# For Us, By Us:

# Indigenous Land-based Science Learning

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A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Education

University of Washington

2017

Committee:

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Program Authorized to Offer Degree:

College of Education

University of Washington

# ABSTRACT

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Indigenous students and families who are learning 'science' or 'STEM' in settler societies (e.g. the United States and Canada) are forced to engage in formal and informal science learning settings that are predominantly founded upon a settler, Western science that not only positions its science as "real" or "The" science, but also positions Indigenous students' epistemologies and ontologies as not "real knowing" or relevant to "real science." This erasure paradigm in science learning settings is a reflection of the large settler-colonial system that seeks to erase and supplant Indigeneity. This must shift if Indigenous student STEM trajectories are to not only improve, but also improve in ways that are accountable to and grounded in their Indigenous value systems, original relations and collective continuances. To build towards this, the current work re-frames and Indigenizes a prominent western human learning theory, i.e. Learning in Informal and Formal Environments (LIFE), to develop an Indigenous theory/story to LIFE, referred to as I-LIFE. Given I-LIFE is a theory/story about Indigenous life-long, life-deep, and life–wide learning, it is responsible for being put into Indigenous practice, i.e. lived directly in land and relations to be made fully meaningful. Thus, the second section of the current work

outlines how I-LIFE unfolded in the form of Indigenous Land-based Science Learning (ILBSL) directly in/with the Cheyenne territory, by Cheyenne people and according to Cheyenne ontology, epistemology, axiology and collective continuance. To achieve this, ILBSL apprenticed and socialized Native students as good ancestors/bio-cultural restoration scientists to story, practice, adapt and synthesize Western science with/according to Cheyenne Science and values (including Sweet Medicine's Adaptation Theory) through an 'unceded time' paradigm. This reciprocal relationing of story and practice, i.e. I-LIFE and ILBSL, respectively, is a promising strategy in increasing Native student learning, retention and trajectories in STEM by Indigenous peoples (i.e. according to Indigenous ontologies and axiologies), for Indigenous peoples (i.e. collective continuance). Together, I-LIFE and ILBSL achieved a pivotal Indigenous learning paradigm that is essential to the resurgence and reclaiming of Indigenous peoples' sovereign knowledges, ontologies, axiologies and collective continuances. Thus, the current work has implications for other Indigenous communities seeking to reclaim their children's learning through ILBSL so as continue their trajectories towards just and viable Indigenous futurities on Indigenous peoples' terms.

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ACKNOWLEDGEMENTS

As with all things in life, this thesis would not have been possible without the relations, lands and lineages I belong to. First, I thank my Cheyenne ancestors Chief Morning Star and Pawnee Woman and my Crow ancestors Pretty Shield and Goes Ahead – who raised many children in their respective families and gave their lives to maintain their responsibilities to land and future generations. Though the histories of the Cheyenne and Crow peoples unfolded differently during nonconsensual, exterminatory white settlement of our territories, they all gave their love and made the best decisions they could so future generations could be. Without my ancestors' love and sacrifice, those of other Cheyenne and Crow ancestors during the Indian Removal area (1870s), and those who came before and have followed since, we would not have collective territories to belong to, to call home and to continue to live into our Indigeneity and our responsibilities to land and future generations. Secondly, I would like to thank my grandparents Lawrence and Barbara and Archie and Evelyn for giving their love and living their lives to raise my parents and their siblings in an era when being Indian wasn't cool and Indians were openly hated and abused for simply being Indigenous (although being Indian has always been and always will be cool). Thirdly, I thank my parents, Alan and Joleen, who have selflessly given their lives to raising me and my siblings on our home territories, for ensuring we were raised to know who we are and where we come from, and for always believing in our dreams, including mine at Dartmouth and UW. Thank you to my husband, Kanishk, who has loved and supported me since my applications to graduate school and who relentlessly believes in who I am and the relations and responsibilities I belong to as a Cheyenne and Crow woman. I also thank my corn sister, Shanny, who looks out for me, provides the sun and shade and sets the template for what it means to be an Indigenous mother and sister scientist. By relation I thank her husband

Jake and their children who have loved me all the same alongside my sister. I also thank my life long friend and mentor, Bonnie, for continuing to support me in my path of creating viable Indigenous science learning settings for youth.

I extend my deepest gratitude to my advisor, Dr. Megan Bang for providing her guidance, light and deep commitment to her responsibilities to land and relations – which have shown me what is possible in my own responsibilities. By relation, I thank her and her family for undertaking a career in academia – a space that is often not friendly to Indigeneity – and collectively attending to this space so as to foster just spaces for good ancestors/scientists and Indigenous sciences to flourish. I also want to say thank you to the many peers I met in my graduate program – thank you for making my learning that much more and for continuing your paths in creating just, equitable learning for all. I also express my gratitude to my Cheyenne language teacher, Setovaaste, who taught me how to speak Cheyenne at Chief Dull Knife College while I continued my graduate program – a necessary and complementary learning that I did not know I needed, until I did. In closing, I thank all my relations, including the Duwamish people (whose territory UW occupies), for making it possible for me to do what I have always wanted to do: connect and attend to the reciprocal relationship between story and practice, university and community. As a Cheyenne and Crow woman and member of a chief's family, I first come from land and relations – this guides my life, including my formal graduate learning at UW. Thus, I am ever grateful to have worked under an incredible mentor, Megan, and to have molded a program where I could lend my lived Indigeneity to academia/story and put story/research into relevant, ethical relation with the kinships and responsibilities I belong to, directly in land, directly at home. I thank future generations for continuing our lineages and responsibilities to land – it is now your time, live it fully. Neae'šem (thank you all).

# DEDICATION

This thesis is framed from a Cheyenne ontology, thus it is my responsibility as a spirit having a human experience to outline how one spirit's lived story has come to be thus far…it represents my attempt to live and articulate what it means to be a good relative/ancestor during this time in our long, deep existence as Cheyenne and Crow peoples. Accordingly, part of our current generations work is to re-Indigenize, repatriate and remake first relations to land regardless of their current settler-colonial state…it is our time to be good ancestors. This thesis, then, is for us, by us – the ancestors…past, present, future…human and more-than-human and our reciprocal relations and relationing with one another.

# SECTION I

## Introduction

Pevehe e'šeevehe, Esevona'e na hehe šehe vehe naa Ná'tsėhéstahe naa Apsáalooke naa Mo'ohtave'e heo meneno na hehe stahe. Good day, my name is Buffalo Woman, I am a Northern Cheyenne and Crow person and I am from Black Lodge. I was raised, alongside my six siblings, by a hard-working nahko'eehe (mother) and neho'eehe (father) on Northern Cheyenne and Crow territories. This thesis is opened this way so as to orient and ground this critical space according to Indigenous ontology and axiology. This thesis was written directly from land and land-based practice, collectively in *relation* and *relationing* to humans and more-than-humans. It was written directly from Indigenous community and land to speak back to story/university to say 'this is how we made meaning of your stories/theories and what they actually looked like when we lived, embodied and practiced them directly in land and our relations at home.' Thus, the current thesis sets out to achieve multiple fronts from and for Indigenous ontologies, epistemologies, axiologies and our collective continuance (Whyte, 2013).

First, it is widely documented that unprecedented inequities exist in Native students' learning of, interest in and identity with "Science" or "STEM" – especially in settler societies such as the United States, Canada and elsewhere (Spang and Bang, 2015; Bang, et. al, 2012; Bang, et. al, 2014; Freidel, 2010; Freidel, 2011). Indigenous students and families who are learning 'STEM' in settler societies are forced to engage in formal and informal science learning settings that are predominantly founded upon a settler, Western science that not only positions its science as "real" or "The" science, but also positions Indigenous students' epistemologies and ontologies as not "real knowing" or relevant to "real science" (Bang, et. al, 2012). Therefore, to address these inequities, persistent forms of Indigenous erasure and improve Indigenous

children's learning of, interest in and identity with science in ways that forward Indigenous present/ence and futurities, the current work stories/theorizes[1] an Indigenous paradigm of Learning in Informal and Formal Environments (LIFE) (Banks, J., et. al, 2007) referred to as I-LIFE. I-LIFE is a theory/story about life-long, life-deep, and life–wide learning according to Indigenous ontologies, epistemologies and axiologies since time immemorial.

Given I-LIFE existed/s before and independent of settler-colonialism, it has found ways to adapt to the forced, violent restructuring of settler-colonialism on Indigenous territories, knowledge, and everyday life. This adaptation is key as Indigenous peoples must find ways to live into their ontologies and axiologies despite this dominating, forced relation. Therefore, part of I-LIFE's adaptation includes the navigation and practice of Indigenous Science and Western Science – but where Western Science is made meaningful through Indigenous ontologies and axiologies – by Indigenous children and families. I-LIFE positions Western science in ways that forward Indigenous present/ence , futurities (Tuck and Yang, 2010) and collective continuances (Whyte, 2013). This approach is significant as it facilitates a synthesized, productive approach for Indigenous students' science learning and identities as it becomes a resurgence and reclaiming move that disrupts settler colonialism and restores human relations with the natural world (and by relation the natural world itself). It also achieves decolonization, resurgence and survivance of Indigenous lifeways, nationhood, territories and futurities (Bang, et. al, 2014).

Secondly, to demonstrate the potential and robustness of the I-LIFE story/theory, this thesis then situated it in practice directly in land and relations via Indigenous Land-based Science Learning (ILBSL) according to Cheyenne ontology, epistemology and axiology. ILBSL

[1] Story/theory (Brayboy, 2006) are used interchangeably in the current work as a way to appropriately address and move across different knowledge traditions, i.e. Indigenous and Western, in setting up the reciprocal relation and relationing between story/theory and practice from an Indigenous epistemology & ontology.

apprenticed and positioned Native students as good ancestors/bio-cultural restoration scientists to story, practice, adapt and synthesize Western science with/according to Cheyenne Science and values. Key to this apprenticeship was resituating and reclaiming Western science in ways that became productive for youth's interdependent-Indigenous-sense-of-self/identities and -of-responsibilities to land, community and relations – a critical ground in which to empower and nurture Indigenous youth (Fryberg and Markus, 2007). Bio-cultural restoration science was taken up in ILBSL as it provided a key translation ground to apprentice Native youth in Indigenous and Western Science traditions. Apprenticing Indigenous youth to become adept and expert at both Sciences is critical as Indigenous communities and nations today need citizens who can expertly navigate and synthesize these Sciences in ways that are productive and accountable to Indigenous present/ence and collective continuances – especially in this time of compounding anthropogenic climate change (Bang and Medin, 2010).

In essence, ILBSL is about apprenticing scientists who see themselves as a part of (not apart from) the natural world and reclaiming this responsibility, relation and relationing (active attendance and acts to maintaining these relations) in all aspects of their lives, including but not limited to formal and informal science learning settings. To achieve this, ILBSL strategically planned for this learning to occur during the summer, referred to as 'unceded time' to the state – i.e. it is Indigenous time and space that has not been enclosed by compulsory, settler schooling, formal science learning expectations, and futurities. Through unceded time, ILBSL opened up and framed multiple dimensions with Indigenous youth that impacted their identities, responsibilities and practices as bio-cultural restoration scientists, thus far (Massey, 2005). Dimensions included Sweet Medicine's Adaptation Theory, emergent everyday Indigeneity and an interdependent-Indigenous-sense-of-self, youth's roles as epistemological and ontological

translators across-settings and across-bodies-of-knowledge, settler-colonialism & racialization of Indigeneity, and Indigenous nationhood. ILBSL utilized these dimensions to contextualize and collectively design and practice a number of bio-cultural restoration scientist practices with/by Indigenous youth. These practices were emergent, collectively storied, lived and made meaningful by youth in relation with human and more-than-human-relations through an emergent everyday Indigeneity paradigm. This everyday paradigm was strategic as it set up youth as good relative/scientist experts whose expertise and identities emerged with everyday practice and meaning-making throughout the program. Even more, this approach mediated a daily practice that youth could continue to attend to and practice/employ beyond their time in the program, including but not limited to their formal school science learning. Lastly, youth's learning and practice through ILBSL resulted in concrete bio-cultural restoration for/by the Northern Cheyenne Reservation, government and nationhood.

