How Discourses of Biology Textbooks Work to Constitute Subjectivity: From the Ethical to the Colonial

by

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A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy

Department of Curriculum, Teaching and Learning

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Abstract

This thesis examines how discourses of biology textbooks can work to constitute various kinds of subjectivities. Using a Foucauldian archaeological approach to discourse analysis I examine how four Ontario secondary school biology textbooks discursively delimit what can be thought and acted upon, and in the process work to partially constitute students/teachers as sex/gendered; neocolonial; neoliberal (and a subject of work), and ethical subjects and subjectivities. This thesis engages the topic of how discourse can constitute subjectivity in science in three basic ways: First, on a theoretical level, in terms of working out an understanding of subject constitution/interpellation that would also be useful when engaging with other sociopolitical and ethical questions in science education. Secondly, in terms of an empirically based critical discourse analysis that examines how various statements within these four textbooks could set limits on what is possible for students to think and act upon in relation to themselves, science, and the world. Thirdly, this thesis represents a narrative of scholarly development that moves from an engagement of my personal experiences in science education and current science education literature towards the general politico-philosophical topic of subjectivity and biopolitics. This thesis begins with a discussion of my experiences as a science teacher, a review of relevant science education literature, and considerations of subjectivity that relate specifically to the specific methodological approach I employ when examining these textbooks. After this I
present five chapters, each of which can be thought of as a somewhat separate analysis concerning how the discourses of these textbooks can work to constitute specific subjectivities (each involving different theoretical/methodological considerations). I conclude with a reflection/synthesis chapter and a call to see science education as a site for biopolitical struggle.
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For Kate,

She tied you to her kitchen chair
She broke your throne, and she cut your hair
And from your lips she drew the Hallelujah...

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Glossary of Terms and Abbreviations

The definitions below are to be thought of as a contextual explanation and not as ‘textbook’ definitions. Their selection is indicative to what I think is important. If terms are bolded in the body of the text there is a chance they will be in the glossary.

**Apparatus** – Giorgio Agamben defines an apparatus in the Foucauldian sense (dispositif) as the intersection of modes of governance, knowledge and discourse, and a field of power relations. Public education could be seen as such an apparatus.

**Archaeology** – A methodology Michel Foucault uses to describe an approach to reading texts (usually in relation to historical work). Archaeology examines a local discursive phenomenon to examine how objects, social relations, subjects, and their inter-relation are constituted through discourse. Archaeology can be thought of as a critical approach to research that attempts to make our current moment/situation seem strange.

**Biocapitalism** – A form of capitalism whereby value is accumulated through the exploitation of immaterial labour, affects, and particular modes of life deemed central to the reproduction of labour and value. A key difference between biocapitalism and capitalism is in the conceptualization of production; the former based on immaterial labour and the later material labour (as well as the resulting immaterial value and material value respectively)

**Biopolitics** – At it simplest, biopolitics involves taking the way populations are governed as an object or focus of politics. In this thesis, biopolitics is set in opposition to biopower, which involves the way bodies begin to be both governed and disciplined.

**Biopower** - The ways populations are managed in modernity. Instead of incorporating the power to make die it instead focuses on enhancing the ‘life’ of the population through public health, education, etc.

**Critique** – Fundamentally challenging the assumptions by which we know or do something. Critique is successful when people cannot look at a taken-for-granted practice the same way.

**Discourse** - Simply a way of representing the world, usually through speech and text. Discourse works to frame the very possibilities of thought and action, social relationships, subjectivity, and even the distribution of material goods. Discourses are productive in that they produce what they speak of (e.g. the scientists).

**Dispositifs** – (see apparatus)
**Ethics** – Defined in this thesis as the outlining of a correct course of action based on a particular understanding of self, responsibility. It involves the designation of ‘right’ action based on an ethical-moral backdrop – often hidden in most cases.

**Genealogy** – A method more expansive than archaeology by which an analyst establishes a terrain for which something emerges. This includes outlining competing discourses, interests of power, institutions and strategies that are involved in the phenomenon’s emergence.

**Global Capitalism** – Capitalism that has largely exceeded the boundaries of the nation-state once necessary for its operation.

**Governmentality** – Governmentality refers to modes of governance whereby individuals are specifically brought to govern themselves in conjunction with institutions, law, and disciplinary forms such as the prison.

**Human Capital** – Coming to see humans as capital in themselves. In this thesis I purposely mean to juxtapose human capital and humans as labour to show that once we conceive of humans as capital it means to render a large part of our existence to the functioning of capitalism.

**Ideology** – The unquestioned social backdrop by which social relations function.

**Immaterial Labour** – Sometimes conceived as cognitive labour; essentially the production of ideas, texts, cultural signs, and services.

**Labour (power)** – The most productive force for human beings, the ability or capacity to do work. The process by which value is sustained in a modern economy.

**Poststructuralism** – Essentially the school of thought that privileges the realization that existence exceeds the structures used to speak about them. Poststructuralism is best understood as a response to the over-deterministic work of structuralism.

**Power** – In the sense of Michel Foucault, power has the following attributes. It is not something someone can hold but is a relation requiring two subjects with the capacity to resist. Power does not simply repress but produces a social body/identity and does so in heterogeneous, strategic ways.

**Scientific Realists** - Scientific realists see science as describing the real world as it is, independent of what we might take it to be.

**Structuralism** – A school of thought which positions human behavior and social organization as a product of larger structures, linguistic, political, social, and otherwise.

**Subject** – A being that has experience, thought, feelings, etc.

**Subjectivity** – The thoughts, feelings, attitudes, opinions, and dispositions of a (human) being.
**Subjectification** – The processes by which a subject is constituted socio-politically.

**Value** – In the Marxist sense is determined by the labour invested to produce something. In terms of this thesis value is something by which labour must be reproduced in order for it (value) to be maintained.
Chapter 1: Teaching Science and Meeting Power Along the Way

He could not get away from that grim notion that true violence is that of the self evident: what is evident is violent, even if this evidence is gently, liberally, democratically represented; what is paradoxical, what does not follow of itself, is less so, even if it is imposed arbitrarily; a tyrant who promulgated preposterous laws would all in all be less violent than the masses which were content to utter what is self-evident, what follows of itself; the “natural” is in short, the ultimate outrage. (Roland Barthes, 1977, p. 85)

I begin by setting out a personal, theoretical, and methodological context for this critical discourse analysis (CDA) involving Ontario secondary school biology textbooks. The central aim of this analysis is to demonstrate various ways discourses found in biology textbooks can work to constitute students’ and teachers’ subjectivities; that is, how the text, through discursive means, works to constitute social, political, and cultural subjects. The word “constitute” is an important word choice; unlike the word construct, constitute gives also means “to be the substance of” as well as the particular way something is formed. Stated slightly differently, this work endeavors to demonstrate how these textbooks can work to constrain and provide choices for what students can typically do, say, and even think. It is this umbrella concept of the subject constituted discursively that serves here to unite the disparate, yet interwoven discourses found within science education materials that aim to shape students as practitioners of science, as well as ethical-economic-sexed-racialized-political subjects. Another aim of this thesis has been to come to terms with a range of theoretical perspectives concerning critical pedagogy, poststructuralism and science education. That is, this thesis, also acts as a site for theoretical play and has led to different questions for further research and thought. I found that the way I began asking after subjectivity, outlined in chapter 3, needed supplementation with other theoretical perspectives and methodological techniques.

This critical research can be seen as entangled in the epistemological and highly politicized debate about whether there can be “objective” and “value free” scientific knowledge, or whether all knowledge is always already tied to specific sociocultural and political commitments (Trifonas, 2012). The research outlined here challenges the notion that science is a rational pursuit only influenced at the margins by political, social, and economic orders. I make the case that what many in the science education community understand to be a free and rational
pursuit of knowledge about the material world is highly constrained and contingent upon various discourses, political projects, and social norms that circulate in science (education). Through the next eight chapters, I engage with various theoretical perspectives to demonstrate how discourses (in biology textbooks) can work to constitute particular type of subjectivities, with the overall intention of demonstrating that scientific knowledge is far more messy and complex than is commonly recognized in science and science education.

Science education has increasingly become the focus of intense scholarship from a wide range of theoretical and methodological approaches, such as ethnography, feminism cultural history and queer theory. As a result, older more traditional views of science, along with science’s long-held epistemological authority, have been challenged by complex and multifaceted understandings that reveal science to be “very much a part of and not apart from the dominant cultural and political issues of the day” (Lemke, 2001, p. 298). Sandra Harding (2006) takes this a step further in her book, *Science and Social Inequality*, arguing that we actually need science knowledge to remain contentious:

Modern western sciences are too powerful a social force for us to want them uncontroversial. What we can reasonably want, however, are controversies that help us think in new and fruitful ways about present and possible future relations between knowledge and power (p. 3).

Analyzing how discourses operate in terms of their social, political, economic and ethical commitments should not only be seen as a negative research activity. On the contrary, it is a positive undertaking to engage with the sociopolitical and cultural fabrics that not only underlie science, but are the very stakes of science!

In looking at how subjectivity is constituted through discourses of biology education, I draw extensively from the work of Michel Foucault - most importantly *The Archaeology of Knowledge*, *The Subject and Power* and, in later chapters, his lectures on the *Birth of Biopolitics* - to highlight how particular sociopolitical commitments are formed in the discourses of four Ontario biology textbooks — textbooks which are often considered objective and free of bias and political agendas (Apple, 1993). Although all textbooks are imbedded in complex patterns of production and can be analyzed in this respect, Stuart Hall (1980) reminds us that, “it is in the discursive form that the circulation of the product takes place, as well as its distribution to different audiences” (p. 91). Hall reminds us that while reality exists outside of language it is
always mediated and produced through discourse, where knowledge is not a “transparent representation” of the ‘real’ but “the articulation of language on real relations and conditions” (p. 95). In the field of science education, Derek Hodson (2003) explicitly calls for an overt politicization of science curricula by continually asking whose interests are being served by particular ‘scientific’ representations and how specific articulations of science are tied to power. Interrogating power-infused discourses in school science texts can challenge oppressive or problematic knowledges in science as well as make space for doing science differently.

The first three chapters of this thesis describe how I have become oriented towards this research and summarize several relevant contexts in the field of science education and philosophy as well as some methodological considerations for conducting this critical discourse analysis. Since this study incorporates both a methodology and a theoretical grounding based largely on the thinking of Michel Foucault, most chapters intertwine in terms of theoretical stances and the methodological approaches (which vary slightly from chapter to chapter depending on what techniques were needed to analyze statements and discursive fragments). In this thesis I have identified four ways these texts can work to constitute particular subjectivities related to sex/gender and sexuality, ethics, a dual colonizer-colonized subjectivity, and a neoliberal-global capitalist subjectivity, the latter that I tie closely with the ‘subject who works’. When I talk about a particular kind of ‘subjectivity’ it will sometimes be placed in quotation marks as I want to stress that the subjectivities I am trying to identify are abstracted categories; an organizing device by which to think about the subjectivity of students and teachers. Originally, I had also wanted to analyze how the texts worked to constitute an ‘epistemological subject’ and a ‘political-national subject,’ but decided not to pursue these, since I would only be outlining what seems quite commonsensical — that textbooks work to constitute Canadians and scientific realists (this is not to say however that these aspects would not be useful for other studies).

