medicine will heal all wounds”.

It was true, the medicine healed the cuts and wounds made by arrows and knives, and not one of the Iroquois was killed in their battle with the enemy. When they returned home, the chief organized the lodges of the medicine and the medicine people, and the name of the society was *Hadidos*. The medicine was called niganigaa – little dose – because its dose was so small.