The centering of Indigenous ontology, epistemology and axiology in the theoretical/story framework and its lived practice is an intentional, necessary move in designing and achieving science learning with Indigenous children, families, and communities and for collective continuance. I-LIFE and ILBSL achieved this reciprocal relationing between storied and lived Indigeneity, respectively. With that, the ILBSL dimensions and practices outlined in the current work are not exhaustive, but rather more importantly, they became critical, collective entry points that made science learning much more expansive, meaningful and inspirational to Indigenous youth. I-LIFE and ILBSL hold significance for increasing Native student learning, retention and trajectories in STEM by and for Indigenous peoples, thus, additional work and research needs to occur to expand and deepen these dimensions and practices, as well as how ILBSL might unfold within more Indigenous territories according to their ontologies, axiologies

and epistemologies. Further, although this thesis was written primarily in the context of Indigenous students' science learning and identities, it also holds significance and promise for non-Indigenous students as I-LIFE and Indigenous axiologies call for all to be good relatives. Additionally, Indigenous science holds the potential to re-humanize much of Western science and relations to land. With that, this work does not contend that it is solely the work of Indigenous peoples to rehumanize our relations with each other and the natural world, but rather that a deep wisdom of Indigenous knowledge is to share and practice it, responsibly, by all (human and more-than-human) if we are to decolonize and reclaim our humanity. Therefore, much more research and practice, according to Indigenous ontologies and axiologies, must occur to expand and deepen I-LIFE and ILBSL not simply in the literature, but just as (if not more) importantly to be lived daily and directly in land and relations so we may reclaim our collective continuances, relations, belonging and well-being within/of the natural world.

## Section II

### My Lineage: Tsétsėhéstâhese and Apsáalooke

I open the current thesis with a narrative of my lineage, to achieve and illustrate a Cheyenne ontology and axiology in coming to know and knowledge sharing. My lineage centers and demonstrates our Indigenous lifeways on our timeline and orientations to land – in this grounding so much more is possible as we do not center our forced relationship with settler-colonialism and are freed from the settler state's propagandistic reality it wants us to make our lives and futures in. Who we are, what are to do in this life goes much farther and deeper than this violent relationship. When we see ourselves within this long, deep, rich lineage we realize that we are who our ancestors taught us to be, i.e. empowered, active actors/relatives/ancestors of our own pasts, presents/ences and futures. The Indigenous ontologies and axiologies I belong to

necessitate that I situate my positionality and relation/ing to the current work. Thus, it becomes paramount that I share the lineages I belong to and to do so it is most appropriate for me to open this space with our creation theories. But before I do, our story protocol requires that I first šeše tohe toe'e hohe sehe mea (burn some cedar) and that the reader(s) hehe sehe mahe tohe hestse (bless yourself). We must then think only good things for our time together, our relations and those yet to come. We thank the earth for providing for us and we come to this moment together, with good hearts, fully present so we may share in this story together and that we then make good meaning of it in our lives and with those we are blessed to call our friends, relatives and relations. May it bring us only good medicine and guidance. Nea'ešem (thank you all).

According to the Northern Cheyenne and Crow worldviews, the below story is a theory about how the world came to be, it is how my ancestors came to be and those of my human and more-than-human relatives, and how I, then came to be. It demonstrates the long lineages and relations we all come from, regardless of our background and the attempts of settler-colonialism and globalization to disrupt our relations with each other and the natural world. The Northern Cheyenne and Crow creation stories are similar and below I tell a version of these two stories/theories of the origin of the earth:

> "The world was covered all in water, there was no "hard land" on which to walk upon. It is said there was only the Creator, water and water beings. The Creator desired land to walk upon. It was at this time he saw various bird relatives swimming. He approached them asked them, 'what is far, far below this water?' They were not sure, but curious and courageous, they all volunteered to find out. Thus many birds dove under the water and each would be gone for a very long time. The Creator and other birds worried that their relative had drowned, but after a while they would emerge – one by one with nothing. After these many attempts by all the other birds, a small duck came forward and said they would go. All the other birds laughed at the small duck, saying there would be no way for small duck to hold breath that long. The Creator said, 'okay.' So small duck dove and disappeared under the water. He was gone for a long time, longer than all the other birds. They all kept watching and waiting, but so much time had passed that they were all convinced that small duck drowned. After all the unsuccessful attempts, they all became convinced that there was no earth below, only water. It was at this moment that small duck came up from the water with earth in its mouth.

> All were shocked and could not believe there was earth below and that small duck brought it up. The Creator took this earth in hand and blew it all around, and the hard land on which to walk around on was created, as were the Cheyenne and Crow, other peoples and other non-human relatives…this is how the earth came to be…"

As Crow people we then engaged in the Great Migration which took us from the Great Lakes region, south, then west and north again until we found the "Sacred Tobacco" in the Big Horn Mountains. As Cheyennes our ontology shows us that we as humans do not originate here – we are simply journeying through this world learning how to be good relatives. We are spirits having a human experience and coming into our learning and practice of what it means to be human, everyday. According to our worldview, embodying or 'being' Cheyenne is not a noun but a verb, thus it is to be lived everyday. It is this sacred responsibility that we have lived directly in land and place, intentionally, since our creation in this world. As Northern Cheyenne and Crow we are now in a time of transition and in world that is rapidly losing its humanity. Medicine people/leaders from Northern Cheyenne (including Sweet Medicine) and Crow foretold of a world where bearded men and strange buffalo would walk among us, eating up all the land and grass – and this would put us at risk of losing our 'Cheyenne-ness', our humanity. These visions of these strange relatives coming have manifested.

It was during the late 1800s that the U.S. Government sought to settle and homestead everything west of the Mississippi – regardless of the Indigenous peoples, like the Northern Cheyenne and Crow, who already lived there – because in their view they "rightfully" "purchased" it through the Louisiana Purchase (1803) from the French. It was after this purchase that U.S. President Thomas Jefferson commissioned the Corps of Discovery Expedition (1804) under Meriwether Lewis and William Clark to travel these lands in search of the Northwest Passage – a trade route that the U.S. wanted badly as it connected to the Pacific Ocean – and to

exercise an illegal settler presence and governance over Indigenous territories. These became the violent and non-consensual settler origins in Northern Cheyenne and Crow territories. Pretty Shield (1856-1944, Crow) and Chief Morning Star (1810-1883, Northern Cheyenne) were witness to this forced settler presence on their lands – though separated by several decades and with very different experiences, narratives and legacies.

Through my Crow lineage, Pretty Shield lived a long full life raising children, grandchildren and serving as a medicine woman to the Crow people. She lived twelve years before the establishment of the "Reservation Era," which involved a large-scale effort by the U.S. government to forcibly and violently confine Indigenous peoples to reservations, including Crow and Northern Cheyenne. Despite this, Pretty Shield married Goes Ahead and joyously lived her life, spoke her language, practiced her medicines, and raised her children and grandchildren as one of the first generations of Crow people on a Reservation. She helped hold up a nation by maintaining, celebrating and living what it means to be Apsáalooke. Through my Northern Cheyenne lineage, Chief Morning Star also lived a long full life serving and leading the Northern Cheyenne people. He married "Pawnee Woman" and they had many children, including Pure Woman (the grandmother I descend from). Chief Morning Star was fortunate to live most of his life moving freely about, exercising our migrations and mobilities – direct reflections of our knowledge systems – in our Indigenous territory that spanned present-day Montana, Wyoming and Colorado and parts of South Dakota. He spent much of his life defending the Cheyenne territory against U.S. settler encroachment in various battles and played a pivotal role in resisting the U.S. government's unilateral, violent and forced removal of Northern Cheyennes to Indian Territory (present day Oklahoma) in 1877. Their sacrifices, strength and relentless resistance to removal are the foundational efforts that led to the Northern Cheyenne Nation's federally-

recognized territory in present-day Montana (est. 1884 through Executive Order). The Crow and Northern Cheyenne Reservations do not reflect the expanse of our original territories nor our original relations in these lands. They are very much settler-colonial strategies to enclose and erase our Indigeneity, however, at the same time, the Reservations allow for collective meaning-making and embodiment of who we are as Indigenous peoples and resurge our collective legacies so we may live them and pass them on to future generations – they represent the collective trajectories our good ancestors put us on through their staunch love and sacrifice.

It is these rich lineages, stories, cultures, language, histories and territories that I hold deeply and seriously. I share these stories because they are the lineages and legacies to land and community that I proudly descend from and have a responsibility to practicing, growing and sharing. I am humbled and honored to say that I come from resolute, strong Indigenous women such as pretty Shield, Pawnee woman and Pure Woman and from a chief's family through Chief Morning Star. As such, I have a deep responsibility of caring for and serving the people, which I am honored and grateful to do. I have done my best to do so by pursuing formal higher learning at Dartmouth College and the University of Washington and finding ways and practices to situate these programs in direct practice in/with community so as to forward our active present/ence and collective continuances (Whyte, 2013) on our Indigenous territories. I have storied my existence according to my Indigenous ontologies and axiologies – as such they tell me that it is my time to be a good ancestor/relative/scientist in this time of forecasted settler change. Thus I have done my best to embody this sacred responsibility and I am grateful to share the relations and relationing I have been a part of in storying Indigenous Learning in Informal and Formal Environments (I-LIFE) and putting it into ethical relation in land and community through Indigenous Land-based Science Learning (ILBSL). This thesis, then, is my attempt to outline

how my responsibilities and relations to land have come to be thus far, according to my Indigenous ontologies and axiologies, which deeply compel me to mentor Indigenous youth and improve their science learning and trajectories in ways that are accountable to our collective continuances.

## Section III

## Indigenous Peoples, Settler-Colonialism and Science

It is widely documented that unprecedented inequities exist in Native students' learning of, interest in and identity with "Science" or "STEM" – especially in settler societies such as the United States, Canada and elsewhere (Spang and Bang, 2015; Bang, et. al, 2014; Freidel, 2010; Freidel, 2011). Indigenous students and families who are learning 'science' in settler societies are forced to engage in formal and informal science learning settings that are predominantly founded upon a settler, Western science that not only positions its science as "real" or "The" science, but also positions Indigenous students' epistemologies and ontologies as not "real knowing" or relevant to "real science." This assimilative and erasure paradigm is the origin of Western schooling in Indigenous communities in which its earliest implementation sought to "kill the Indian and save the man" (Reyhner and Eder, 2006). To achieve the killing of the Indian, but saving/making of their humanity, Native children were forcibly removed from their homes and sent to boarding schools where they were forbidden to speak their languages, kept from their families, and were victims of non-consensual experimentation and sexual assault (many native children also died at these schools). Although these settler learning systems have somewhat improved, this origin of settler schooling strategically laid the groundwork for setting up formal and informal learning settings in Indigenous communities and much of the trauma experienced by earlier generations still emanates in Indigenous communities and relations to

date. This bears mentioning as settler-colonialism deeply and strategically informed/s formal and informal learning settings and utilizes Western science/STEM as one tool in which to continue the simultaneous forced erasure and indoctrination of Indigenous peoples into the settler state, all towards the achievement of settler futurities on Indigenous lands, bodies, and relations. This, then, is the settler context Indigenous students, families and communities are forced to navigate across their lives and within their territories, including their children's learning of and identities with 'science' in formal and informal learning settings, thus far.