The above categories of subjectivity represent fields that I felt were most pressing at the beginning of this thesis and since then have come to form the basis of a more politicized engagement in science education, which will be elaborated in chapter nine. In this chapter, I outline other aspects of subjectivity that are pressing for future analyses, such as a more rigorous engagement with ethical questions, colonization, and spaces opened up through biotechnology. Some of these topics emerged after this thesis work began; for example, the topic of ethics,
discussed in chapter 4, emerged only after studying these texts for several months. This thesis moves from a focus on discourse and its role in the constitution of subjectivity in science education towards processes of subjectification in broader contexts; such as a conception of the biopolitical as taken up by Hardt and Negri (2009). It is a trajectory in my doctoral studies that has introduced a proliferation of tensions that have come to shape future research questions and what I see as underdeveloped sites of resistance. However, before entering into specifics of this discourse analysis and concomitant theoretical engagement with various aspects of subjectivity, I feel it necessary to give a clear rationale about why such research is imperative for the field of science education, along with a concise narrative of how I came to consider this research a necessary part of a larger critical project for science and education.

1.1. Why Question Science and Why Foucault?

Though many who work in, or study, science, share my experience of ‘scientific enculturation’ it is worth speaking about, mainly because such an enculturation is often more or less denied. In my experience, it is quite often tacitly understood in science classes that students and teachers are learning ‘truth’. I began my postsecondary education in the biological sciences with a focus on evolutionary theory and behavioural genetics, which included sociobiology and the biology of moral systems. During this time, I was initiated into an extremely realist/positivist epistemological culture that viewed other ways of knowing, and the situated nature of knowledge as naive at best (both in terms of epistemological inferiority and the misguided character of the people who think such things) and a threat to progress at worst. Such an initiation includes how everyday relations to knowledge and the other aspects of the world are discussed. This kind of enculturation includes not just the content of lectures, but campfire conversations, what kinds of histories of science are given credence, the way scientists are constructed, and of course who gets to speak and be spoken about. In all cases of such enculturation the messages of the enculturation are received – as Barthes (1972) argues as long as the concept is understood the myth has succeeded. Identifying as a White, heterosexual male1 provided a context that made it very easy for me to accept ‘universalist’ representations of the world given in my ‘scientific education’ at face value. That is to say, what was being presented did not challenge the social

1 This identification involves both ‘not identifying’ but also open disavowal of all others in order to produce the
order nor did it challenge the use of reason within historical, sociopolitical and cultural realities. As a result of these experiences, I began my career in education believing in objective universal knowledge that could be obtained rather easily through the absorption of content and straightforward deduction and induction using quantitative data. But the point here is that along with these epistemic beliefs came notions of who legitimate knowers were (e.g. White European men), who still needed to be educated (anyone not using the language and methods of science), as well as ideas about what constituted a human being (a rational, cis-gendered male whose behaviour follows ‘scientifically determined’ patterns); all people were to be accepted, but there were hierarchies and some, in my experience, various kinds of sexualities or femme performances, were attributed a kind of abhorrence. All of this was, of course, not admitted outright, but came to be part of everyday social relations, the way I viewed myself in relation to others, political institutions, and beliefs about the world. I recall “campfire” conversations with my friends in the sciences where we spun awful tales while claiming scientific rationality. Despite the radical skepticism that is supposed to be attached to science we were quite often very sure of our claims!

Jean-Francois Lyotard’s (1984) description of the transmission of scientific knowledge can help us see, at a very basic level, why such depoliticized and unproblematic ways of knowing can easily prevail in cultures of science. For Lyotard, scientific knowledge involves strict rules between the addressee and sender of statements, rules that do not apply to narrative knowledges. First, the sender of knowledge must be able to show proof of what they say as well as reasons to refute other statements. The addressee must also be able to give assent to what she hears, making her a potential sender herself and subject to burden of proof and refutation, after which she then becomes equal to the sender — when the addressee accepts such conditions she enters into the world of scientific scholarship. Equals are needed to judge the truth quality and the competence of the sender. The point here is that modern science as a language game rests on clear assumptions about what counts as truth and who is the speaker; therefore, the way science is practiced necessarily sets a particular emphasis on the neutrality of the speaker and addressee, his/her ability to think ‘rationally,’ and their uniform similarity (I recently have

\[2\] In the sense of Lyotard (1986), language games legitimate and authorize particular ‘moves’ within a community. The rules of one language game govern how knowledge is constructed – individuals more or less stick to the rules of the particular language game they are playing. Science, according to Lyotard, is one such language game.
argued that it is in a socially engaged ‘universality’ that part of science’s radical nature lies. It is when this equality isn’t fulfilled (oppressive power is held between sender and addressee) and when the situated nature of the speaker is not taken into account that an oppressive universality begins to take hold (Bazzul, 2013)). In this atmosphere, it is easy to see how a more open, ‘multiplicitous’, and nuanced perspective of what is said, who is speaking, and the relationship between knowledge and the social order may be inherently difficult.

What first caused me to question the status of science likely goes back to my daily life experiences in Beijing and Kyiv, where I lived and worked as a science teacher. In both China and Ukraine, humanist values were frequently espoused by expatriates living in these countries, yet the social and everyday life of the local people, who had far less materially, seemed to have certain qualities that my life in Canada lacked in terms of the attention given to social interaction. During these years, I read voraciously, which seemed to kick-start my imagination. I started to think less conservatively about the way things are and more openly about the way the world could be. In terms of science, I was introduced to the ideas of Paul Feyerabend (1975, 1978) and Thomas Kuhn (1996) — which emphasized the imbedded nature of scientific “discoveries” in various cultures and social structures, assertions which ran counter the conventional wisdom of school science departments. When I first encountered Foucault’s Truth and Power interview, I felt it set forth a mode of thought for the sciences and science education that could tie knowledge to vested power configurations — however Foucault’s work remains very much underused still in science education. Altogether these texts left an appreciation for the situatedness of every systematized epistemic culture, and helped me realized that the science being taught in schools could not easily be recast in any other way besides the one culturally maintained by disciplinary and power-invested imperatives. I vividly recall the words of my former department head at Pechersk School International when I questioned the need for standardization of two extremely different grade 9 science classes: she looked at me with wide eyes and exclaimed, “But, science doesn’t change!” If school science as a major cultural

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3 Two works I feel especially compelled to mention are Thomas Mann’s Dr. Faustus, and Haruki Murakami’s Hard Boiled Wonderland and the End of the World. The first title questions our nature to understand cultural development even with the very best scholarship and literary intentions. The second science fiction title highlights the importance of a fundamental social reality to the material world and stimuli.
practice is complicit in so many injustices, oppressions in the world, such as environmental
destruction and domination of the global south by the global north (Harding, 2006), then science
as a site of the use/exposure of power needs to be spoken about and acted upon!

The awareness of unchallenged epistemic assumptions in/about science education,
however, was/is not enough to begin a process of transformation. Alongside questioning the
epistemology of science came the awareness of many injustices and larger systemic inequities. A
good example here is the framing of how people come to think about bodies, sexuality and
gender. It seems clear that science education today is still complicit in propagating oppressive,
simplistic, dualistic views of sexuality as if they were fact (Bazzul & Sykes, 2011; Snyder &
Broadway, 2004). For those of us who do not (cannot!) (will not!) fit neatly within two rigid
categories of sex/gender and sexuality, discourses of science and science education can work to
marginalize and make life virtually unlivable. At Pechersk School International, I was able to see
first hand the way our science programme was complicit with the overall political relations
between parents, students, teachers and the host country. That is, ways of speaking about science
pushed an enterprise-business driven science, where political legitimacy was given to “Anglo-
American” narratives of scientific practice, history and discovery, even though 40% of our
students were Ukrainian, with another 40% or so coming from non-English speaking regions.
Planned environmental projects and initiatives to help local communities were frequently
squashed for the sake of learning disembodied content. In this way, typical relations of power,
where the ‘international westerners’ held sway over ‘local Ukrainians,’ became a mirror for
inequitable international relations.

Efforts to bring ‘science and society’ together is often mired in typical assumptions about
the separation of scientific knowledges from all others (Lyotard, 1984) — a separation which
works to (artificially) split those knowledges that are political with those that are purely
objective. The following work entails ‘reblurring’ this binary by making an effort to show the
way particular discourses of science and science education limit the possibilities of thought and
action for students and teachers of science from a particular Foucauldian/poststructural
perspective — which I feel carries with it a subversive, yet still in many ways positivistic
perspective (questions of modernity, its presence and uses, therefore remain quite open in this
thesis).
Since science education is not static, and due to its great instrumental power, it can be seen as a *site of political struggle*. This political battle can be framed in social justice terms and, as I argue in the final chapter, as a site of biopolitical struggle over subjectivity (and the stakes are high). My aim is not to take away science’s empirical use (although this is a possibility); quite the reverse, as science is needed to forge solutions to present and future oppressions. At the same time, I see my task as an educator, first and foremost, as ‘making trouble’ with what has come to be taken as natural and commonsensical. The quote at the beginning of this thesis, from Roland Barthes’ autobiography, encapsulates my sense of direction and outrage concerning work in education. Barthes essentially argues for the restoration of the historical and political complexity to things, outlining the difference between words that are meant to be a call to action, or to act on things, and words that simply signify larger concepts that can mask historical, material and political realities (Barthes, 1972). Similarly, in my work, I try to trouble what we view as commonsensical or natural in science education text, a task that is often met with dismissal by science education researchers looking instead for what the ‘correct formulation’ *must* be. However, critical science educators can take inspiration from Foucault’s (2003) words concerning his own work and whether one must know the way forward after critique:

> But my project is precisely to bring it about that they “no longer know what to do”, so that the acts, gestures, discourses that up until then had seemed to go without saying become problematic, difficult, dangerous. This effect is intentional (p. 256).

My experiences in education have revealed that *often critique is actively disallowed* by those who would have the critic design and implement a grand reform (even rhetorically in discussion). Foucault (2003) stresses that this is not necessary:

> Under no circumstances should one pay attention to those who tell one: ‘Don’t criticize, since you’re not capable of carrying out the reform’. That’s ministerial cabinet talk. Critique doesn’t have to be the premise of a deduction that concludes, ‘this, then, is what needs to be done’. It should be an instrument for those who fight, those who resist and refuse what is. Its use should be in the process of conflict and confrontation, essays in refusal. It doesn’t have to lay down the law for the law. It isn’t a stage in a programming. It is a challenge directed to what is (p. 256).

This thesis may also be considered as an essay in refusal of ‘what is’ the contents of science curriculum materials. My overarching goal for science and science education is to problematize the way forward, reintroduce historical, political, and philosophical concerns as something not to
be mastered or known, but grappled with — and if allowed to ‘reformulate’ curriculum materials I most certainly would try.

As Foucault showed, the very universals we use to describe our situation are historically contingent. While many would agree that science materials have a ‘bias’ or contain representations that are culturally situated, few have taken this further to describe exactly in what ways discourses found in textbooks actually limit what can be thought or acted upon. This type of engagement, one in which subjectivity is central, sidesteps statements like: ‘It can all be explained by the political dispositions of the authors’ or ‘Well yes, we need more informed science education materials.’ Though these are not incorrect or invalid statements, they locate the problem in the author function of the text; thereby not producing any comprehensive analysis or critique that focuses more on what the text is saying or doing. This analysis privileges the level of discourse over that of the perspective of the authors, which allows the analyst to give closer attention to what is being said (quite literally). The advantage is that assumptions can then emerge from the text or discourse, rather than having to find their locus in some rational mind (of an author). Ironically, to look at the way subjectivity is constituted requires also that an analyst minimize the importance of the subject itself!

1. 2. Subjectivity: The Always Already Unanswerable Question

My relation to truth and subjection goes back to childhood and my experiences within a religious community where it was necessary to believe in the literal truths held by the community. My religious education has helped form an attachment to truth and subjection in terms of how I have come to see the importance of subjection, subjectivity and discourses of truth. It is not a coincidence that I have taken as my object of critique the discourses of ‘scientific’ truth since, in my youth, I was made to engage a very absolute religious truth. This truth was actually called ‘the truth’ by community members and it was taken as fact over science, medicine, and history. A common turn of phrase that is still used is: ‘Is she in the truth’ or ‘How long has he been in the truth’? The relevance here is that both truth discourses were comparable in the realism that they embodied. For me science, regardless of its attachment to empirical evidence, is a truth discourse that operates in much the same way as religious truths and can just as easily distribute the effects of power.
However, to simply state that my purpose is a reckoning with ‘truth’ and its ability to wield the effects of power would be missing at least half of the story in that it is within these truth discourses that a subject finds their freedom and identity. Being a Christian in this particular religious community allowed me to see that through subjection to Doctrine and the will of the community – all things were possible. It brought much happiness and also much agency. The attachments to my own subjection were palpable in part because this particular organization made them visible in its instructional publications. This kind of education helped me realize that subjection forms positive attachments that define what we think is possible. However, instead of just asking “where is the power in all of this truth!?” we can ask “but, who is the subject is required of this truth?”. In what ways is my freedom both an affirmation and a negation? Over the years I began to question these truths, especially when I began to study science. So in my religious community it began with the idea that the events of the bible did not have to be material events, and that other Christian churches were also correct. This questioning led to an undoing of who I was a member of this religious organization. In the same way, the questioning of science in this thesis is a part of the process of my undoing as a subject of science – it is a process of change.

In order to change (be changed) we can ask after the processes of subjectification (how we become subjects). One thing my religious experience has also taught me is that when one wants to amend the rules/practices by which they live at a fundamental level they will become undone. Everything will not be the same afterward. What if this could happen in/with science? What if science students, scientists, and the public could fundamentally change their subjection to the laws of science? What would be the result? How would we come undone?

In the end, not only is there “no real” subject of science - just the tracing of broad discourses and the products of these discourses; situated, multiple, subjectivities - there is also no theory of the subject that will stand in these postmodern times. But, it is in this difficulty that Foucault’s reversal of the politics of ontology seems most pertinent – in our very attempt to posit how the subject operates, ontological considerations must be situated in a epistemic, historico-political order. In this way, Foucault seems always useful in reversing the ontological question of what can be with how has it come to be that we this can be.
Chapter 2
Science Education, Discourse and Subjectivity

To call a presupposition into question is not the same as doing away with it, rather it is to free it from metaphysical lodgings in order to understand what political interests were secured in and by that metaphysical placing, and thereby to permit the term to occupy and to serve very different political aims (Judith Butler, Bodies that Matter, 1993)

In this chapter, I provide a theoretical background and starting point with reference to three interrelated areas: science education; curriculum and textbooks; discourse and subjectivity. In the following chapter, I tie various aspects of this theoretical background into a general methodological framework for thinking about and examining how subjectivity can be partially constituted by discourses in science education and, specifically, Ontario biology textbooks. An overarching concept that drives much critical work in education is the idea that the classroom (along with other disciplinary institutions such as the factory) is a place in which ways of comporting, ethical forms, and self discipline are instilled — as Foucault (1977) develops in Discipline and Punish. In other words, the classroom and its contents developed as a site for the production of subjectivities from the very advent of formalized schooling. As Kendall and Wickham (1999) state, however, the site of the school also remains optimistically “experimental” as a historically situated locus of technologies, bureaucracies, and rationalities (p. 123). In outlining how discourses found in four biology textbooks work to constitute sexed/gendered, colonizer/colonized, neoliberal global capitalist, and ethical subjectivities, my intention is to help educators see possibilities for reworking these subjectivities and discourses towards social justice, anti-oppression, and even goals we cannot yet envision, such as alternatives to specific ethical orientations discussed in chapter 4.

Concerning curriculum studies, I agree with Gazatambide-Fernandez and Theissen (2008) that accepting broad approaches to curriculum studies requires educators also accept a wide variety of theoretical lenses that have relevance, and, at times, may not be directly related to practical experience. This holds true in science education, where intense focus on the acquisition of abstract concepts tends to obscure critical theoretical questions related to the curriculum content itself (Harding, 2006). Connelly, He and Phillion (2008) maintain that the incredible diversity of curriculum studies means that “established theoretical sources in one topic may be mostly unknown or perhaps supplanted by competing theoretical positions in a related
topic” (p. x–xi). Curriculum studies of Science education is a good example of this phenomenon, since it has yet to see the consistent use of ‘poststructural’ approaches to curriculum reform, such as those that align with sociopolitical methodologies and thought (Carter, 2011). As Giroux (1981) insists, engaging with curriculum is no less than engaging with socio-political and cultural struggle; and this research is one attempt to carry out a vision of curriculum still much needed in science education over thirty years later.

### 2.1 Recent Challenges to Science and Science Education

While few would dispute the importance of science and technology in societies today, the objectivity and neutrality of science have been eroded by an increased focus on historical, critical approaches to knowledge that demonstrate science to be socially produced and ideologically invested — a cultural product like anything conceived by humans (Lemke, 2001; Trifonas, 2012). Lyotard’s (1984) provocative claim in *The Postmodern Condition* that science is just one of many “language games” (p. 10), with its own particular rules and assumptions, was one of the watershed moments indicating science’s loss of epistemic authority. Michel Foucault’s (1980) historical archaeologies revealed how discourses that purport to be objective are also inextricably linked to power in that “it is not possible for power to be exercised without knowledge, and that it is impossible for knowledge not to engender power” (p. 52). Foucault (2003) encourages us to shift our focus from typical associations of power and knowledge in relation to science (e.g., parliamentary influences on science research), as he argues “it is not so much a matter of knowing what external power imposes itself on science as of what effects of power circulate among scientific statements, what constitutes, as it were, their internal regime of power …” (p. 303).

At the time scholars like Foucault and Lyotard were writing, the philosophy of science was still very much under the thrall of thinkers such as Karl Popper, who was interested in developing a common sense realism based on objective knowledge and falsification (Popper, 1972, 2002). Though Cathleen Loving (1991) calls Karl Popper the “scientist’s philosopher” (p. 825), a glaring oversight in the work of Popper and others, and what should concern educators, is the lack of attention given to cultural realities in science (Cohen, 1980). Resistance to realism within the field of the history and philosophy of science perhaps started recognizably with Kuhn’s (1996) work regarding scientific revolutions — which demonstrated, using historical
examples, that science could be true to its guiding theories and rationalities and still be false, ultimately leading to ‘revolution’. Aiding the adoption of Kuhn’s ideas was Feyerabend’s (1975) insistence that while knowledge can have validity outside of the knower, it cannot be separated from the cultures that produced it. Science’s long accepted claim to epistemological superiority has now become bound to the consideration of cultural codes, social interests, and economic imperatives (Carter, 2007). In light of this, science education policy documents, curricula, and print materials such as textbooks should not escape constant interrogation. If science is a sociocultural activity, is it enough to simply state that scientists are ‘influenced’ by their societal, cultural, and personal knowledge(s)? Or do we press for more interaction, engagement, and even conflict from/with the sciences?

A common argument against the consideration of science as a fundamentally cultural practice is that science as objective and real knowledge is precisely the anecdote to knowledge predicated on power – that we should instead look to what is true as the source of emancipation (Sokal & Bricmont, 1998). While not disagreeing with this argument to some extent, one immediate effect of such a statement is to divorce the human activity of science from all other human activities that are infused with power, resulting in a strong demarcation between science and any other form of knowledge. Moreover, if a demarcation between science and society persists, so that the core of science is said to only be mildly influenced by social and cultural factors instead of being a fully integrated part of the social order, “science cannot be held responsible for any of the negative effects that occur outside the laboratory or after the research ends, even if the consequences are perfectly predictable by them or by others” (Harding, 2006, p. 32). A critical examination of scientific discourse endeavours to expose knowledge, assumptions, values, and viewpoints whose political and historical ‘character’ has been eroded and/or passed off as something ‘natural’. Roland Barthes (1972) identifies such erosions and erasure as essential for the formation, propagation, and tenacious longevity of myths. A mythical science (education) is a science (education) whose knowledge(s), concepts, practices, and institutional positions are presented as unproblematic or holding an a priori commonsensical place in discourse, school and life.
2.2 Discourse, Curriculum and the Textbook

David Blades’ (1997) work, *Procedures of Power and Curriculum Change*, deals explicitly with the difficulty of curriculum change in science education when it is still deeply mired in traditions of modernity. Blades affirms that major curriculum reforms in North America occurring after the second world war were extremely positivistic, thereby “leading naturally to the consideration of curriculum development in science education as scientific problem” (p. 20). Blades calls for a postmodern approach to science education, involving “thinking and speaking about curriculum change in ways not thought or spoken before, an attempt to break free from the defining frames of modernity” (p. 3). While postmodern approaches to science education do not distinguish themselves from modern ones by claiming to speak or think in new ways (on this point I must disagree with Blades), modernity as a culture or as an approach to knowledge can limit the way in which we see the world by not allowing a simultaneous multiplicity of views regarding science. Stuart Hall (1995) outlines modernity as consisting of a wide variety of features, including enlightenment values and the ideal of continual progress; and while Foucault (2003), in his essay *What is Enlightenment*, reminds us that we do not have to be “be for nor against the enlightenment,” science educators need to recognize that Western Modern Science (WMS) Aikenhead (1996) is very much intertwined with other enlightenment ideas such as universal reason, and the nation state. When speaking of curriculum research that challenges the traditional ideological and discursive constructs of modernity, more postmodern/poststructural approaches offer a way to question knowledge and discourses in science education that are typically taken for granted.

Consideration of how discourses, texts, or relations of power work to constitute subjectivities is scant in the field of science education. However, Peter Ninnes (2002) has been successful in asking these kinds of questions in his work regarding space science and national politics in science textbooks, as his inquiry is concerned with “the range of ideas” and “perspectives students can legitimately adopt” (p. 559). Julie McLeod (2000) affirms the link between particular subjectivities of class and gender over long periods of time drawing from Bourdieu’s notion of Habitus, but maintains that the link between schooling and subjectivity be “presented not simply as an interesting theoretical dilemma, but also as a relation that needs to be understood in the context of actual material and everyday practices” (p. 518). In terms of sex education, Janssen (2009) demonstrates how educational discourses generate ‘a ‘curricular
subjectivity’ that reduces subjects to their ‘appropriate’ or ‘entitled’ trajectories’” (p. 6).