To address this, many Indigenous scholars and practitioners are leading resurgence and decolonization efforts around the world to disrupt settler normativity and reclaim their original knowledges, values, nationhood, territories and relations to each other and to land – including reclaiming and resurging Indigenous children's learning of and identity with 'science' (or more aptly 'sciences') (Bang, et. al, 2014; Tuck, McKenzie, & McCoy, 2014). The crux of these efforts lies in improving Indigenous students' science learning and trajectories in ways that are accountable to and grounded in their Indigenous value systems, original relations and territories. To achieve this, productive science learning and identities for Indigenous students on Indigenous terms must involve the navigation and practice of Indigenous Science and Western Science – where Western Science is reclaimed and re-made through Indigenous ontologies and axiologies. This approach results in Indigenous students, families and communities grounding their meaning making and application of Western Science in ways that align with their value systems and forward their collective continuances. This is a key strategy that must be employed by Indigenous peoples because it simultaneously forwards Indigenous resurgence, Indigenous collective continuance (which by relation involves the continuance of the natural world) and Indigenous resistance to and dismantling of the settler regime, including its attempts to utilize

Western Science to erase Indigeneity and forward its futurity. The following sections come together to address and illustrate how these simultaneous strategies can be achieved through the reciprocal relationing of story and practice, i.e. Indigenous Learning in Informal and Formal Environments (I-LIFE) and Land-based Science Learning (ILBSL).

## SECTION IV

## LIFE and I-LIFE

**LIFE-long-wide-deep.** It is clear that the dimensions at play in Indigenous students' science learning and identities with 'science' expand beyond those that are typically taken up in formal and informal science learning settings. These learning settings must be reclaimed to address these dimensions if science learning is to become productive for Indigenous peoples and futurities – including but not limited to the trajectories of Indigenous students in STEM fields and in ways that first ground them in their value systems, knowledges and original relations. Consequently, this thesis stories/theorizes an Indigenous approach is to "Learning in Informal and Formal Environments" (LIFE) (Banks, et. al, 2007), referred to as I-LIFE.

LIFE is a foundational theory that framed and frames much of the inquiries and investigations of human learning. LIFE's basic contention is summed up in what it calls: LIFE-Long, LIFE-Wide, and LIFE-Deep learning. According to Banks et. al (2007), LIFE-Long is learning that, "begins in our earliest experiences of play, physical activity, and opportunities to plan and carry out ideas and work projects alone and with others. This learning shapes our foundation for curiosity, eagerness, communication, and persistence in continuing to learn and to keep on learning" (p. 13). LIFE-Wide learning is, "Experience in management of ourselves and others, of time and space, and of unexpected circumstances, turns of events, and crises…Here we figure out how to adapt, to transport knowledge and skills gained in one situation to another, and

to transform direct experience into strategies and tactics for future use" (Ibid). LIFE-Deep learning is: "Beliefs, values, ideologies, and orientations to life…Religious, moral, ethical, and social learning bring life-deep learning that enables us to guide our actions, judge ourselves and others, and express to ourselves and others how we feel and what we believe" (Ibid). In essence, LIFE-Long learning is learning that occurs across an individual human's lifetime, LIFE-Wide learning is learning that is applied and adapted by an individual human across various events/activities/contexts throughout one's life, and LIFE-Deep learning includes the values and morals that guides one's action and interaction with other humans throughout their life. The principal nature of this human learning paradigm lies in the nexus of these three dimensions, which is realized by positioning humans as independent actors whose learning agency begins when an individual is born (LIFE-long), situating human learning as only being informed by other humans (LIFE-Wide), and where human values are informed and practiced solely according to a human perspective or what human believes are ethical and moral absent of what the natural world requires of humans to be in ethical relation with it (i.e. anthropocentric) (LIFE-Deep).

**I-LIFE-long-wide-deep.** Although LIFE-long, -wide and -deep learning has expanded what is possible in researching, designing and practicing human learning, it is not a sufficient paradigm to do so from and for Indigenous ontologies, axiologies and collective continuances. Therefore, an Indigenous LIFE (I-LIFE) paradigm has been developed via the current thesis that centers Indigenous ontology and axiology. Brayboy (2005) summarizes how story/theory are defined from this place: "stories serve as the basis for how our communities work. For some Indigenous scholars (and others), theory is not simply an abstract thought or idea that explains overarching structures of societies and communities; theories, through stories and other media,

are roadmaps for our communities and reminders of our individual responsibilities to the survival of our communities" (p. 324). Consequently, I-LIFE is a story that is framed from Indigenous ontology, epistemology, axiology and methodology to story/theorize human learning.

**I-LIFE-Long learning** is learning that begins before one is conceived as it is learning that is inherited from one's ancestors and learned and practiced through the oral tradition since 'time immemorial'. I-LIFE-Long learning occurs through the collective storying and practice of knowledge across generations, i.e. intergenerational. It is about lineage (past/descendancy), inheritance (present/current generations) and legacy (future/generations yet to come). I-LIFE-Long is learning that Indigenous peoples are born into and have a responsibility to practicing, adapting and 'updating' via collective experience and practice of their knowledges directly in land. This iterative and fluid design of I-LIFE-Long learning is strategic in that it recognizes agency and animacy throughout the world and universe. In this view, the universe and planet are not static and conditions change and move over time. Thus, Indigenous knowledge and learning originates from direct, lived relations to the natural world (including those from past ancestors, i.e. lineage) and is then storied through the oral tradition that is 'updated' through these collective observations in natural world changes (i.e. inheritance/current generations) so it may be shared laterally with current generations and passed on to future generations (i.e. legacy/generations yet to come) through the oral tradition.

**I-LIFE-Wide learning** is learning that occurs across human and more-than-human relations, knowledge systems and settings. I-LIFE-Wide maintains that humans not only engage in learning with each other, but also with more-than-human relations (e.g. sage, buffalo, water). Critical to this then is the creation and adaptation of human learning that is built from direct lived experience with/from the natural world. I-LIFE-wide also includes ethical and respectful learning

that occurs across different epistemologies or knowledge systems (e.g. Indigenous and Western Sciences) and across different peoples/societies/nations (e.g. Cheyenne, Ojibwe, Yupik, India, etc). I-LIFE-Deep, then, holds that human beings learn from each other and from/across their distinct knowledge systems (that each have their own axiologies and ontologies) – and they story and put them into practice laterally, inter-dependently and genealogically across human and more-than-human relations directly in land.

**I-LIFE-Deep**'s fundamental premise is that learning that does not occur only for learning's sake nor that humans have the 'right to' know. Rather, learning is embedded within a constellation of values and ethics that specify that humans have a 'responsibility to' learn, know and share knowledge in direct relation/ing with humans and more-than-humans (which sets up how humans come to know and what is means to know). The creation and practice of such values and ethics, then, are not solely constructed from an anthropocentric perspective but by what the natural world requires of humans to be in ethical relation with its processes/becomings (e.g. seasons). Even more, I-LIFE-Deep involves the responsibility of putting into practice the knowledge humans have storied and come to learn – this relationship between story and practice is reciprocal, thus humans must actively facilitate the iterative and reciprocal nature of lived and storied participation with all natural world relations. I-LIFE-Deep is about attending to human and more-than-human *relationing* (the active attendance/verb to maintaining good relations) through our knowing. I-LIFE-Deep is essentially storying/theorizing, learning, practicing and living what it means to be a good relative and ancestor to land, humans and more-than-humans. In sum, I-LIFE-long-wide-deep is cumulative, fluid, adaptive, iterative, ever-becoming, storied and practiced, land-based, genealogical, inter-generational and not only occurs across different contexts/settings but also across knowledge systems and human and more-than-human relations.

I-LIFE has existed since time immemorial and independent of any forced relation with settler-colonialism and Western Science. Simply put, it is because we (human and more-than-human) are (Cordova, 2007). With that, I-LIFE and Indigenous peoples are currently in a violent, hegemonic relationship with settler-colonialism and Western Science, thus I-LIFE has adapted to address this forced relation through resurgence and collective continuance. With that, I-LIFE does not seek inclusion into the settler state, i.e. it is not multi-cultural education or knowledge to be absorbed and interpreted through settler epistemologies, ontologies, normativities and learning settings. Instead, I-LIFE is after Indigenous futurities on Indigenous peoples terms/values and does so with an additional set of tools (i.e. decolonization, resurgence and survivance). By doing so, I-LIFE achieves multiple moves simultaneously to maintain trajectories of Indigenous peoples' collective continuances. First I-LIFE maintains active presence and practice of Indigeneity according to their 'original instructions', i.e. Indigenous stories/theories of creation, ontologies and epistemologies. Secondly, it disrupts the strategic erasure of Indigeneity and dominance of settler colonialism on Indigenous lands and across learning settings (be they Indigenous or settler). Thirdly, it reclaims the relation thus far with Western Science/ways of knowing by integrating and practicing it in ways that are interpreted and made meaningful through Indigenous ontologies and axiologies (i.e. put into practice by Indigenous peoples according to their stories/theories, values and responsibilities to the natural world). Even more, I-LIFE's reclaiming of Western Science/ways of knowing results in re-humanizing it by growing its shortcomings and putting it back in direct, reciprocal relations with past, current and future generations of humans and more-than-humans. The following section outlines the design and lived practice of I-LIFE-long, -wide and – deep through Indigenous Land-based Science Learning (ILBSL).

## SECTION V

### For us, By Us: Indigenous Land-Based Science Learning

The second component to this thesis, as Indigenous Learning in Informal and Formal Environments (I-LIFE) would necessitate, is the practice of I-LIFE in context and relations – answering the question "what does I-LIFE-long-deep-wide look like in practice, practice that is intentionally built in land and human and more-than-human relations." This question is taken up in the context of an Indigenous Land-Based Science Learning (ILBSL) that is storied and practiced from Cheyenne ontology, epistemology, axiology, methodology and territory, thus making it science learning 'for us, by us.' However, before this is outlined, it is important to put ILBSL in relation to outdoor, place-based and land-based education.

**Outdoor and Place-based Education.** Outdoor and placed-based education are learning settings that are predominantly constructed to occur outside of the classroom and build upon Western science that is first learned in formal, classroom based learning settings. Furthermore, they are built from and center settler orientations to land, place and time by default, i.e. settler narratives, knowledge and orientations are taken up as 'The only knowing' to/of land. Outdoor and placed-based education make this hegemonic presumption in the same way that formal, indoor science learning settings do. This move reifies the settler fiction that Indigenous land and peoples exist for the service of settler present and futurity. Therefore, though outdoor and placed-based education connect and build relations with nature in ways that are not possible in formal, classroom based settings, they nonetheless perpetuate the hegemonic presence and centering of settler normativity and science on Indigenous lands. Through zero-point epistemology (ZPE) (Mignolo, 2007), placed-based and outdoor education simultaneously dismiss and supplant

Indigenous orientations and knowledge to/with land all toward settler legitimacy and Indigenous erasure (Bang, et. al, 2014).