Milewski’s (2009) historical work about the nature curriculum in Ontario outlines how new bodies of outdoor knowledge can intentionally and unintentionally formulate new kinds of subjectivities (e.g., a kind of appreciation for nature that will prevent young people from moving to cities). However, the most powerful work, and one that will be mentioned periodically throughout this thesis, is Elizabeth McKinley’s (2005) account of the conflict involved in being a woman of colour, Maori, and a scientist. McKinley’s analysis brings to the surface how the subjectivities of Maori women scientists are always already partially constituted by the universal white body of the ‘scientist’ making the realization of a ‘Maori women scientist’ very difficult, if not impossible, to attain for these scientists. McKinley provokes the reader by asking: What kinds of subjectivities are constituted in science and how do some eclipse others? What possibilities could be opened by reworked or renegotiated subjectivities in science?; What can become the framework for this reworking or renegotiation?

2.2.1 Textbooks (What is a text?)

This dissertation engages the question of what a text(book) is, politically and culturally. Texts can be conveyors of a many types of discourse. In this sense, they are entangled in a web of other discourses where, to adopt from Jacques Derrida and place it in Foucauldian terms, ‘there is no outside of discourse’. This is because anything non-discursive must be mediated through discursive means, pictorially or through a grammatically ruled language. All texts therein systematically form the objects (and subjects) of which we speak. For Bruno Latour (1987), even ‘facts’ concerning the natural world in the physical sciences follow a priori discursive descriptions and justifications. These justifications have to do with current discourses of nature, argument structures which themselves are beholden to further discursive restrictions. As Foucault (1972) states in *The Discourse on Language*:

> It is always possible one could speak the truth in a void, one would only be in the true however, if one obeyed the rules of some ‘discursive’ policy which would have to be reactivated every time one spoke (p. 224).

In the same lecture, Foucault cites the example of Gregor Mendel who spoke “truth” however did not fit within the sanctioned objects and biological concepts, thus he could not be ‘dans le vrai’. Science (education) texts, then, can be seen as a set of sanctioned statements comprising a set of discourses, with their own rules about what is allowed to count as true, what statements
can follow, and who can speak such statements. In this way, as Fairclough (2010) claims, texts also “have social, political, cognitive, moral and material consequences and effects” (p. 14); and while these effects and consequences may not be ‘regular,’ in that they affect every situation or individual, they have the potential to be causal to other actions. In this sense, a text can also be defined by the effects it has on individuals; even those who do not work with the text!

. Historian of science Thomas Kuhn (1996) affirms the importance of science textbooks in his seminal work, The Structure of Scientific Revolutions, when he describes them as “the site where each new generation of citizens and scientists learn to practice their trade” (p. 1). Kuhn notes that, “to an extent unprecedented in other fields, both the layman’s and practitioner’s knowledge of science is based on textbooks and a few other types of literature derived from them” (p. 137). Mody and Kaiser (2007) describe texts in a positive light when they point out that: “Scientific textbooks rarely stay repositories of finished work, or mere logical reconstructions of reigning theories. Rather, for more than two centuries, textbooks have provided authors, publishers, teachers, and students a forum for intellectual and pedagogical improvisation” (p. 384). The study of textbooks is crucial as they represent “archaeological traces” of former and current regimes of knowledge (Bensaude-Vincent, 2006, p. 668). While science content in textbooks can be understood, at least partially, as “an idiosyncratic reconstruction of the authors, informed by the specific aims they implicitly or explicitly hold” (Duit, 2007, p. 116), often textbook content is perceived as natural rather than subjective interpretations of reality (Sleeter & Grant, 1999).

Textbooks also are, however, an outcome of complex human interests related to specific economic and power objectives (Luke, 1988). Michael Apple’s (1991) work on textbooks distinguish them as,

... no less than the organized knowledge system of society. They participate in creating what a society has recognized as legitimate and truthful. They help set canons of truthfulness and, as such, also help re-create a major reference point for what knowledge, culture, and belief, and morality really are (p. 4).

Since textbooks are invested with such power and legitimacy, it is imperative they are seen as what Umberto Eco (1989) in Opera Aperta calls, ‘open’ texts; that is, a text with a wide range of interpretations and meanings. Quite often, textbooks of science are thought to take up Eco’s category of a ‘closed’ text; or, a text taken to have a singular meaning — a conveyer of content.
If understood this way, students and educators miss valuable opportunities to challenge what is often seen as knowledge ‘already known’ about the world. As Connelly et al. (2008) maintain,

[...]here are equally compelling reasons for focusing our attention on the textbook as official arbiter of official knowledge. Texts are simultaneously economic, political, and cultural. Because of this they can act as a lever to pry lose the complex relationships between what counts as legitimate content and the realities of inequality in the larger society (p. 26).

Educational standards to minimize discriminations, oppressions, and discourses of social injustice exist, and it is useful to look at one of the Ontario Ministry of Education’s general standards concerning bias in textbooks of all subjects:

The content must be free from racial, ethnocultural, religious, regional, gender related, or age-related bias; bias based on disability, sexual orientation, socioeconomic background, occupation, political affiliation, or membership in a specific group; and bias by omission. The material should present more than one point of view, and be free from discriminatory, exclusionary, or inappropriately value-laden language, photographs, and illustrations (Ontario Ministry of Education, 2008, p. 8).

This statement provides a glimpse at the power of textbooks and their many potential discriminations and oppressions. One thing to note here is that when the ministry approves any textbook it is implicitly making the claim that it is free from an extensive list of oppressive possibilities, and not written from only one point of view. However, the same ministry document also mandates that all weblinks provided to students as resources in the text be exclusively from a Canadian government website. The reason given for this stipulation is to ensure accuracy of information, but this example illustrates that textbooks promote an already biased state-sanctioned point of view. Consequently, any textbook approved by the MOE must always already accept a bias within in its own approval policy whilst claiming to be bias free. My point here is that educators and educational institutions as well as students need to speak about curriculum resources in a way that acknowledges their inherent political motivations!

Understanding complex and multifaceted effects of power contained within textbooks needs to become an integral component of a comprehensive science curriculum that prepares students to become critically active in “sciencivic” issues (Erin Sperling, personal communication, March 31, 2010). Derek Hodson’s (2009) call for balance in school science
curriculum requires students to become familiar with the purposes of scientific language and the sociocultural contexts of the ‘big ideas’ in science. Even in terms of the basic usages of scientific knowledge, Hodson states “that understanding and using an item of scientific knowledge entails knowledge of its role and status as well as its strengths, weaknesses and relationships to other knowledge items …” (p. 173). John Rudolph (2005) recognizes that the kind of science often described in textbooks, *an internal search for truth in isolation from societal concerns*, regularly fails to serve or enrich the public good. This thesis goes further in its endeavour to show how the discourses of textbooks constitute subjectivities related to sex/gender and sexuality, colonizer/colonized, ethical issues in biology, and neoliberal, global capitalism and the ‘world of work.’

### 2.3 A Word About the ‘Author Function’

While it is often the case that textbooks are written by many authors and stakeholders, such as publishing companies, ministry advisors, teachers, and science education consultants, the analysis reported here *downplays* this aspect. Making an effort to minimize the textbook authors’ intentions is consistent with Foucault’s archaeological tendency to, as much as possible, disrupt the author function of texts, that is to say, not trying to intuit the intentions of the textbook writers (Foucault notes that the author function has become a specific organizing principle in modernity with the oeuvre as the unit of this organization. Since Foucault does not see individuals as autonomous from larger discourses that delimit thought, organizing texts this way is somewhat arbitrary as the name of the individual would tell us nothing about the discourses inside the text). This involves setting go of the notion that texts are the specific creation of the minds of the writers. There are at least two immediate reasons for this. First, focusing on the author function is more or less tied to the notion that independent rational minds write unique texts. While I do not disagree with this to *some* extent, subjects *always speak* within larger discourses that circulate — and these discourses sets the limits what can be said, thought or acted out. The opposite view of texts can be seen in the analyses of someone like Harold Bloom (2002) who tends to organize his literary thinking around the genius of master writers. Going further using Judith Butler’s (1997) terms, textbooks have a performative function in that they produce what they name in a “discursive performativity” (p. 107).
This leads us to the second reason for minimizing the author’s intentions, namely that focusing on what one thinks the author was trying to say, and thereby trying to delve into a deeper meaning, can distract the reader or analyst from focusing on what the text literally says on the surface, literally. Although acts of reading are always, to some extent specific interpretations, in a Foucauldian archaeological context the analyst tries, as much as possible, to concentrate on the surface literal meaning of statements without trying to infer some kind of meaning under the surface. This specific effort can lead to a reading of the statement that is less beholden to what we think the authors might be trying to say and focuses more on what they did say thereby freeing the statement, to some extent, from assumptions of both the reader and the writer. In this sense, as Kendall and Wickham explicitly state, in a Foucauldian analysis “we cannot go beyond this discursive ‘surface’ to a ‘deeper inside’ of ‘thought’: the surface is all there is” (p. 37). In other words, there is no deeper reality to which to refer. The textbook authors likely have intentions, but what is salient in this analysis are the discourses found within the textbooks, the limits they set, and the specific ways they may work to constitute a particular kind of subjectivity. Considering texts to be representations of larger discourses at work, rather than just the rational thought of specific author(s), provides the warrant to ‘defocus’ on the authors’ intentions, and helps the analyst to see the text as a sample of these larger discourses. This technique also represents one key aspect of Foucault’s analyses as he tried to account for phenomena outside an idea of the human mind or consciousness through discourses at play, material conditions, and technologies of power. The immediate result of such a stance is the extra-complexity added to analyses. This is not to say that the author function does not have some importance in this analysis. Like all authoritative documents (government documents for example), textbooks often do not publish the specific author of chapters or sections. In this way, the discourse in textbooks takes on a certain quality of objectivity; its author is less of a ‘who’ than a ‘what.’

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4 Speaking about the author function at this point, before the methods chapter, is representative of all the conversations I had with colleagues about the function of the author (namely with, Erin Sperling, Larry Bencze, Darren Hoeg, and Joanne Nazir). This led me to confront some specific criticism – for example it is not the case that we can drop the author function and look entirely at the surface of text – rather these practices are methodological tendencies.
Another important aspect of these textbooks is the power effects circulating with the discourses due to their pretense of speaking ‘scientifically’ — in the sense of speaking in an objective manner. For this reason, the analysis of science textbooks takes on a different kind of importance than inquiries in other subject areas because science unavoidably endeavours to speak a kind of ‘truth.’ As Foucault (1984) maintains, truth is conjoined to power, meaning that when science speaks about human affairs it is coupled with a significant measure of power and effects of power. For example, statements concerning sexuality may be uttered in every corner of our social world, but when they are spoken about objectively they imbibe a kind of power related to the authority of ‘the one’ (science) who can speak. This aspect of science (education) discourses is a partial answer to objections such as: ‘So what? Many curriculum materials are homophobic,’ or ‘of course the Ontario government promotes its own agenda in schools’. The point is that homophobia and other political agendas are forwarded under the assumption of objectivity and come with the exercising of power. It is this aspect that makes this following theoretical engagement and analysis all the more necessary.

A vital aspect to this research, both in terms of theoretical engagement and the empirical work, are its broad political objectives. Since science is complicit with oppressions, it is always already politically engaged and often not for the better. In education, this means putting science under various levels of analysis in order to engage the specific areas where science contributes to oppression. This thesis is specifically concerned with the way discourses of science education work to constitute sex/gender and sexuality, colonizer/colonized, neoliberal/capitalist worker, and ethical subjectivities in an effort to engage science education scholarship in larger sociopolitical struggles. My hope is to provide some insight into how science education is entangled in these struggles, and what it can potentially mean for students who are entangled and constrained within these discourses, to open up new points of inquiry. Foucault (1972) targets the site of choice in the Archaeology of Knowledge:

Should [the principles of the individualization of discourse] not be sought rather in the dispersion of the points of choice that the discourse leaves free? In the different possibilities that it opens of re-animating already existing themes, of arousing opposed strategies, of giving way to irreconcilable interests, of making it possible, with a particular set of concepts to play different games? (p. 40)
If it can be shown that these discourses work to frame possibilities of thought, then we can rework them.

Reworking, or asking after subjectivity is not a process that stops; therefore, the results of this work with textbooks should not be taken as the way forward. Insisting upon this is in keeping with poststructural ways of knowing, which do not privilege one way of knowing (any one explanation) over another. Having said this, advocating against (or for) anything found in the discourse of biology textbooks can be attributed to my particular ethico-political position as informed by all aspects that historically and politically situate my work. However, if my position is political and historically situated, there is less closure on what else can be thought.

2.4 Subjectivity and Discourse

One who breaks an unjust law must do so openly, lovingly, and with a willingness to accept the penalty. I submit that an individual who breaks a law that conscience tells him is unjust, and who willingly accepts the penalty of imprisonment in order to arouse the conscience of the community over its injustice, is in reality expressing the highest respect for law… Martin Luther King Jr, 1993

This thesis follows Michel Foucault’s ideas concerning the constitution of subjectivity. Subjectivity constituted through discourse serves as the main organizing theoretical concept by which Ontario secondary school biology texts are examined. It is likely that Althusser’s (1998) work on ideological state apparatuses (ISA) and the formation of subjects through them influenced Foucault’s thinking regarding subjectivity. According to Althusser, ideology operates first at the level of the institution (i.e., family or school) then at the level of consciousness. Schools and their perceived neutrality or ‘naturalness’ is, for Althusser, an ideal ideological apparatus, and it is this ‘naturalness’ of schools, and by extension disciplinary knowledges such as science, that becomes key for understanding the interpellation of subjects by ideology. According to Foucault, disciplinary discourses and knowledges not only contain rules for what can be said or not said, but what kinds of future statements may be formulated. This point is somewhat crucial for understanding the importance of this study, as scientific research tends to have no less than giant effects on daily life and environments. Althusser argues that it is the very denegation of ideology, as is the case in many school boards that claim to present curricula free
of bias or oppressive content, that comprises an important aspect of the character of ideology: “Ideology never says: ‘I am ideological’” (p. 118). For Althusser, “Ideology is only made possible by the subject,” and, in addition, “all ideology has the function of constituting concrete individuals as subjects” (p. 299). Althusser makes the point that individuals always-already are subjects in that they are constituted before they realize their subjectivity. He recognizes the almost ironic ambiguity of a ‘subject’ when he maintains that, “the individual is interpellated as a (free) subject in order that he shall (freely) accept his subjection” (p. 303) — a point later re-articulated by Foucault, who contends that power can only be exercised over free subjects. John Fiske (1998) agrees that as subjects are constituted and interpellated by institutions many ideological connections are sustained between these institutions: “Thus the education system, for example, cannot tell a story about the nature of an individual different from those told by the legal system, the political system, the family, and so on” (p. 307). Taking Althusser’s notions of ideology very broadly, we can ask questions related to what is taken to be natural in schooling, or in Foucault’s (2003) terms, what is most necessary or indispensible. Although there is an obvious continuity between Althusser and Foucault, the latter utilizes notions of discourse and ‘episteme’ (the collection of discourses that form the historical a priori by which statements are rendered admissible and inadmissible) to help explain how subjectivity is constituted while simultaneously distancing himself from more Marxist notions of ideology. An advantage to focusing on discourse rather than ideology is that ideology (in its most commonly used Marxist form) is often tied to a political agenda that must already be clear and demands the implicit assertion that one can speak outside of ideology, and that one doesn’t necessarily have to take economic/material conditions as ideology’s precursor (Foucault, 1980). A focus on discourse allows people to examine the very way the symbolic and the real are constructed without automatic reference to a distinct political agenda or false consciousness (Mills, 1997).

This study maintains that the subject “is not someone who is necessarily activated by particular truths in discourse but is itself constituted by particular truths in discourse (Rasmussen & Harwood, 2003). Succinctly, Foucault’s work demonstrates how the various subjective positions we take up are constituted by specific possibilities of thought and action found within discourses where the nexus of truth and power circulate. It is often thought that power is at the centre of Foucault’s work, yet he states, “it is not power, but the subject that is the general theme of my research” (Foucault, 1982, p. 209). As uncomfortable as this may be for science educators who believe strongly in a free humanist subject position (Essentially the unitary Cartesian subject
that believes in its own self-containment, uniqueness, and pure ability to think and reason (Mills, 1997, p. 33)), considering the constitution of subjectivity can be a useful tool to consider how discourses actually operate in science education. Quite understandably, more poststructural ideas of the subject have provoked fierce debates about human agency, for if our very subjectivity is constituted through discourse what hope do we have for change? For those who reject the idea of a discursively/ideologically constituted subject it can nevertheless be said that whatever idea of the subject we embrace the discourses that the subject must use are already present and at play (Foucault, 1972). Foucault (2003) reminds us: “At this level, it’s not so much a matter of knowing what external power imposes itself on science as of what effects circulate among scientific statements” (p. 303). It is not about emancipating the ‘truth’ or a pure way of thinking about science, but of “detaching the power of truth from the forms of hegemony, social, economic, and cultural, within which it operates at the present time” (p. 318).

The subject or agent of knowing in critical feminist terms is from-the-start not monolithic or singular, this can stand in stark contrast to the “singular, Rational Man of Enlightenment Thought” (Harding, 2006, p. 68). In her essay, Contingent Foundations, Butler (1995) quickly addresses the critique that a unitary, free, rational, Cartesian — and thereby stable — subject is needed as the foundation of political thought and by extension science. Requiring a particular definition of the subject position is in her terms “an authoritarian ruse by which political contest over the status of the subject is summarily silenced” (p. 36). Butler elucidates well a key point concerning poststructural conceptions of the subject:

There is no ontologically intact reflexivity to the subject which is then placed within a cultural context; that cultural context, as it were, is already there as the disarticulated process of that subject’s production, one that is concealed by the frame that would situate a ready-made subject in an external web of cultural relations (p. 46).

One reason for this is because the subject is always already constituted through power relations. As this relates to power and the conduct of individuals, Foucault (1982) claims that we must think of conduct as a questioning of governing:

The exercise of power consists in guiding the possibility of conduct and putting in order the possible outcome. Basically power is less a confrontation between two adversaries or a linking of one to another than a question of government (p. 789).
To Foucault, governing is a general term that essentially means to “govern the possible field of actions for others (p. 790); state institutions have come to play a prominent role in rationalizing, centralizing and authorizing these power relations. On top of this, and this is an aspect that thesis approaches but does not quite outline, are the modes of subjectification that involve “the way a human being turns himself into a subject” (Foucault, 1982).

It is in this spirit of political and intellectual challenge to traditional notions of subjectivity that science students and science educators can begin to question how their own subjectivities have been (partially) constituted through education. As Butler (1995) maintains, this does not mean we can never say “I” anymore but that we ask after the processes of the subject’s construction as well as its political meaning. This means not necessarily doing away with any version of subjectivity but to recognize the problematic nature of its formation, which may allow us to glimpse the power inherent in the way we come to a ‘scientific’ situation, opportunity or problem. It allows us to interrogate how our fundamental views of what can be done, even thought, are discursively formulated by theoretical positions, material conditions, along with what is excluded. Indeed, it is the very constituted nature of the subject that is the pre-condition for radical change. As Butler (1995) states, “for what is it that enables a purposive and significant reconfiguration of cultural and political relations, if not a relation that can be turned against itself, reworked and resisted” (p. 46)? If we are then always-already constituted as subjects as we enter science classrooms/labs/fields (and when we find ourselves there), the kinds of questions we ask will also be contingent on these subjectivities. If we as educators take the time to ask after the types of subjectivities we take for granted we can begin to reconfigure what understand to be legitimate scientific knowledge and inquiry, and in this way politically engage our own constituted selves.

Avoiding an over-simplified reification of any notion of the subject may mean viewing subjects as just as contingent as the meaning of a photograph like Roland Barthes (1981) describes in Camera Lucida:

… a photograph cannot be transformed (spoken) philosophically, it is wholly ballasted by the contingency of which it is the weightless, transparent envelope...it points a finger at certain vis-à-vis, and cannot escape this pure deictic language. That is why, insofar as it is licit to speak of a photograph, it seemed to me just as improbable to speak of the photograph” (p. 5).

Since subjectivity in individuals, like a photograph, is formulated by circulating discourses, truths, and material contingencies, we must be careful not to pretend we can define the subject; rather it may be better to focus attention on a subject — even though this subject will never be entirely describable. Bronwyn Davies’ (2006) work concerning power and the subject in education highlights
a key aspect of hope when thinking about altering or working (re)constitute different subjectivities. She maintains there is always something provoking a power relationship, and the suddenly reformulated will of those held in subjection, which is in line with what Foucault argues; power is often exercised over those “only insofar as they are free” (Foucault 1994, p. 342), or believed to be free. Freedom is always possible even when the power that constitutes subjects is invisible. Therefore, to bring it around full circle vis-à-vis discourse and the subject, Kendall and Wickham (1999) state the relationship for Foucault in the following way:

Subjects’ actions take place in discourse, and subjects themselves are produced through discourse. Subjects are the punctuation of discourse and provide the bodies on and through which discourse may act...Human action within discourse is always positional, that is, it always occurs through a subject position having a space between two poles of knowledge, the discursive and the non-discursive (p. 53).

As mentioned previously, this research keeps in mind that, for Foucault, a key aspect of constituting subjectivity involves subjects being active in constituting their own selves. This involves no less than the constitution of one’s relationship to one’s self, an idea Foucault (1988) takes up later in his work in the History of Sexuality Volume 3: Care of Self. Concerning this aspect of turn-toward-self aspect of subject constitution, Foucault (1988) has this to say:

I would say that if now I am interested, in fact, in the way in which the subject constitutes himself in an active fashion, by the practices of self, these practices are nevertheless not something that the individual invents by himself. They are patterns that he finds in his culture and which are proposed, suggested, and imposed on him by his culture, his society, and his social group (p. 11).

Students of science will constitute themselves in terms of the limits and possibilities for the specific ways science students can come to think of themselves as future scientists and political subjects. However, it should be clear that science education and its texts cannot be solely responsible for any one aspect of a particular constituted subject as we are bombarded by many discourses daily, often with conflicting power interests.