**Land-based Education.** To move beyond the enclosures and erasures of outdoor and place-based education and re-center Indigenous ontologies and axiologies on Indigenous lands, Indigenous scholars/everyday citizens have storied and practiced a new paradigm referred to as land-based education (Tuck, McKenzie, & McCoy, 2014; Bang et. al, 2014; Simpson, 2014). Land education centers Indigenous stories, belongings, practices, values and orientations to land, space and time, while simultaneously disrupting settler normativity, timescales and ZPE. That is "Land education puts Indigenous epistemological and ontological accounts of land at the center, including Indigenous understandings of land, Indigenous language in relation to land, and Indigenous critiques of settler colonialism…" while simultaneously dislocating settler futurities (Tuck, McKenzie, & McCoy, 2014: 13). Indigenous Land-based Science Learning (ILBSL) seeks the re-centering of Indigeneity and dislocation of settler normativity to land similarly to land education, while also making new possibilities for youth's interdependent-Indigenous-sense-of-self and science identities through I-LIFE-long, -wide, and –deep learning, unceded time, emergent everyday Indigeneity and in specific grounding in Cheyenne ontology, epistemology, axiology and territory.

**Indigenous Land-based Science Learning.** The story, design and practice of Indigenous Land-based Science Learning (ILBSL) were grounded in Cheyenne ontology, epistemology, and axiology and directly on/with Cheyenne territory with Native youth. ILBSL emerged as a science learning settings that was 'for us, by us' – meaning it was made, storied and practiced by Cheyenne people and values for Cheyenne people and relations to land on Cheyenne territory. A principle foundation of ILBSL, then, was Sweet Medicine's adaptation theory – a Cheyenne

story rooted in Cheyenne ontology and axiology – that is outlined below in the author's own words:

> At the beginning of time, Sweet Medicine, a sacred Cheyenne leader and scientist, was apprenticed and trusted with the original instructions of life at Sacred Bear Butte. After he received these instructions he was responsible for sharing them with the Cheyenne people, so the Cheyenne would know and practice what it means to be human. Over his many lives, Sweet Medicine offered countless teachings that the Cheyenne have grown, practiced and adapted thus far, including Cheyenne epistemology and Science. Before his last life, Sweet Medicine provided one last theory/vision to the Cheyenne people. He told the Cheyenne there would come a time when white bearded men with strange buffalo would come and eat up all the grass – they would seek to change everything, including the land and Cheyenne lifeways. Sweet Medicine said this would be a time where the Cheyenne people would be asked to remember, adapt, and practice their Cheyenne values. He said that if the Cheyenne did not adapt, they would become like them and in so doing, lose their humanity (i.e. their "Cheyenne-ness") and natural relations.

From a Cheyenne worldview and history, the Cheyenne and much of the world are currently in this time of change that is a result of forced historical and ongoing settler-colonialism within/on the Cheyenne Territory, including the forced learning and practice of Western science in formal and informal learning settings, tribal laws and policies, and many daily facets of Cheyenne life – a theory/vision posited by Sweet Medicine before first contact was made between Cheyenne people and white settlers. The Cheyenne are not the only Indigenous peoples who are confronted with this change and the call for adaptation. Potawatomi scholar Kyle Whyte aptly contextualizes adaptation as a global phenomenon for Indigenous peoples who are forced to adapt in the face of settler-colonialism and settler, anthropogenic climate change. Whyte (2013) maintains that, "Tribal concern with collective continuance, then, is a concern with maintaining the capacity to be adaptive with respect to relational responsibilities, or all those relationships and their corresponding responsibilities that facilitate the future flourishing of tribal livelihoods" (519).

Collective continuance precisely aligns with Sweet Medicine's adaptation theory and were employed in ILBSL. ILBSL holds seriously that it is incumbent upon current and future generations of Cheyenne people to put Sweet Medicine's theory into practice so as to continue Cheyenne present/ence, futurity and collective continuance.

Framing ILBSL from Sweet Medicine's adaptation theory is a practice of the I-LIFE-long-wide-deep story, especially in the context of re-centering Indigeneity for Indigenous youth's science learning. First, Sweet Medicine's theory firmly reasserts the active presence and centering of Cheyenne orientations to land, place and space, while simultaneously disrupting the recent, but dominant settler narrative of manifest destiny and Indigenous victimhood. ILBSL makes explicit that time and Cheyenneness did not begin (nor end) when settlers came to Turtle Island – this is the I-LIFE-long piece as Cheyenne presence has existed since time immemorial directly on their territories. Secondly, Sweet Medicine's theory becomes paramount for Cheyenne persons today as it is the work of current generations to be good ancestors/relatives by creating adaptation practices and stories with this 'new way of life,' according to Cheyenne ontology and axiology, directly in land and human and more-than-human relations – this is the I-LIFE-wide piece. Lastly, Sweet Medicine's theory informed ILBSL's positioning of youth as good relatives/bio-cultural restoration scientists who are now responsible for putting Sweet Medicine's theory into practice by adapting and synthesizing Western science with Cheyenne knowledge/science and in ways that forward Cheyenne collective continuance – the I-LIFE deep piece.

**Unceded Time and ILBSL Dimensions.** ILBSL strategically planned for learning to occur in the summer months as this is 'unceded time' to the state – i.e. it is Indigenous time and space that has not been enclosed by compulsory, settler schooling, formal science learning

expectations and futurities. Furthermore, it is a transformational, generative space for Indigenous peoples to attend to and reclaim their forms of learning, knowledge and values and pass them on to future generations without the imposition of settler learning yardsticks or benchmarks. Through unceded time, ILBSL opened up and framed multiple dimensions with Indigenous youth. These dimensions are cross-cutting, inter-dependent and iterative – meaning they work and change across and with each other over time, practice and contexts collectively with/by Indigenous youth scientists. ILBSL intentionally utilized these dimensions to contextualize and collectively design and practice a number of bio-cultural restoration scientist practices with/by Indigenous youth as they are dimensions thus far (Massey: 2005), that impacted their identities and responsibilities as good relatives/bio-cultural restoration scientists. These dimensions included the following: Sweet Medicine's Adaptation Theory (as outlined above); emergent everyday Indigeneity and an interdependent-Indigenous-sense-of-self; epistemological and ontological translations/ors; settler-colonialism & racialization of Indigeneity; and Indigenous nationhood and governance.

Emergent everyday Indigeneity and an interdependent-Indigenous-sense-of-self. The nature of an emergent everyday Indigeneity paradigm allowed for youth to become and emerge, through daily practices, in their interdependent-Indigenous-sense-of-self and -of-responsibilities to land, community and relations on a daily basis – a critical ground in which to empower and nurture Indigenous youth becomings (Fryberg and Markus, 2007). Thus nothing was foreclosed nor pre-determined for what is possible for their identities and trajectories. This paradigm was informed by multiple elements that Indigenous peoples interact with/practice daily, including those designed from their own knowledge systems and values (e.g. Sweet Medicine's adaption theory and Cheyenne language) as well as those forced upon them through the violent

restructuring of Indigeneity by settler-colonialism (e.g. the Northern Cheyenne Reservation and compulsory schooling). This paradigm set up learning to be situated within youth's everyday lives and meaning making – a powerful move that positioned youth as scientific experts and practitioners of their own knowing (Zimmerman and Bell, 2014). More specifically, this paradigm situated Indigenous youth in daily, lived, micro-embodiments of Indigenous/Cheyenne ontology and axiology (i.e. story/theory was lived and put into everyday practice, meaning, relations), while simultaneously affording the daily exercise of everyday methods of Indigenous resurgence in ways that empowered youth to reclaim their Indigeneity and disrupt settler-colonialism (Corntassel, 2012).

Epistemological and ontological translations/ors. Another crucial dimension to ILBSL included the preparation of Indigenous youth to adeptly navigate, synthesize and translate across-settings and across-bodies of knowledge, i.e. Indigenous and Western sciences, with/according to Cheyenne Science and values. To do this, bio-cultural restoration science was taken up in ILBSL as a prime translation ground in which to apprentice Native youth as scientists in Indigenous and Western Science traditions for a few reasons. First, it held space and recognition of the direct destruction that has been done (and is being done) to the natural world by humans, including anthropogenic climate change. However, ILBSL also intentionally named the historical and ongoing role of settler-colonialism in the destruction of the natural world and relations, especially on Indigenous lands – and how it must be dismantled if true natural world relations are to be fully restored and done so for Indigenous peoples' collective continuances – a dimension that is new to bio-cultural restoration science, literature and practice. Secondly, bio-cultural restoration simultaneously implicates humans as being responsible for restoring the natural world relations. However, what ILBSL and Indigenous Sciences add to this is that humans are

inherently a part of (not apart from) the natural world and have a responsibility for actively attending to natural world relations and relationing since time immemorial (not time since humans began destroying the world at some arbitrary point in time – this is a Western Science orientation to the natural world). ILBSL and Indigenous Sciences also do not hold a fixed view of the natural world where humans have to work towards restoring a static, archetype state of the natural world. Instead, ILBSL and Indigenous Sciences are after the reconnection and renewal of humans in all their relations, human and more-than-human – i.e. the active restoration of/attendance to natural world relations and relationing is what matters and will cumulatively lead to a healthy, thriving world. In so doing, humans become more fully human as well.

Despite the distinct differences that Indigenous and Western Sciences have, they can also find intersections that become productive for preparing Indigenous youth to be adept and expert at both Indigenous and Western Sciences. This hybrid approach is critical as Indigenous communities and nations today need citizens who can expertly navigate and synthesize these Sciences in ways that are productive and accountable to Indigenous present/ence, futurities and collective continuance – especially in this time of compounding anthropogenic climate change (Bang and Medin, 2010; Whyte, 2013). Lastly, as discussed previously, school-based science learning has been predominantly hostile to or dismissive of Indigenous ways of knowing, thus, the everyday emergent Indigeneity framework enabled ILBSL to apprentice youth to carry on these practices and learning on their own so that they become the experts and active makers their own learning (Simpson, 2014) beyond their time in the program. This was extremely productive for Indigenous youth as it opened up a way for them to apply their skills as epistemological and ontological translators in their school-based science learning and reclaim these settings in ways that forward their collective continuance on Indigenous terms.

Settler-colonialism and racialization of Indigeneity. Another dimension that framed ILBSL was the explicit naming of settler colonialism and the historical and ongoing impacts it has for Indigenous peoples and relations to land, including how it employs Western Science to advance its interests and racialize Indigenous peoples. To get at this, ILBSL made explicit that sciences are cultural, meaning they are a socially constructed way of understanding the world that is informed by a society's ontology, axiology and methodology. Western Science, for example, is informed by euro-centric values and beliefs. Given Indigenous youth predominantly are socialized and taught from early ages that western science is 'the inherent way of knowing' the explicit explanation that Western Science is culturally constructed was a powerful place to begin as it deconstructed Western Science's false claim to supremacy – this then opened up new possibilities of what 'science' is for youth. This newly opened space was then attended to by introducing youth to Indigenous knowledge, sciences and practices and their rich lineage to these as Cheyenne persons.

Moreover, Indigenous youth are citizens of their own nations, yet they are often implicitly and explicitly socialized as racialized beings within and outside their communities (Brayboy, 2005). Thus, ILBSL made explicit that racialization of Indigeneity is a dangerous, well-thought out tool of settler-colonialism as it turns the conversation (and thereby the possibilities and becomings) of Indigeneity into one about race, not citizenship. This move is strategic and achieves the ongoing present/ence of settler-colonialism because it turns Indigenous peoples/Indigeneity into (compulsory) subjects of the settler state – they simply become additional, though racial minority, citizens. This forced inclusion forwards settler futurities and erases Indigenous ones by stripping Indigenous citizens of their inherent nationhood that exists previous to, independent of and beyond the settler state. To acknowledge Indigenous nationhood

is to directly contradict and upset the settler narrative that North America, i.e. Indigenous territories, was empty and ready for conquering (including the Indigenous peoples who already lived there). Thus to protect its false narrative, belonging and futurity on Indigenous lands, settler-colonialism must turn Indigenous peoples into racialized beings who are lost subjects in need of saving and belonging by/to a white settler state. ILBSL explicitly pushed back and unveiled this racialized framing of youth's identities and belongings to land with youth.

Indigenous nationhood and governance was another key dimension that was taken up in ILBSL to develop youth's identities and becomings as 'good relatives'/bio-cultural restoration scientists. Indigenous peoples are sovereign, political nations in and of themselves. This political and legal sovereignty originates from each Indigenous nations origin stories and original relations to land. Indigenous peoples are citizens of their own nations and forced citizens of the U.S. settler state (e.g. Indian Citizenship Act of 1924). Thus, according to Cheyenne ontology, to be good relatives Indigenous youth scientists work in service not only to land and relations, but also in ways that forward Indigenous nationhood and sovereignty. The Northern Cheyenne, for example, have and have always had their own form of Indigenous governance, that was given to them by Sweet Medicine. Cheyenne governance involves a number of complex dimensions, but in general, it is comprised of the Council of 44, societies and the sacred hat and sacred arrows – thus it is not simply about the physical world, but also the spiritual (even the word governance falls short of fully encapsulating what has guided the Cheyenne for millennia). With this, settler-colonialism has violently rearranged Indigenous forms of governance into mini-federal bureaucratic government systems, known as Indian Reorganization Act governments (1934, IRA). The Northern Cheyenne Tribal Government (NCTG), for example, is federally-recognized by the U.S. as an IRA government. As such it has a constitution, an executive branch (President

and Vice-President), a legislative branch (tribal council members from each Reservation district) and a judicial branch (tribal court and judges). Federal recognition, albeit forced and used to maintain the settler infrastructure and power on Indigenous lands, cannot be understated as it has real and lasting physical, monetary and social consequences for Indigenous peoples. Therefore, ILBSL clarified the distinction between inherent Indigenous nationhood and federally-imposed-recognition for Indigenous youth scientists as one of their responsibilities includes being expert and adept at both systems, thus far, and finding ongoing methods to leverage both for Indigenous collective continuance.

**ILBSL Good Relative/Bio-Cultural Restoration Practices**. The above dimensions framed the context, thus far, in which ILBSL worked from. The "how" of ILBSL manifested in a constellation of practices – practices that are collectively built, renewed and grown by youth scientists. The following practices were informed by Indigenous and Western Science traditions, while maintaining their design and accountability to Indigenous ontology, axiology and collective continuance. These practices were used to develop Indigenous youth's learning of and identities with sciences as they positioned and socialized them on a daily basis as practicing scientist experts, directly on the land. These practices were collectively storied, lived and made meaningful by youth in relation with human and more-than-human-relations. Even more, youth did not engage in these practices for the sole sake of learning them or without context – rather they practiced them directly in context, meaning their learning and practice resulted in concrete bio-cultural restoration for/by the Northern Cheyenne Reservation and government (i.e. I-LIFE-Deep piece). Lastly, ILBSL paid youth as full-time temporary employees for two-and-a-half months. This became critical and productive for Indigenous youth as ILBSL simultaneously apprenticed them in being a good relatives/bio-cultural restoration scientists, while also fulfilling

the immediate financial responsibilities they have to family. The practices are outlined in detail below.

**Cheyenne language pedagogy and practice**. A first practice that opened up ILBSL from a Cheyenne ontology and axiology was the learning and practice of the Cheyenne language by youth scientists. Youth were encouraged throughout the program to speak what Cheyenne they could and to not feel ashamed for speaking their language. The shame of speaking stems from systemic, settler assimilation via border schools whereby their elder relatives were forcibly removed from their homes and sent to white boarding schools where they were forbidden to speak their language (and beaten if they did) and coercively taught to speak only English. Thus, this shame of speaking one's language has been passed down to current generations. To combat this, ILBSL explicitly exposed this genocidal attack on previous generations to youth and re-framed their language speaking as a resurgence and reclaiming of who they are, and that they could do so safely through ILBSL and with each other. This safe space was cultivated by adults, but most impressively by youth themselves as it became space where they could explore language learning proudly and alongside each other. ILBSL specifically took up an everyday resurgence paradigm (Corntassel, 2012) with youth's Cheyenne language speaking by encouraging youth to speak what Cheyenne they can, when they can during their everyday Indigeneity (e.g. when greeting each other, offering a prayer, smudging, when talking with little ones or plants).

After this collective space was made explicit and cultivated, the Cheyenne language learning and speaking became one of the most fascinating practices to unfold as youth organically assumed the initiative and responsibility to teach each other how to introduce themselves in Cheyenne and where they are from. It almost provided that internal 'permission'

they needed so as to be made safe (and not ridiculed for their mistakes or made fun of) when speaking the language. Many youths entered the program already speaking some of the Cheyenne language and knowing their Cheyenne names. For those youth who were newer to the language, they were encouraged and taught by their peers to speak basic Cheyenne language and their individual Cheyenne names. This positive peer mentoring and curiosity further prompted youth to learn their Cheyenne names directly from family members. Thus, youth brought together Cheyenne language learning and pedagogy they were taught at home and put the pedagogy and language into practice with each other throughout the ILBSL program. As a consequence, by the end of the summer, all youth were able to speak basic greetings and introduce themselves in Cheyenne. For example, youth learned how to say (and spoke with confidence):

> Pevehe e'šeevehe, _____ na hehe šehe vehe. To'tooe manhano na hestahe.
>
> *Good day. My name is _____. I am from Ashland.*
>
> Nea'eše.
>
> *Thank you*.

The Cheyenne language pedagogy and learning were truly mediated and motivated by youth scientists with ongoing encouragement by adult mentors via an everyday resurgence paradigm. Even more, their Cheyenne language speaking directly overlapped with other bio-cultural restoration scientist practices. For example, youth greeted and introduced themselves when they presented their research projects at the conclusion of the program and when they recorded their collective youth digital story. Beyond the actual speaking of the language, this Cheyenne language practice became a powerful place for youth to reclaim their identities as Cheyenne people as they were able to speak to each other in the language that their ancestors did, including

Sweet Medicine. This was a practice of I-LIFE-long learning as it positioned youth back in relation with their ancestors, the very ancestors who passed along the language through their ancestral legacy and whereby youth inherited it from their belonging to their rich, land-based lineage. In future years of the program, ILBSL will continue to deepen this youth-led, everyday resurgence Cheyenne language pedagogy and learning setting.

**Cheyenne orientation to time, place & becomings**. A second bio-cultural restoration scientist practice included explicit centering of Cheyenne orientations to time, place and becomings. Just as the thesis opened with Cheyenne theory and orientation to time, so too did ILBSL. Adults in the program utilized storywork (Archibald, 2008) and written texts to share Cheyenne histories and stories. For example, throughout the program an adult mentor shared their iteration of the Cheyenne creation story, the Cheyenne theory of the great race and the Sweet Medicine Adaptation theory with youth. Youth were then asked to collectively discuss and make meaning of them. Even more, youth furthered their Cheyenne storywork when they conducted their research projects where they interviewed Cheyenne elders and other Cheyenne community members about Cheyenne belonging to place, sacred places, medicines/healing practices and Ethnobotany. Youth also engaged in written texts on Cheyenne knowledge and science for their research projects. This practice worked hand-in-hand with another ILBSL practice, i.e. **reading, discussing and making meaning of peer-reviewed journal articles and books** predominantly by Indigenous scholars and scientists. Youth engaged in a number of readings that covered the following topics:

- Cheyenne Science: For example, *Plant Lore of the Northern Cheyenne* by William Tallbull (expert Ethnobotanist scientist who was apprenticed by his grandmothers);

- Indigenous orientations and narrations to history: For example, *An Indigenous People's History of the United States* by Roxanne Dunbar-Ortiz;
- Native youth identities & learning: For example, "Looking for learning in all the wrong places: urban Native youths' cultured response to Western-oriented place-based learning" by Tracy Freidel (2011) and "Land as pedagogy: Nishnaabeg intelligence and rebellious transformation" by Leanne Simpson (2014);
- Indigenous and Western sciences and research methodologies: For example, *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants* by Robin Kimmerer (Potawatomi scientist and professor) and "What is Indigenous research methodology?" by Shawn Wilson (2001);
- Federal Indian Law and governance: For example, *American Indians and the American Political* System by David Wilkins and Heidi Kiiwetinepinesiik Stark;
- Indigenous and Western forms of Mapping: For example, "Indigenizing, contextualizing, and applying GIS technology and spatial analysis to meet the needs of Native students and communities: A view from the sky" by Lisa Lone Fight (Mandan, Hidatsa and Arikara Scientist & Educator) (2012); "Notes toward a Native Feminism's Spatial Practice" by Mishuana Goeman (Tonawanda Band of Seneca Professor) (2009), and "Facing the Future: Encouraging Critical Cartographic Literacies In Indigenous Communities" by Jay Johnson, Renee Pualani Louis and Albertus Hadi Pramono (2006);
- Decolonization and Indigenous Resurgence: For example, "Re-envisioning resurgence: Indigenous pathways to decolonization and sustainable self-determination" by Jeff Corntassel (2012); and

- Lastly, youth engaged in a number of different readings and sources when they compiled their references for their research projects.

These good relative/scientist practices were further augmented by another practice, **i.e. on-site and online guest lectures by practicing, professional Indigenous scientists**. Guest lectures covered a wide-range of topics and professions that intersected with bio-cultural restoration science in some capacity. For example, one guest lecturer was a Native graduate student at the time and was pursuing her Ph.D. in remote sensing. She shared her master's research on Indigenous geoscience with youth, while also teaching them remote sensing and GPS methods that can be employed respectfully with and by Indigenous communities. Another guest lecturer was a recent Native graduate in Biology who was serving as a Fisheries Biologist for U.S. Fish and Wildlife Service in Montana. He shared his interests in STEM, post-secondary experiences and career trajectory in Fisheries Biology. He also taught youth how and why to measure water turbidity and temperature at a local fish habitat on the Reservation. A third guest lecturer was a lifetime, professional Native scientist who worked for his tribe at the time. He provided a lecture to youth regarding Crow geography and wayfinding, oral histories and relations to place, including the Crow Great Migration theory. Additionally, local practicing Cheyenne scientists presented their work to youth that included indoor and field based learning regarding prairie dog and black-footed ferret habitat and relations, wetland and upland plants and habitats (e.g. plant anatomy, identification, ecological roles and responsibilities, and Cheyenne stories and protocols for harvesting plants) and water systems (e.g. measuring water wells and learning differences in ground and surface water) on the Reservation (these are emphasized in detail later). To further expand youth's exposure to professional Indigenous scientists, ILBSL engaged youth in pre-recorded online video lectures/talks by Indigenous scientists. For example,

Dr. Leroy Littlebear's (Blackfoot Professor) online Native Science Fellows Annual lecture series (Hopa Mountain) on Blackfoot Geology, Dr. Robin Kimmerer's TEDex Sitka talk on 'Reclaiming the Harvest,' and Dr. Greg Cajete's (Tewa Professor) talk on Indigenous Knowledge and Western Science. All of these talks were available on youtube at the time of their screening during the ILBSL program. Youth also engaged in a screening of the PBS documentary *Before There Were Parks* (2009) that chronicled Indigenous knowledges and orientations to Yellowstone and Glacier National Parks. Following each presentation youth engaged in a "debrief session" mediated by them and adult mentors. Adult mentors helped situate the presentations within the larger dimensions on ILBSL and bio-cultural restoration for youth as a way to help them position these lectures/presentations in relation to their learning, identities and becomings as good relatives, i.e. bio-cultural restoration scientists.