Another major tension related to the discursive constitution of subjectivity is where does that leave political agency? Both Foucault and Butler have endeavoured to answer this question. Foucault maintains the very nature of power embodies a kind of resistance so that power doesn’t merely dominate: “If power was never anything but repressive, if it never did anything but say no, do you really believe we should manage to obey it?” (Foucault, 1980, p. 36). Thus, for
Foucault, discourses infused with power *produce*, as well as repress. Power implies a relationship that can be interchanged. As mentioned above, Butler sees the constituted nature of the subject as a necessary precondition for turning power relations back on itself. As Žižek (2006) states in a discussion of Lacan’s symbolic realm, our having actual free choice may indeed not be the case from the moment we accept living in a society, as this acceptance in itself is imposed and not a free choice. In other words, *from the very beginning freedom or agency is either paradoxical or limited*. However, this thesis forces the question of how we can ask after the constitution of subjectivities and resist this constitution.
Chapter 3: Methods and Methodology

The methodology outlined here represents an approach to discourse analysis from an archaeological perspective in order to carry out microanalyses of science education discourses. When I started this analysis thinking that such microanalyses were not so important to the main goals of science, teaching big concepts, skills and techniques, and at best could only represent an anterior voice to these major research priorities. I have since changed my mind precisely because of the marginalized position of such research concerns. I noticed that many in science education seem to want to (desperately?) encapsulate science in a grand, universalizing way. That is to say ‘science is like this, science is like that, science gives us this, science gives us that’, which arguably comes from the fact/value split outlined by Bruno Latour (1986). Considering what a focus on science education discourse allows us to see, sociopolitical commitments, cultural practices, and the limits of its ‘power’, it seems to me that ‘big questions’ may not matter so much. From this perspective they are irrelevant because science is always already ideological or committed (Trifonas, 2013), and so science is always already ‘never this’ and ‘never that’.

As stated in the previous chapter, this thesis draws extensively from the work of Michel Foucault, in order to bring to the surface specific political, cultural, and epistemological underpinnings that circulate in the discourse of Ontario biology textbooks. Discourses of textbooks can arguably be transformed into particular social practices, such as school science and ‘professional’ science, through relational and conditional language, not simply language that represents the ‘natural’ world. Discourse analysis as employed by Foucault and others, challenges concepts thought to be universal, and has ‘de-idealized’ scientific knowledge by showing its arbitrary discursive embodiments and materiality (Vighi & Feldner, 2007, p. 151).

Discourse in the Foucauldian sense can be used interchangeably to refer to a general domain of all statements, or group of statements, that systematically form the very objects we speak (Foucault, 1972). These statements are not only made within a social context but work to maintain social contexts. As Sara Mills (1997) explains, “[s]tatements are for [Foucault] those
utterances which have some institutional force and which are thus validated with some sort of authority – those utterances, which for [Foucault] would be classified as ‘in the true” (p. 61). Statements must always be justified with a specific discursive, disciplinary backdrop that governs them to know if they are true or not (Foucault, 1972). An example of such a statement could be, “Science has always operated on the basis of competition”, spoken within a curriculum resource would have the authority of a statement and ostensibly have effects in the real world pertaining to institutions of science or what scientific research communities would look like. Thus, discourse in general can be thought of as a group of statements, with institutionalized force, having profound effects on how people think and act (Mills, 1997). Perhaps the entire spirit of the future research detailed here can be summarized with Davies’ (2006) imperative for education:

We must take responsibility for examining the documents and discursive practices that are taken for granted in schools and universities, and ask: what conditions of possibility are they maintaining for us and for our students (p. 436).

Thinking about discourses in the Foucauldian sense involves the consideration of textbooks as set of discourses or discursive formations that are open to analysis and criticism along with the sets of relationships that exist between them. Pertaining to Foucault’s discursive formations, Sara Mills (2003) states these are to be thought of as regular associations in discourse:

The term “discursive formation” is used by Foucault to refer to the regular associations and groupings of particular types of statements; these are groupings of statements which are often associated with particular institutions or sites of power and which have effects on individuals and their thinking (p. 64).

The principal approach to discourse analysis utilized in this thesis derives from Foucault’s (1972) methodology of archaeology. Archaeology for Foucault differentiates itself from genealogy in that it is snapshot of larger discursive realities while genealogy pays attention to changes to discursive realities over time. (Foucault, 1981, p. 70). Foucault advocates the use of archaeology (over genealogy) when examining local discursivities, such as discourses in textbooks (Foucault, 1980). In taking an archaeological approach, one must try to isolate the various relations between statements in the discourse — even when the authors are unaware of such relations. This can be done by dropping, as much as possible, the pretence of unity in the text and, instead, focussing on the specificity of the statement’s emergence, as well as giving
attention to its correlation with other statements. By deliberately not trying to infer what was meant to be inferred by statements, their very banality is brought into question. As Foucault states: “to maintain it in its consistency, to make it emerge in its own complexity” (Foucault, 1972, p. 31). Another use of dropping the pretence of the author that wasn’t mentioned in the last chapter is that it allows groups of researchers to analyse utterances across a wide variety of texts. Once discourses are more visible, we can see how they operate through a “delimitation of a field of objects, the definition of legitimate perspective for the knowing, and the fixing of norms for the elaboration of concepts or theories” (Foucault, 1977, p. 199).

Archaeology aims not to necessarily expose hidden meanings of the statements found in the discourse or the silence of some alternative discourse, but capture statements in their own complexity; as Foucault further clarifies, “to remain at the level of the discourse itself” (p. 53). Foucault insists we should try and analyse statements in regards to theirs authors, ...

Archaeology encourages us to engage in a task of analysis “that consists of not – of no longer treating discourses as purely groups of signs, (signifying elements referring to, contents and representations) but as practices that systematically form the objects of which they speak” (Foucault, 1972, p. 54). An archaeological analysis does not seek to discern whether statements, ‘scientific’ or otherwise, are ‘true’ or not, but looks at the domains around which these utterances are situated, how we are constituted by them, and “how what is said to be true and false makes things ordered and pertinent” (Foucault, 2003, p. 252). Foucault (1970) affirms in The Order of Things that his aim is to:

.. to reveal a positive unconscious of knowledge: a level that eludes the consciousness of the scientists yet is a part of scientific discourse, instead of disputing its validity and seeking to diminish its scientific nature (p. ix).

Thus, it is not the veracity of the truth of statements that is of fundamental interest in a Foucauldian discourse analysis, “but the effects in the real world to which they are linked” (Foucault, 2003, p. 257). To Foucault, discourses of education are a “way of maintaining or modifying the appropriation of discourses, along with the knowledges and powers they carry”
(Foucault, 1981, p. 64). For example, the Ontario Ministry of Education (2008) requires school science texts to cover a minimum of 85% of government curriculum expectations, these texts must be seen as being inextricably linked to (state) power and the effects of power irrespective of the empirical ‘truths’ that may be communicated in the texts.

Archaeology is not a “nailed down” methodology as can be seen by the various methodological adaptations taken in this thesis. I found that it was quite necessary to shift both the theory and method depending on what questions were being asked of the text. As can be seen in chapters five and six, viewing images as discourse became a way for me to get at a discourse of whiteness and masculinity that may have not been possible with just linguistic signs. Another adaption to the general method can be found in chapter four, where I examine discourse from the perspective of a specific definition of an ‘ethical situation’ and chapter eight where I take discourse as revealing a set of repeated practices with lab/science/investigations. However, Kendall and Wickham (1999), in their book Using Foucault’s Methods, distil some basic tenets of the methodology. These tenets have been summarised in table 3.1, and since they are only general guidelines I have also outlined how I have used, modified, or interpreted these techniques in the following chapters below.

**Table 3.1. General Assumptions and Aims of Archaeological Research (Kendall and Wickham, 1999)**

<table>
<thead>
<tr>
<th>Assumptions:</th>
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<tr>
<td>i) In seeking to provide no more than a description of regularities, differences, and transformations archaeology research is non-interpretive</td>
</tr>
<tr>
<td>ii) In eschewing the search for authors and concentrating instead on statements (and visibilities), archaeological research is non-anthropological.</td>
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<table>
<thead>
<tr>
<th>Aims:</th>
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<tr>
<td>i) To analyse the relation between one statement and other statements</td>
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<tr>
<td>ii) To chart the relation between the sayable and the visible</td>
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<tr>
<td>iii) To formulate rules for the repeatability of statements (or the use of statements)</td>
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<tr>
<td>iv) To analyse the positions established between subjects in regard to statements</td>
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<tr>
<td>v) To describe surfaces of emergence – places within which objects are designated and acted upon</td>
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<tr>
<td>vi) To describe ‘institutions’ which acquire authority and provide limits within which discursive</td>
</tr>
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objects may act and exist

vii) To describe ‘forms of speciation’, which refer to the ways in which discursive objects are targeted. A ‘form of speciation’ is a system for understanding a particular phenomenon with the aim of relating it to other phenomena.

3.1 How these Aims and Assumptions are Manifested in this Thesis

In this thesis I have made specific use of these over all aims and assumptions. The first assumption has meant that scientific truth has not been specifically called into question, nor are the discourses taken to be inherently flawed. Rather, they are representative of particular discursive regimes. As shall be discussed below, I have however compromised archaeological research in that I have interjected my political positions for the purposes of analysis (something Foucault tried to avoid). This can be seen all through this thesis when I take a polemic stance against sex/gender binaries (chapter 5) and universalizing discourses that operate in colonizing ways (chapter 6) and neoliberalism (chapter 7).

In chapter five this thesis broaches the relations between the visible in the sayable through a reflective display of images. Specifically, how race and gender can be seen in selected images. Here I found that new analytical tools were needed to analyse these images, and in this regard I have used Roland Barthes’ notion of the punctum and studium to help define what is ‘wounding’, but also a context of the photographs (as guided by a critical perspective on race/sex/gender and sexuality). Noting how something appears in its (first) emergence is a technique I employ in chapter six. For example when the words society and industry/agriculture appear discursively, the statements give a specific meaning to the word society; one that occludes non-agricultural, industrial societies as devoid of culture. This is to say that archaeological aims and aspects of discourse analysis are to be thought of as an overall backdrop for this project whereby they can be employed and supplemented as need, in situations that warrant them.

Meaning and Interpretation

Lindsay Prior (2003) maintains that documents can be used in qualitative research by either looking at their content and/or how they function in context. While the situated and contextual qualities of any text are extremely important, I have chosen to focus on a ‘theoretico-
discursive’ examination because I feel discourses of science and science education have been largely ignored for being: apolitical and banal; known for naiveté; and only influenced by external economic and political agendas, thereby leaving the conception of a purely science discourse intact. I have also chosen to engage multiple bodies of literature from political economy to postcolonialism, as exploring more than one type of subjectivity requires constantly recasting how the analyst makes sense of these subjectivities — one theoretical framework is simply not sufficient. This work is intended to help lay some groundwork that takes subjectivity in science education as a research concern, for example in ethnographic studies of how various modes of subject constitution are taken up and negotiated by students.