These ILBSL practices worked side-by-side to grow Indigenous youth's learning and identities in ways that were based in and accountable to their Cheyenne ontologies, axiologies and collective continuance. They were also intentionally academically rigorous as the breadth and depth of the readings, lectures and indoor and field-based learning reflected those at the college and graduate levels. Together, these practices also showed youth that settler racialization is a false framing used to erase their and supplant their Indigeneity so as to collapse them into the settler state and undermine the belonging and citizenship they already possess as citizens of their own Indigenous nation(s). These stories and practices also showed youth that Indigenous presence, including theirs and that of their ancestors and descendants, is not dependent upon a settler narrative or recognition. Rather, it emanates from Indigenous stories and relations to land and from the long, deep time of their lineages and presence on land (e.g. Cheyenne and Crow creation stories). Unveiling this strategic racialization of their Indigeneity became a powerful and

empowering move for youth in which to further develop their identities as good relatives/bio-cultural restoration scientists as it showed them that they are not the oppressed, impoverished racial minority victims that white settler society makes them out to be. Instead, they are in fact formidable ancestors with a deep sense of belonging and responsibility to land, ancestors and future generations. As powerful as this move was, it does not negate the fact that Indigenous youth experienced and continue to experience racism on a regular basis and that settler-colonialism is ongoing– however, it became an everyday, empowering way for them to resist this racialization in their daily lives, not just in science learning settings, as it provided them a more expansive (i.e. an Indigenous) way in which to conceive of their interdependent-Indigenous-sense-of-self/identities and -of-responsibilities to land, relations and collective continuance (Romero, et. al, 2013; Whyte, 2013).

Even more, the reading and discussion of peer-reviewed readings and presentations conducted by Indigenous scholars and scientists served as role models and inspiration to Indigenous youth as youth saw for themselves that this type of work is possible, i.e. science/knowledge made meaningful by Indigenous scholars and scientists in the literature and directly in land/community. Further, ILBSL apprenticed youth to make meaning of and interpret knowledge/information from a variety of sources so as to draw critical conclusions of their own. Additionally, what is key in these practice is that they made explicit the different epistemologies, ontologies and axiologies that inform different works, not just the differences in results or conclusions from one body of knowledge. Youth were mentored to interpret and take up the differences in these works that emanate from differences in Indigenous and Western sciences and axiologies. This is where the navigation of multiple epistemologies became paramount (Bang and Medin, 2010), as well as laying the critical ground to root the synthesis of Indigenous and

Western sciences through bio-cultural restoration science. Storywork and written texts that centered Cheyenne and other Indigenous ontologies, knowledges and axiologies became key for youth as they had little to no exposure to Indigenous narratives to land inside and outside of their formal schooling experiences.

Together, these practices were direct embodiments of I-LIFE-long learning as it situated youth back in their relations and relationing with the Cheyenne stories/science they were born into, stories practiced and carried on through their ancestors who lived directly in land since time immemorial. They were also practices of I-LIFE-wide learning as they positioned youth back in relation with their non-human relatives, e.g. plants and water, as they learned the stories and protocols for knowing these relatives. These practices also embodied I-LIFE-deep learning as they deepened youth's learning and attention to their human and more-than-human relations – which is a direct practice of Cheyenne science and ontology which maintain that to be fully human, one must maintain active, everyday relationing with their human and more-than-human relations.

Additionally, a vital bio-cultural restoration practice was the completion of **field work & engagement with premier technologies that resulted in concrete bio-cultural restoration for the Northern Cheyenne Reservation and Tribe.** Across these land-based field projects, youth engaged with and applied premier GPS and GIS technologies to obtain and analyze geodata, respectively, in ways that forwarded their bio-cultural restoration work and in ways that remained accountable to Cheyenne ontologies, nationhood and collective continuance. Overall, time on the land was semi-structured – this was key as ILBSL is not concerned with controlling or determining how youth should engage with/on land, rather ILBSL endeavored to utilize Leanne Simpson's "Land is Pedagogy" paradigm when engaging youth in land-based science

learning and practice (Simpson, 2014). A key element of Simpson's land pedagogy maintains that children and youth are already inquisitive and should be positioned and trusted as active makers of their own learning. A critical role of adults then is to attend to and cultivate this learning. Thus, time on the land was partially structured to the extents of catalyzing youth to lead their learning for themselves and finding emergent mediation of their learning – i.e. those points that emerged across space/time as needed/determined by youth were then attended to by adults. This is in stark contrast to many of the formal and informal learning settings Indigenous and non-Indigenous youth are positioned in everyday, whereby time and learning is highly monitored, organized and dictated by adults. ILBSL did not want to do this, instead ILBSL sought to position youth as active makers and experts of their own learning and learning trajectories when engaged in land-based field work. The land-based field projects they completed are listed and detailed below.

Prairie dog habitat mapping. Early on in the program, youth were shown how and why prairie dogs are keystone relatives to the prairie by several adult Indigenous scientists through indoor and land-based pedagogy (Simpson, 2014). Before going out in the field, youth listened to a presentation by Indigenous and non-Indigenous scientists about the ecologies of prairie dog towns and the relations Cheyenne hold with these sacred relatives. Youth were then taken out on the land, specifically a prairie dog town, to learn how to utilize GPS units to collect geo-data (in the form of polygons) so as to measure the size of the town utilizing an acreage unit (acreage of prairie dog towns is used as one measure to determine the health of these habitats over time and their potential to repatriate the endangered black-footed ferret to their Indigenous territory (in order to survive, black-footed ferrets require a minimum of 1,500 acres of inter-connected prairie dog towns, i.e. within $\leq$1.5 km of each other)). Youth obtained acreage of the prairie dog town

(and those subsequently mapped by youth throughout the summer) in teams. One to two members preceded the other team members holding the GPS unit by about 30 feet and planted flags around the perimeter of the prairie dog town. The youth holding the GPS unit then followed these flags and picked them up as they passed. This method was used so as to accurately and efficiently map the perimeter of these towns as in some instances some prairie dog burrows may appear to be active but in fact are not and therefore cannot be counted as active prairie dog town acreage for the purposes of re-introducing the black-footed ferret. Following this day and half of training, youth were assigned up to ten active prairie dog towns on the Reservation and were relied upon as expert scientists who were responsible for collecting data in the field and bringing it back to the office for analysis and aggregation in ArcGIS – just as any other adult scientist in the department would have been. Youth's prairie dog mapping/data collection resulted in concrete bio-cultural restoration for the Northern Cheyenne Tribe and government as this data was needed to aid the Tribe's continued efforts in recovering, repairing and repatriating relations in these habitats, including but not limited to the repatriation of the black-footed ferret to their Indigenous territory (which includes the present-day Northern Cheyenne Reservation).

Cheyenne Ethnobotany. ILBSL utilized a land-based pedagogy (Simpson, 2014) to teach youth and engage them in the practice of Cheyenne Ethnobotany. First, youth were provided shared copies of *Plant Lore of the Northern Cheyenne* (by William Tallbull). This book outlined the Cheyenne name (in Cheyenne and English) and English Scientific name of plants and everyday Cheyenne uses of these plants. Youth's learning of Cheyenne Ethnobotany was complemented by storywork by adult mentors in the program so youth could also learn Cheyenne stories of plants, the protocol for attending to active relations with plant relatives and the time of year to harvest them via the oral tradition. Youth were taken out on the land to learn

about plant relatives and how to identify plants as they are in their everyday natural relations, as well as put Cheyenne plant protocols into practice. Although adults actively mediated youth's learning of Cheyenne Ethnobotany, ILBSL leveraged land pedagogy so youth could be positioned as active makers and practitioners of ethnobotanical knowledge and protocols. For example, when ILBSL brought youth out on to the land to learn and practice Cheyenne Ethnobotany youth were shown some plants and told stories about these plant relatives. Youth were then encouraged to navigate land on their own and spend time talking with plant relatives on their own or with a peer. Youth were encouraged to speak whatever they wanted with plant relatives, sketch them and simply be in land. Another example of Indigenous youth's practice of ethnobotanical knowledge and protocols resulted when they collectively harvested chokecherries and man sage. They cleaned and prepared the chokecherries and made the sage into bundles. Youth then gifted a bag of berries and sage bundles to their research project interviewees. These active practices of identification and harvest achieved bio-cultural restoration for the Northern Cheyenne land base as it reconnected youth, elders, community members and plants in direct relation with each other.

Measuring water wells. The ILBSL also introduced youth to their water relative by teaching youth the importance of ground-water monitoring through water wells. Youth were mentored in this practice by an Indigenous Water Scientist who took them out on the land, specifically a water well site. This particular well measured the ground water flow near one of the Reservation's main watersheds. An Indigenous Water Scientist explained that ground water is one part of the water cycle and why monitoring this particular stage is important. Youth were taught that ground water monitoring is a responsible practice of Indigenous science as it positions humans in active relation and relationing with water. Through this regular active

attendance to ground water, Tribal Water Scientists can determine the health, quality and flow of ground water over time. The Indigenous Water Scientist further explained the methods in manually measuring the flow of water wells, which involved the insertion of a narrow PVC pipe into the well until it was submersed below the water table and took on water. The next step involved pulling the PVC pipe back up the surface with its attached rope and pouring the water from the pipe into a large plastic jug. This process was repeated until the jug was full with water. The next step involved calculating the length of time that was needed to fill the large plastic jug, along with the volume measurements of the PVC pipe and plastic jug to determine water flow on that particular date. Youth were shown these steps by the Indigenous Water Scientist, but were then responsible for completing the task from start to end so as to practice it for themselves and conduct their own calculation of the water flow at this well site. The youth's efforts resulted in concrete bio-cultural restoration for the Northern Cheyenne Tribe as their calculation was used for that day's water well flow measurement.

The land-based field project approach was a particularly productive pedagogy for Indigenous youth scientists as it engaged in them in direct youth/learner led bio-cultural restoration practices, which culminated in the production of data that was utilized for the Northern Cheyenne Tribe's ongoing management and monitoring of Tribal wildlife, plants and water on the Reservation. Youth's land-based field projects were reflections of I-LIFE-Long-Wide-Deep learning. First, I-LIFE-Long manifested in these field projects as Indigenous youth went out on the land and built upon their Indigenous knowledge lineage about particular relatives and 'updated' their Tribe's collective knowing/knowledge for present and future generations (which further led to the advancement of the Tribe's sovereignty and self-determination around wildlife and water management). Secondly, I-LIFE-Wide was taken up in the land-based field

project pedagogy as Indigenous youth scientists employed their Indigenous knowledges and those from the Western tradition to understand their natural relations with prairie dogs, plants and water. They also employed these traditions in obtaining data on the health of their relations. Moreover, they were positioned in direct relation and learning with/from their natural relatives. Thirdly, I-LIFE-Deep emerged in these field projects as Indigenous youth actively attended to their relations and relationing with prairie dog, plant and water relatives. In sum, these land-based field projects served as an authentic culmination of Indigenous youth's identities as good relatives/bio-cultural restoration scientists as they put their knowing in to direct, lived practice with/on the Northern Cheyenne Territory and in service to Cheyenne collective continuance.