At a basic level, there are three ways an analyst could go about determining meaning from texts. The first is to focus on how the text is produced through a detailed focus on the various writers and authors along with socio-political and economic realities that shape how the text is constructed. The second entails an examination of the text itself, that is the specificities of the discourse vis-à-vis other discourses. The third way involves the reception of the text, how it is taken up by readers, and how the interpretation plays out in social contexts. While meaning has to do with all three of these aspects, this analysis focuses only on the texts. Justification for conducting an analysis such as this, outside of the Foucauldian and poststructural arguments already given, is simply that any one of the three basic ways to analyze texts is inexhaustible. For example, Maurice Di Giuseppe (2007), who was successful in defending his dissertation at OISE/UT, gave attention to the production of a textbook in regards to the various processes and stakeholders involved in its publication with some attention to the text itself save the way the text portrays the pedagogical construct ‘nature of science.’ Considering all three modes of analysis may also force the analyst to provide some kind of ‘comprehensive’ picture related to what was intended or why something was produced, what was produced, and how exactly it was taken up in social relations. Such an analysis, is a massive endeavour and may be possible if one were to focus on one aspect of the text; for example how it portrays, challenges, or creates racializations. Conversely, this analysis investigates several kinds of discourses within the texts, their interrelations, subtleties and specifically at the way these textbooks set relations between subjects and things, other subjects, and to self. Concerning the inter-relatedness of these, Foucault (2003) states:
It is well known that control over things is mediated by relations with others; and relations with others in turn always entail relations with oneself, and vice versa. But we have three axes whose specificity and whose interconnections have to be analyzed: the axis of knowledge, the axis of power, the axis of ethics …how are we constituted as subjects of our own knowledge? How are we constituted as subjects who exercise or submit to power relations? How are we constituted as moral subjects of our own actions?” (p. 55)

These relations inform the way I read the texts in terms of how the texts work to set these relations. This is not to say that there are not many other ways to read texts. As my colleague Erin Sperling pointed out to me, my thesis is predicated on a way of reading that privileges front to back and the other organizational structures of the book (table of contents, etc) even if I am not aware of such structures and ways of reading (Erin Sperling, personal communication, September 6th 2012). While I have endeavoured to disrupt the text, for example by providing a display of images and statements that outline a discourse (e.g. race/sex/gender and sexuality – chapter 5) or the contents of specific structures (e.g. lab/performance tasks – chapter 8), I take well the point that there exists different ways of reading these texts that would produce different objects and meanings.

3.2 Considerations of Method

One major tool in this thesis has already been described. That is, reading the text whilst dropping as much as possible the pretence of unity and not being overly focussed on the intentions of the writer, but instead more focus on what is being said on the surface. This includes omissions and silences in the texts, as these, too, must follow the particular rules of what can be said and not said within a discourse. Another tendency I wish to account for is the bringing in of second-order judgements in my analysis. Kendal and Wickham (1999) describe these as ahistorical judgements that gain their authority from the discourse of another investigation. While Kendall and Wickham discuss second-order judgements in light of historical analysis, there still exists the precariousness of making second order judgements and interpretations based on a secondary discourse I bring to the analysis (postcolonialism, critical pedagogy, etc.). Doing so means possibly “betraying” Foucault’s general commitment to contingency and the historical situatedness of discourse. Foucault was also against polemics because he felt their intent was to silence another. However, throughout this textbook analysis, unthoughtful second-order judgments may be avoided using two basic methods. The first is not
to question the veracity of truth claims given within the discourses of these textbooks, but only isolate effects of the discourse, the limits it sets on action and, if possible, to roughly identify some rules of the discourse. The second method is simply to *acknowledge these second order judgements when they arise*; for example, in an anti-capitalist interpretation of the texts. Some second-order judgements that I make are positions about which I feel very strongly. A way to retain conviction and commitment to these positions is by identifying them as *political positions*. For example, in my treatment of the political economic aspects of these texts, a call to mitigate and rework global capitalist agendas can be seen both as a *second-order judgement* but also as a *political position* thus retaining the judgement’s relativity and plasticity. I feel applying second order judgements from a particular political perspective marks one significant difference between the work I have done with these texts and work Foucault might have conducted (likely perhaps Foucault would be asking broader questions across a wide variety of texts). One reason for this difference is that I am situated within at least two disciplinary boundaries, science and education, the former holding me to texts relevant to science students and educators, the latter to a framework of critical pedagogy and socio-political thought where oppressions are meant to be interrogated for the marginalized and common good.

This analysis also employs ‘finer tools’ of discourse analysis, such as those developed and described by Gee (2011). These include examining a wide range of grammatical structures, using semiotic systems of meaning, making what seems ordinary strange, framing the many contextual, unspoken realities of the text, investigating how the text formulates identities, as well as how the text works to (re)distribute social goods (Fairclough, 1995; Gee, 2005). Analyzing science language sometimes requires approaches that consider the specific grammatical and metaphorical formations often used when writing ‘scientifically’ (Halliday, 2004). Appendix G contains a list of these techniques.

Each textbook was interrogated using the techniques above (and in Appendix G), along with coding procedures (Neuendorf, 2002) to keep track of the various themes related to subject constitution inherent in these textbooks. Investigating a particular discourse involved both the targeting of specific sections of the text where the discourse (e.g., sex/gender and sexuality) was evident. In some cases, particular discursive features or themes of the text were specifically sought — such the binaric constructions that occur around sex/gender and sexuality or the myths
of science listed above. In other cases, particular themes of subject constitution emerged such as those related to a colonized/colonizer subjectivity.

As Howarth (2000) advises when conducting discourse analyses, one must allow the conceptual framework to be “sufficiently open and flexible enough to be stretched and re-structured in the process of application” (p. 139). Although some argue that critical discourse analysis works to promote methodological anarchism (Habermas, 1987), Howarth (2000) maintains that discourse analysts merely modulate their concepts to suit the particular research problems they face; thereby keeping safe distances between truth, representations, the social world, and the constituted subjects that carry out actions. As Fairclough states concerning the analysis of texts, “it should be seen as an open process which can be enhanced through dialogue across disciplines and theories, rather than a coding in the terms of autonomous analytical framework or grammar” (p. 16). Discourse analysis lends itself well to research that opposes the hegemonic practices “which endeavour to produce social myths and collective imaginaries” (p. 136). In order to engage in the kind of science education that works to reform(ulate) oppressive conditions, science education scholars need to recognize these hegemonic practices and effects in the discourses that constitute future citizens and scientists.

This research is to be seen as an entirely subjective analysis, although it may use the language and speaking position of objectivity rhetorically when discussing empirical claims. My perspective is framed by the political positions that guide this research that entail questioning the way the texts portray sex/gender, western Eurocentric science, and consumerist capitalist, neoliberal values.

### 3.3 Text Selection and Research Questions

The texts selected for this analysis are four provincially-approved, according to the Trillium List (an approved list of all ministry approved textbooks for use in Ontario secondary schools) biology textbooks an Ontario secondary school student may encounter if she intends to study biology at a post secondary institution (Ontario Ministry of Education, 2011). All four textbooks are from grades 11 and 12, thereby narrowing the scope to discourses that fit more securely within the disciplinary knowledges of the biological sciences. Table 3.2 lists the books that were used in this study and others will likely be added as the analysis proceeds.
Table 3.2. Biology textbooks used in this study.

<table>
<thead>
<tr>
<th>Textbook Title and Publishing Year</th>
<th>Textbook Title</th>
<th>Publishing Year</th>
<th>Author(s)</th>
</tr>
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There are two reasons why biology as a discursive knowledge was chosen for this work. First, my background in the biological sciences allows me to understand the content knowledge of these texts to a satisfactory level and tease out aspects of ‘scientificticity’ from other aspects (such as what constitutes the specific political orientation of statement) thereby allowing me to put these meanings aside (my goal is not decide whether the scientific knowledge is true or not). Secondly, like Foucault’s (1984) identification of psychology as an ideal science for study due to its ‘dubious’ position between science and understanding the human, the biological sciences are also an ‘ideal science’ to look for the effects of power due to its engagement with human understanding (as Rabinow and Rose (2006) argue, any science that applies its knowledge to humans is part of what Foucault calls biopower). While the science textbooks in grades nine and ten are of particular importance, since they attempt to deal with the mandatory science content and learning outcomes that every student in Ontario must learn, they do not include some of the (bio)power-infused discourses science students encounter in biology textbooks, for example, discourses concerning ‘human ecology’ and ‘human sexuality.’

The research questions that ‘drive’ this thesis are given in Table 3.3. One topic that emerged after data collecting began, and will be the subject of the next chapter, is the kind of ethical subjectivity that may be constituted through the discourses of textbooks.

Table 3.3 Sample Research Questions that may help frame the constitution of subjects in Ontario Biology Textbooks:
Overarching Research Question:

How do various discourses in Ontario biology science textbooks work to constitute various subjectivities?

Focussed Questions:

Political/economic
Are there specific political commitments associated with scientific practices or knowledge(s)? What constitutes the relationship between subjects and the state? What political rationalities circulate amongst statements? How are future scientists, citizens, and subject constituted within specific economic imperatives or ‘philosophies’ such as neoliberalism or global capitalism? What assumptions are made about our current economic order?

“Western” Hegemony and Colonialism
How is a student made to think of themselves as someone who knows or can know something? Who (or what groups) are venerated as ‘knowers’? What ways of knowing are excluded? How are various “non-western” societies portrayed?

Gender/Sex and Sexuality
Are diverse knowledge claims about the natural world considered? What is portrayed as universally human and what are the possible effects of this portrayal? How does the text work to constitute a sexual subject (Is heterosexuality given as a de facto sexuality)? How is gender constructed and then discursively entangled in social and material relations?

Ethics
How are students and teachers constituted as ethical Actors? ‘Who’ must students be before they can proceed to make ethical decisions and take action? What choices are available for students in terms of ethical thought and action; and what does this mean for subjectivity?

As Gubrium and Holstein (2000) point out, Foucauldian discourse analysis does not just describe subjectivities; it more specifically describes the kinds of subjectivities that are meaningful in the discourse. While the discursive data obtained from biology textbooks provides rich insight into how subjects are constituted through science education materials it must be remembered that textbooks do not exist in a vacuum. Again, we can take note of what Lindsay Prior (2003) encourages us to remember about documents in research - namely that “their status as documents depends not so much on features of their intrinsic existence, nor on the intention of their makers, but on factors and processes that lay beyond their boundaries” (p. 2). This means discourse analysis should be also be related to the way documents can be utilized against hegemony, oppression, and the effects of power.
3.4 Introduction to the Five Content Chapters

Over the course of the five content chapters and the two concluding chapters this dissertation should be seen as working towards two related but distinct objectives: i) Engaging post-structural thought in order to (re)conceptualize science as a cultural activity via discourses that carry and produce effects of power; ii) isolating the various ways Ontario biology textbooks work to constitute subjectivity. This thesis is, therefore, to be seen as melding multiple theoretical perspectives with empirical work regarding texts. Each chapter can be seen as a related yet distinct engagement with subjectivity and, therefore, I feel, requires a greater engagement with theory than might be typical for a thesis in science education. Chapter 8 is the culmination of both this theoretical engagement, in which I call for science to be thought of as a site for biopolitical resistance in terms of the constitution of subjectivities.