**Storywork journals**. Storywork was furthered implemented by youth by keeping and maintaining personal journals throughout the program. Youth utilized their journals as another tool in which to make meaning of their everyday Indigeneity experiences and identities with the readings, guest lectures and field/land work the program engaged them in. For example, Youth utilized their journals to write out their thoughts and observations when out in the field/out on the land – this was a crucial mediation of their apprenticeship as good relatives/bio-cultural restoration scientists because they made meaning of and interpreted readings and Indigenous scientists stories/theories directly in their active relation/ing with land. Youth were asked (not required) to share entries their journal entries with other youth and adult mentors in the program in a collective setting. This was a productive practice to engage youth in scientific reasoning and arguments from a storywork paradigm that centered Indigenous ontologies and axiologies (and not in the ways that are typically defined from a Western science paradigm). What is critical and made possible with/through storywork is that it privileges processes, becomings, relationships and relationing that emerge in that moment amongst the human and more-than-human relatives

that are present and participating at particular moments in time, land and place (which would not otherwise emerge should even one relation be absent) (Archibald, 2008). Thus storywork is less concerned with "a" or "the" right answer when employing natural world/scientific reasoning and arguments. This becomes critical when preparing Indigenous youth as practicing relatives/scientists as it facilitated a safe space (via journals) for youth to develop their reasoning and arguments and then put them into collective relationing with each other to develop collective storywork reasoning, argument and story/theory about the natural world (i.e. I-LIFE-Wide learning). Even more, production of youth-led storywork reasoning and argument is not static nor satisfy that "one" or "the" answer Western Science paradigm, but is rather ever-becoming as it keeps space for changes in relations and natural world phenomenon – this is a direct practice of I-LIFE as I-LIFE maintains that knowledge production is iterative, ever-evolving and adapting to the state of natural world relations, thus far.

**Design and fulfillment of a research inquiry using Indigenous and Western Research Methodologies.** Another practice and culmination of ILBSL was the design and fulfillment of a research inquiry by Indigenous youth scientists. Youth synthesized Indigenous and Western sciences and research methodologies to design, address and conduct their inquiry. Youth were mentored throughout the program to conduct such a synthesis via the practices outlined above and by facilitating multiple, explicit research and writing sessions. One of the first sessions ILBSL facilitated with youth focused on explaining to youth what is meant by "research" (from Indigenous and Western paradigms), the basic structure of a research inquiry (i.e. Research Question, Introduction, Methodology and Methods, Results, Analysis and Conclusion sections) and Indigenous and Western research methods (e.g. storywork, interviews and secondary sources). About half-way through the program, youth were asked to select their

research topic and design a research question that most interested them. Their final research inquiries resulted in the following:

- "Sacred Plants of the Northern Cheyenne": This inquiry asked: How can Traditional Northern Cheyenne knowledge and Western knowledge systems of plants be combined to create a meaningful understanding of wild medicinal plants and their uses?
- "Resource water vs value of water: Indigenous Societies & Western Culture": This inquiry asked: Why are groundwater and surface water important in Western and Indigenous Societies?
- "Oral Tradition: A Glance at Native Plant Flower Relatives": This inquiry asked: Using Traditional Ecological Knowledge, as a framework what are the uses and importance of plant flower relatives?
- "God-made vs Man-made: Native American Medicine vs European": This inquiry asked: What are the differences and similarities of Indigenous and European medicinal practices and is one more effective than the other?
- "Orientations to land and place: Indigenous and Western Worldviews": This inquiry asked: How do people conceptualize places based on Western and Indigenous worldviews?

All of the above research inquiries were driven by a scientific investigation that utilized Indigenous and Western research methods to address the research question. Each youth designed their own interview questions, contacted their interviewees and utilized storywork methods when they 'interviewed' everyday community members who were viewed as experts in their fields (e.g. water, Cheyenne Ethnobotany, healing practices, sacred places). Youth supplemented these sources with secondary sources, such as peer-reviewed journals articles and reports. Youth then

synthesized and analyzed these sources to illustrate their results. They conducted their conclusions based off of their primary and secondary sources. Youth utilized power point to organize their research projects and engaged in several practice sessions of their presentations with each other and adult mentors to refine their presentations. Consequently, these research inquiries were truly youth-led. Figure 1 (below) is presented to illustrate how one youth conceptualized, organized and implemented Indigenous and Western Research methodologies and methods in their research inquiry:

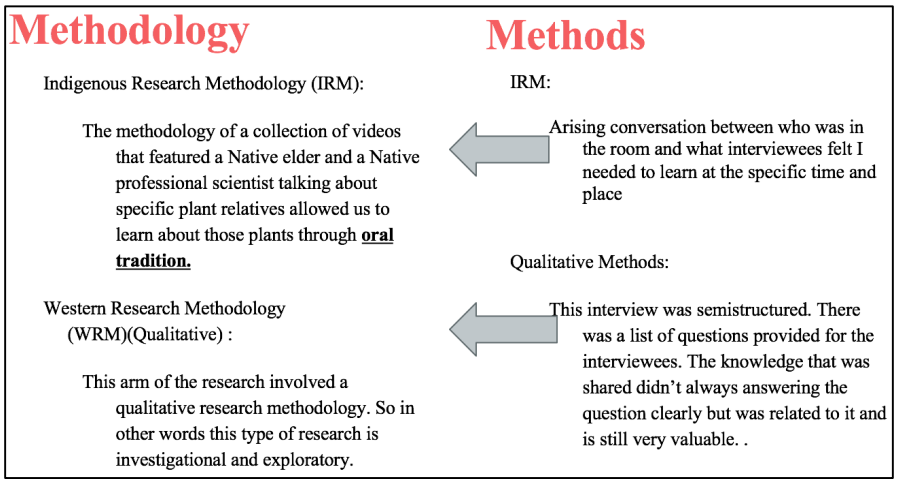


**Figure 1. Powerpoint Slide included in a Youth Scientist's research project**

Youth organized their research inquiries into a power point document so they could present their research during the-end-of-the-program symposium. The symposium was an ultimate culmination of of I-LIFE-Long and their becomings as bio-cultural restoration scientists as they presented original work they solely conducted and authored (thereby contributing to their legacy they will leave for future generations), and where those humans who matter most to them bore witness to their embodiment as practicing scientists, i.e. family and community members. Even more, youth presented their research at a national conference on Indigenous fish and wildlife management where audience members were lifetime, professional Indigenous scientists.

This served to extend their interdependent-Indigenous-sense-of-self as practicing bio-cultural restoration scientists to another setting as their work was taken up in national conference space by/for peer Indigenous scientists – a practice that professional scientists must engage into have their work recognized. I-LIFE-Wide was also deeply reflected in this practice as it facilitated youth's reconnection with their human (i.e. interviewees) and more-than-human relations (i.e. plants/medicines, water and sacred places) and they utilized Indigenous and Western Research epistemologies and research methodologies to do so. Lastly, I-LIFE-Deep was taken up in this research project practice as Indigenous youth scientists conducted their inquires according to their Indigenous axiology, i.e. in ways that maintained ethical relations with human and more-than-human relatives.

**College preparation practices**. Embedded across the above bio-cultural restoration practices were college preparation practices that supported Indigenous youth in preparing for life at college and in ways that maintain their accountability to their Indigenous ontologies, axiologies and collective continuance. For example, engaging youth in critical readings and storywork journaling apprenticed them in preparing applying and making meaning from a variety of sources and constructing sound arguments. Another example, is that ILBSL taught youth how to conduct research that is ethical according to their Indigenous axiologies and ethically synthesizes Western knowing with their ways of knowing. Youth's research presentations also prepared them for college as college students must be adept at organizing their arguments/positions and publicly presenting them. I-LIFE was reflected in this practice as it extended Indigenous youth's identities and responsibilities to college (I-LIFE-Long and -Wide) and positioned college as one tool for them to continue their preparations as good relatives in attending to Cheyenne collective continuance (I-LIFE-Deep).

**Collective design and production of a digital youth story.** A last and compelling practice of ILBSL was the collective design and production of digital story by Indigenous youth scientists. Youth scientists led this digital story through and through, with peripheral guidance, encouragement and mediation by adult mentors. Youth engaged in a number of brainstorming sessions to propose and finalize the topics and dimension of their collective youth digital story. Ultimately, youth designed their digital story to reflect their lived everyday Indigeneity and their learning and becomings as Indigenous scientists that were meditated through ILBSL. Youth audio and video recorded, captured photos, compiled and produced their digital story by using their Iphones and the program's Ipad and Imovie. Youth opened their digital story with video recorded segments of them introducing themselves in Cheyenne and sharing the lineage and families they descend from. The digital story then transitioned into youth observations and critiques of how settler-colonialism seeks to racialize and enclose their Indigeneity in ways that forward settler futurities, by settlers (external colonization) and by people in their own communities (internal colonization) through audio recording and images that reinforced their audio narrative (e.g. a photo of a white female model wearing only a bikini and headdress on a runway). Youth pushed back on this by highlighting the learning and becomings they achieved through ILBSL and how ILBSL empowered them to reclaim their Indigenous identities. In the video they stated:

> "We have been gifted with a sacred legacy of strength, resiliency and traditional knowledge. This knowledge lives on within our very beings. Our DNA, hearts, spirits and lands give sanctity to our people. The projects we completed required us to spend time, explore and reconnect with the Cheyenne homelands. As witnesses to Maheo'o's creations we can see that there are elements of human nature that mimic patterns of the natural world."

The digital story proceeded to address the following questions, respectively:

- *"How can Northern Cheyenne culture and land be preserved?"*
- *"What responsibilities do we hold to the land?"*
- *"What can our plant relatives teach us as humans?"*

To address these questions youth illustrated images of them engaging in bio-cultural restoration scientist practices over the course of their participation in the ILBSL program and offered their individual responses to each of the above questions. The shared youth message of the first question expressed their strong, interdependent-Indigenous-sense-of-selves and that they have a responsibility to attending to and carrying on the sacred legacies and responsibilities their ancestors gave them. Their collective message to the second question articulated their responsibilities in reclaiming their relationships and relationing to Mother Earth, especially given the cumulative destruction of the natural world by humans. The last question was addressed by each youth where they highlighted a plant relative that spoke deeply to them and taught them lessons in being human. Therefore, youth discussed different plant relatives and the teachings they learned from their plant relative. For example, one youth chose to talk about the plant known as Black Root to Cheyennes (or Echinacea) that is used as a general numbing agent, e.g. toothaches. One brief lesson she offered was that one can be beautiful and practical. Another youth chose the plant known as Elk Mint to the Cheyenne (or Bee Balm) that is used to perfume everyday items (e.g. pillows), one's self or one's horses. She told the story about how, according to Cheyenne customs, when brothers and sisters become older and begin their own families they can no longer talk with each other. So to show he still had love and care for his sister, a brother would rub Elk Mint all over his sister's horse and when she went to ride or feed her horse she would smell the perfume odor of the flower and she would be reminded of the love she and her brother still held for each other. This youth said that this plant reminded her of her brother as she

does not get to see him often, but when they do see each other he expresses in small ways his love and care for her. Overall, the collective digital story resulted in a youth-led narrative about their everyday and emergent Indigeneity, including their interdependent-Indigenous-sense-of-self and becomings as an Indigenous scientist that was mediated through the ILBSL program. The digital story also creatively illustrated the learning and responses they had to questions that must be asked of them as good ancestors in this time of change (as forecasted by Sweet Medicine). Even more promising for employing this practice in the everyday of Indigeneity and expansion of ILBSL in other settings was the use of everyday technologies (i.e. technologies that youth already have access to and are using in their everyday lives) in producing the youth's digital youth story.

The utilization of a collective youth digital story was an emergent medium and pedagogy that embodied I-LIFE-Long-Wide-Deep learning. I-LIFE-Long emerged in this practice in the form of Indigenous youth's collective narrative that illustrated their lineages and responsibilities to the collective continuance of their lifeways and language for current (i.e. inheritance) and future (i.e. legacy) generations. Indigenous youth also employed their Cheyenne language in their narrative – which was an explicit exercise of I-LIFE-Long, i.e. speaking the language of their ancestors and carrying it on for themselves and future generations. I-LIFE-Wide materialized in this practice as youth employed oral, collective storywork and simultaneously reclaimed and re-positioned Western digital technologies to design and illustrate their Indigenous youth narrative. I- LIFE-Deep manifested in this practice as youth employed their digital storywork to collectively story the learning and practices they engaged in and how they lived what it means to be a good relative and ancestor to land, humans and more-than-humans through ILBSL.

## Section VI

## Discussion and Conclusion

It is clear that the learning Indigenous students, families and communities engage in daily, since time immemorial and thus far is incredibly complex and ever-becoming in ways that are built from their own epistemologies, ontologies and axiologies as well as those that are forced upon them through settler-colonialism and Western Science. The current work endeavored to attend to these complexities through the development of an Indigenous LIFE-Long-Wide-Deep learning story that then emerged in practice via Indigenous Land-based Science Learning (ILBSL) on the Cheyenne Reservation and alongside Indigenous youth. ILBSL set out to achieve multiple dimensions with youth from a Cheyenne ontology and axiology, including the critical framing that Sweet Medicine's Adaption theory provided. This story contextualized the identities, becomings, and responsibilities of Indigenous youth thus far and provided the background in which to develop, implement and make-meaning of predetermined and emergent ILBSL dimensions and practices with youth. The ILBSL dimensions and practices served to develop Indigenous youth's STEM learning, identities, and trajectories within an emergent everyday Indigeneity framework and interdependent-Indigenous-sense-of-self paradigm. ILBSL, through Sweet Medicine's adaptation theory, posited that the work of current generations aka good ancestors is to find ways to adapt and synthesize Western Science in ways that align with Cheyenne values and Science and forward Cheyenne collective continuance (which by relation includes the natural world and relations). Therefore, ILBSL specifically took up bio-cultural restoration science as a key translation ground between Cheyenne and Western Sciences in which to facilitate Indigenous youth's everyday becomings and practices as good ancestors aka bio-cultural restoration scientists. ILBSL purposely occurred during the summer

months/'unceded time' as it provided Indigenous only space, meaning it was time and learning that was accountable to Indigenous ontologies, axiologies and collective continuance. ILBSL also intentionally developed its practices to be academically rigorous so as to supplement and grow Native youth's preparation for college STEM programs, but in ways that kept their trajectories accountable to their Indigenous relations and original instructions.

Although the ILBSL program set out to achieve multiple things with youth (e.g. attending to their identities and becomings as good ancestors from a Cheyenne ontology and axiology and being explicit with youth that their work throughout the program would culminate in meaningful bio-cultural restoration for the Northern Cheyenne Tribe and a final research project and presentation), there were also a number of design principles that emerged from the program as it progressed and unfolded. This emergent design piece helped ILBSL come full circle as it held space for youth to emerge and direct their own learning and becomings. One design practice that emerged was how ILBSL planned the program from week-to-week so as to hold space for youth's emergent learning and becoming. For example, youth read a piece on Native Science v. Western Science early on in the program (an intentional strategy) so youth had various questions they posed to the Indigenous adult scientists who managed the program, including myself. I and another mentor would walk the article through with them and provide them examples and translate it in to language from their daily lives. If youth needed more space to process and attend to their emergent learning of Native Science and Western Science, then ILBSL would create that space by carrying that topic in to the following week or weeks. This was a common practice for a variety of topics/readings throughout the ILBSL program. Related to this was setting up and attending to the reciprocal relationship between what is learned inside, i.e. guest lectures and readings, and what is learned on the land. For example, youth's reading of "Land is Pedagogy"

by Leanne Simpson introduced them to a youth-/learner-led pedagogy, thus youth put this in to practice when they were on the land learning about their plant relatives. They then brought this learning back to their research projects. These practices fortunately emerged and made science learning, identities and becoming more appropriate for Indigenous youth as they allowed for ILBSL to meet youth where they were with their understandings and becomings with land-based science learning.

Moreover, Indigenous erasure can (and has) easily slip in to learning settings, even those designed and practiced by Indigenous peoples. This slippery erasure occurs implicitly and in the case of ILBSL could easily have done so through the guest speakers and articles that were presented to youth. Therefore, ILBSL was strategic about the guest lecturers and the articles that were provided to youth, i.e. ILBSL purposely arranged for Indigenous Scientists and Indigenous scholarship to dominant the space and for non-Indigenous Scientists and scholarship to be selectively introduced. Even more, I, as the lead Indigenous designer and scientist, participated in the guest lectures and read all the articles/books the youth did so that I could be aware of the narratives Indigenous youth were taking in, especially during lectures that were offered by non-Indigenous folks – this did not occur to me at first, but rather emerged as I realized it was my responsibility as an ethical, Indigenous Scientist apprenticing Indigenous youth to become scientists. This monitoring and awareness of narratives and claims made by guest lecturers and readings was done so as to reassert the centering of Indigenous narratives and orientations to land and self, while also minimizing white, settler narratives of Indigenous relations to land and the erasure these narratives can have for youth's Indigenous sense of self. These also worked to disrupt the dominant white narrative that Indigenous peoples can only show up in certain spaces/roles (e.g. poor and impoverished on Reservations) and not in others (e.g. expert

Scientists who construct rigorous science on their own homelands). To help facilitate these, I would sit with youth following lectures and readings to re-contextualize these sources of knowing in relation to our Cheyenne ontologies (i.e. our responsibilities as good human relatives) and collective continuances so as to maintain emergence of Indigenous youth's meaning-making and identities on our terms.

In addition, to reiterate again here, settler-colonialism is a strategic structure that works outside (i.e. external colonization) of and within (i.e. internal colonization) Indigenous communities to achieve its end game: i.e. the perpetuation of settler present/ence and futurities on Indigenous lands. It is ugly and it is violent. It also does not care about the victims and collateral damage that happen in its name, especially if they are Indigenous. In fact, if they are, the better, as part of settler-colonialism's game is to eliminate and supplant Indigenous existence to/on land – past, present and future. This ongoing violence emanates today, and unfortunately within the Cheyenne community – and ILBSL was not immune to it. Thus, an additional emergent ILBSL dimension that developed came in direct response to the internal colonization practiced by Cheyenne people. First, ILBSL was continually regarded by community members as not being academically rigorous or 'truly' preparing our Indigenous youth for college, let alone STEM degrees. It is not certain if this was because community members themselves were not socialized to read graduate level articles, books and engage in guest lectures so they did not realize the academic rigor and depth of these tools and/or they thought Indigenous youth are not capable of rising to such rigor and/or the K-12 school systems (they are used to) do not utilize these types of learning tools so ILBSL must not really be engaging youth in rigorous learning environments and/or they continue to cede the summer time (taken up as unceded time in ILBSL) as 'time off' from 'real learning' and/or they thought summer time and the rest of the

year (i.e. the school year) do not overlap or connect, thereby whatever is done in summer time has no relevance to the real learning that happens in schools (whereby school learning is exalted as THE learning for Indigenous children and families to reclaim and serve their Indigenous nations/collective continuance). A second internal colonized response from community (that was deeply tied to the first) regarded summer time as a time to send Indigenous youth 'away' to places other than the Reservation. The theory here is that by doing so, youth can see what is possible and different through learning experiences that are "off-the-rez." This in and of itself is not colonized (I mean I 'went away' to Dartmouth and UW so these can be productive practices, yet it hinges on how we as adults contextualize these 'away learning experiences' for our youth and put them back in direct relation to our collective continuance), but when it is regarded as the default option or we fail to contextualize these 'away experiences' for our youth, it erases the possibilities of creating meaningful, robust learning environments directly at home, by us, for us. It is a move that continues to cede our Indigenous children to 'other' (typically white) learning environments where our children are continuing to be socialized to think of themselves and relations to land from a white, settler lens away from their territories and everyday relations/ing. When we do this it subtly and passively sends the message that 'real learning' and learning that shows youth different possibilities of their Indigeneity cannot manifest on the Reservation. To be clear here, these are internal colonized responses to what ILBSL is and what the summer (as unceded time) can open up for Indigenous communities and collective continuance. These also were not held by every single Cheyenne person, rather they are dominant, colonized social messages that we knowingly or unknowingly socialize our children in. These emerged as internal (i.e. coming from the community) pieces that ILBSL did not anticipate. However, their emergence became productive as they prompted ILBSL to create adaptive, resistance and

disruptive practices to this internal colonization. Such practices are needed if we are to create robust, viable and transformative science learning for Indigenous youth on our terms, on our territories and for our collective continuances.

Furthermore, in utilizing an emergent design framework here, i.e. reflecting on the ILBSL program, there are future practices that ILBSL will take up so as to continually grow. First, the next year of the ILBSL program will offer youth college credits through Chief Dull Knife College (the local tribal college). Secondly, ILBSL will deepen storywork with youth by engaging them in collective exercises where they create theories about natural world relations/phenomenon that are based in the oral tradition passed down to them as well as their observations/experiences with the natural world. Thirdly, through the award of a competitive grant, ILBSL will have the financial resources to engage youth in land-based field work that will be mediated by Indigenous Scientists at Yellowstone National Park, the Big Horn Mountains Medicine Wheel and other culturally-significant places that do not reside on the Reservation, yet reside on ancestral Cheyenne territory. ILBSL will also be able to organize a college campus visit to Montana State University (MSU) where youth will be exposed to their post-secondary STEM options, professors (Indigenous and non-Indigenous), current Native students and resources. Additionally, these financial resources will also make it possible to employ local Cheyenne scientists/elders who will apprentice youth in Cheyenne axiologies, language, and science practices, e.g. Ethnobotany and plant processing, Ethno-Ornithology, and buffalo meat processing. Even more, with support of the grant, ILBSL will be able to pay for national Indigenous scientists who are doing land-based, collective continuance work to travel to the Northern Cheyenne Reservation to share their work with youth, thereby expanding youth's understandings and becomings of what is possible as an Indigenous scientist. Lastly, youth will

be taught about how Indigenous science and activism can productively come together to take a stand for non-human relatives, e.g. their water relative through a Northern Cheyenne "Water is Life" week that was organized by a local Indigenous Water Scientist and will culminate in a collective mural on the Reservation that illustrates the Cheyenne stories of and relations with water. ILBSL will continue to hold space for other dimensions and practices that will emerge over the course of the next ILBSL program.

The ILBSL dimensions and practices outlined here are not exhaustive, but rather more importantly, they became critical, collective starting points that made science learning much more expansive, meaningful and inspirational to Indigenous youth. Therein lies the significance and potential of I-LIFE and ILBSL – apprenticing and cultivating Indigenous youth as experts/good ancestors/bio-cultural restoration scientists. The centering of Indigenous ontology, epistemology and axiology in the theoretical/story framework and its lived practice is an intentional, necessary move in designing and achieving robust science learning with Indigenous children, families and communities and for Indigenous collective continuance – ILBSL did just that. Even more, the current thesis achieved a transformative methodology in resurging and reclaiming Indigenous ontologies and axiologies as it positioned Indigenous story/theory and practice (i.e. storied and lived Indigeneity) in reciprocal relationing with each other – a critical practice and paradigm that must be taken up to help build towards robust and viable Indigenous futurities on Indigenous peoples' terms. Additional work and research needs to occur to expand these dimensions and practices, as well as how ILBSL might unfold within more Indigenous territories according the ontologies, axiologies and epistemologies of these territories. Further, although this thesis was written primarily in the context of Indigenous students' science learning and identities, it also holds significance and promise for non-Indigenous students as I-LIFE and

Indigenous knowledge systems call for all to be good relatives. Indigenous science also holds the potential to re-humanize much of Western science and relations to land. Thus, Indigenous knowledge must be shared and practiced, responsibly, by all if all (human and more-than-human) are to reclaim their responsibilities to each other and our collective futures.

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