The next chapter engages the question of how discourses of science work to set limits on a kind of ethical subjectivity. It looks at how the specific discourse around ethical situations work to frame an approach and outcome of ethical situations? Chapter five is a re-visititation of how textbooks work to construct sex/gender, where I reflect on earlier research that I conducted with Heather Sykes (Bazzul & Sykes, 2011). Chapter six is an investigation into how discourses work to construct both a colonizer/colonized subject — that is, how they are both constituted simultaneously in through these texts. Chapter seven and eight attempt to deal with a neoliberal capitalist subjectivity these discourses work. In chapter eight I take a slightly Marxist/Althusserian approach and think about the role of repetition when it comes to subjection through investigations/activities in the textbooks as well as examine the discourse around careers to think about what kind of subjectivity (humans as human capital) is being prepared for the ‘world of work’. Each chapter then is a kind of microanalysis that begins anew with its own theoretical, and even methodological, considerations. Many different kinds of lenses and considerations are necessary to try and capture an archaeological vivisection! The last two chapters are concluding chapters. In chapter nine, I reflect on the scope of the thesis, some interconnections between the chapters, and how the analysis will shape the future of my work in education. Chapter Ten represents the culmination of my years of study at OISE/UT — expressed as a kind of manifesto, and currently guides my work as a science educator.
3.4.1 Theoretical and Methodological Shifts of This Thesis

While this chapter lays out the general methodological approach to looking at discourse in these texts I think it important to describe the deviations taken in each of the chapters, since each chapter involves a somewhat different analysis. Since discourse analysis is an emergent and open methodology (Howarth, 2000) these deviations have allowed for a multifaceted thesis that examines several areas where these textbook discourses can work to constitute subjectivity – rather than just one theoretical and methodological approach to examine just one aspect of subjectivity (e.g. neoliberal subjectivity). For example, in the next chapter, which is related to how the texts work to constitute ethical subjectivities, I found it useful to identify the discursive moments where students are meant to decide a right course of action based on a sense of responsibility (‘what should be done’). This technique isolates these discursive fragments from others in attempt to examine the range of choices and contexts provided to students. While other discourses in these texts certainly contribute to ethical perspectives, this technique was intended to partially separate what these texts cover in terms of content, and what ethical actions and positions they allow when students are actually given a chance to think and act along these lines.

The most significant supplementing of the approach to discourse analysis and archaeology outlined in this thesis occurs in chapter five where I reflect on various images in the text and considering how they represent aspects of sex/gender and sexuality and race. As stated above, I employ some concepts from Roland Barthes in order to treat these images as discourse and read them accordingly. This exercise is archaeological in the sense that these images make the relation between the sayable and the visible more apparent. It also suspends the ‘intention’ of the images in favour of reading what is on the surface. The postcolonial analysis in chapter six is a highly theoretical chapter that deals with the relations between rethinking science and its discourses. Its strength lies in its conclusion that troubling science means shifting the epistemological frame that is already in place. Lastly, in chapter eight I use this particular basis for discourse analysis and archaeology to examine a set a ‘series of practices’ comprised of the lab/performance activities of these textbooks. For this analysis I employ an approach more in line with Althusser and Butler’s notion of repetitive practices as they relate to subject constitution. That is I bring the role of repetition to the surface. These deviations from the methodology outlined here are necessary to better treat and discuss the discourse found within these textbooks. Whereas a more typical analysis that focuses on one aspect of these texts (e.g.
representations of scientists) could easily fall under one theoretical frame and a few pre-determined modes of analysis I found that work with diverse entry points requires constant shifting. That is to say, without such a multifaceted approach exploring multiple notions of subjectivity may not be possible.

There is a ‘negative benefit’ from placing different kinds of foci concerning subjectivity together. I’ll here just give two examples: first, in chapter six, when thinking and examining a kind of colonial subject, it may become apparent that the current theoretical frame used for this research (outlined in the last three chapters) is inadequate to really interrogate these texts — although I still endeavour to engage postcolonial theory and subjectivity within the frame of this thesis. Second, in the chapter related to sex/gender there exists also the pressing question of “what do we do next” as education scholars? These are constructive consequences of this research; first, because, in the case of the sex/gender chapter, they point to the limits of critique whereby it is desirable to go forward with something different (there are times when the critique, for a brief moment, is over). In the case of the colonizer/colonized subjectivity chapter, it seems apparent that a new theoretical frame, and set of tools, is necessary to get at the discourse — for example, based on the psychoanalytical concept of ‘stereotype’ set out by Homi Bhabha and how these operate in science education texts. The chapter is not a failure in this regard but instead involves a ‘backwards’ method whereby beginnings of a tool become the product of the empirical work (to some extent I think the same could be said for the use of repetition in chapter 8). “Hitting a wall” becomes necessary before one can move on with further critical work. This thesis can be seen as an engagement with subjectivities that oscillates between a focus on the empirical data found within the textbooks used and the philosophical questions they open. As Hardt and Negri (2000) write: “This is humanism after the death of Man: what Foucault calls ‘le travail de soi sur soi,’ the continuous constituent project to create and re-create ourselves and our world” (p. 92). What follows should be seen as the beginnings of a push to rework subjectivities constituted through science education and new realizations of self.
Chapter 4: How biology textbooks work to constitute ethical “subjects”: health, population, and policy

Words are never only words, they matter because they describe the contours of what we can do.

( Slavoj Žižek, First as Tragedy then as Farce, p. 109)

This first content chapter explores how ethical exercises/situations found in secondary biology textbooks work to constitute a specific kind of “ethical subjectivity”\(^5\), that is, one who thinks and acts ethically. While it may appear that students can approach ethical exercises, circumstances, and decision-making situations from a free rational perspective, it is also the case that discourses found in science education materials work to constrain the possibilities of ethical thought and action and help constitute the kind of subjectivity \textit{necessary} to act ethically in particular pedagogical situations in science education. It is recognized that these textbooks do not fully constitute any sort of subjectivity, as this requires repeated actions and interactions of many social actors, various discourses and techniques of power, and other technologies and strategies that attempt to shape the conduct of others. As this chapter suggests, it is not \textit{any} ethical thought or action that can be undertaken within the discursive frame of textbook exercises and questions where ethical questions and situations are found; furthermore it is not \textit{any} subject that can \textit{easily} take up the role of ethical actor in terms of the way ethical issues are presented in these texts. Using examples from these four Ontario secondary school biology textbooks I shall demonstrate that the way student and teachers can engage in situations where they must decide a right or just course of action is highly constrained by the discursive framing of these issues. The implications for educators is that it may be both desirable and necessary to try and rework the frame by which ethical issues are engaged, what constitutes direct ethical actions, and ‘who’ ethical actors in science education can be.

\(^5\) The term ethical subjectivity is used here to mean to kind of subject the text works to constitute discursively at particular moments where students are called to think/act ethically. Here, again, it can best be thought of as a construction to outline a loose form of subjectivity constituted by the discourse in the texts and \textit{not} as some universal ethical subject. Any kind of “actual/virtual” ethical subject of science education would have to be traced in a way that would allow for a multiplicity of forms on both ends of the power relationship continuum as well as many other factors besides textbooks that are involved in constituting subjectivity such as practices of teaching and the organization of classroom activities.
The stimulus for this chapter comes from conversations at the Canadian Society for Studies in Education Conference in Waterloo, Ontario (2012) where Erin Sperling, Hagop Yacoubian, Anastasios Siatras and I, spent hours talking about science’s relation to citizenship and the kind of citizen that science education forms and should form. Judith Butler’s (2005) book, Giving an Account of Oneself examines what it means to answer the call of accounting for one’s actions. Like Butler, the motivation for this work is not to denounce the way these textbooks frame for ethical action, but to partially outline norms of ethical thought and action so that we may pose different ethical concerns and forms of engagement. Butler cites Adorno in maintaining that moral questioning surfaces when norms of behavior have ceased to be self-evident in a society. In this way, this work is part of a process of rendering the ethical situations in these textbooks as no longer self-evident and therefore suggests that, for various reasons, we need new ethical engagements. At the same time I became particularly interested in “ethical relations to self”, something Michel Foucault (1985, 1986) develops in a historical analysis of antiquity in The Use of Pleasure and Care of Self (History of Sexuality Volumes 2 and 3), as well as in the lecture series, The Hermeneutics of the Subject (Foucault, Gros, Ewald, and Fontana, 2005). While this chapter does not explicitly deal with “relations to self”, it does underline the importance of examining the link between subjectivity and ethics in the fields of science and education. Foucault (1997) underlines a substantial gap in political thought regarding subjectivity and ethics when he states, “contemporary political thought allows little room for the question of ethical subject” (p. 294). Considering the big challenges (current and impending catastrophes) that face human societies in the 21st century, the relation between ethics, science and political thought is perhaps more important than ever. Interwoven within the constitution of an “ethical subjectivity”, of course are other subjectivities, partially constituted through science education discourses, such as those related to sexuality, politics and economy, and colonization (e.g. a “subject” who may or may not disregard indigenous knowledges but devalues it nonetheless). However, this chapter will focus primarily on themes that come from discourse in these texts surrounding situations where students are brought to make ethical decisions. It is understood that the entire text works to constitute ethical attitudes, therefore this chapter should be seen as only one way of examining how these textbooks may work to constitute ethical subjectivities by focusing on the specific discursive situations where students are brought to make an ethical decision.
Results from the examination of ethical exercises/situations (where students are explicitly asked to think or act in ethical ways) in these four Ontario biology textbooks suggests that to think and act ethically in science education students must engage in ways intricately linked to the consideration of the following: responsibility of government; personal and population health, and policy reform; lifestyle habits; and broad regulation of substances, practices, and organizations. This analysis does not seek to be a polemic against these themes of ethical orientation, but instead to better understand what these themes entail in order to think about what kind of ethical orientations are possible.

This chapter will proceed through three interrelated sections. The first section briefly outlines the context of this chapter in terms of science education, ethics, and some specific methodological approaches for this analysis. The second section discusses discursive excerpts from the four Ontario textbooks. The third section attempts to situation some reoccurring themes related to ethics in terms of responsibility of government, population and health, and policy and regulation through a discussion of Michel Foucault’s (Foucault and Senellart, 2010) lectures concerning the rise of population and state governance. Concluding, I call for an open, multifaceted discussion of ethics in science education that can diversify the themes described here and, to some extent, science education scholarship to date.

4.1 Ethics and Science Education

Some have taken the time to think more closely about ethics specifically within science education. For example, Derek Hodson (2009), in his comprehensive outline of scientific literacy, dismisses the claim that simply by learning about science as a courageous pursuit of truth outside of personal interests and prejudice, for example learning about Merton’s (1973) norms of science, students will “naturally” become more ethical; and instead claims that “science would benefit from transfer of ethical standards in the opposite direction” (p. 12). Bioethicist Michael Reiss (1999), whose work has influenced numerous science education scholars (Hodson included), has attempted to provide guidelines for teaching ethics in science, which includes criteria for coming to valid ethical conclusions such as: the internal consistency of argumentation; the relation of arguments to already existing ethical frameworks; and whether the ethical conclusion achieves validity and consensus through debate. While this approach to ethics in science education is extremely useful one can also see how specific this approach is to ethics
in its reliance on logic, validity, consensus. It assumes that all of the contours of ethical questioning can be brought forward in the style of ethical debate. Critical educators are aware that many ethical actions, conclusions, and practices that arise (and arrive!) in the classroom do so through emotional trauma, suffering, spiritual beliefs, personal experiences, and experimental ontologies. This is to say that there is always an assumed ethics in science education, but also that ethics can be remolded by merging science education with ethical thought from “outside”. The latter may happen through an engagement with social theory and moral philosophy as well as detailed bioethics. Hodson’s warrant for the infusion of an ethics with/into science education involves a description of the moral-ethical uncertainty we face living in (post) modern times. However going further, is not the world on the brink of several looming economic, social, and ecological catastrophes? Science education as a site of struggle concerning how we come to view ourselves must take on various, overt forms of ethical engagement because our current global situation demands it.

This may also mean disregarding what would seem like good pragmatic advice, such as Michael Matthews’ (1998) call for modest goals in history and philosophy of science (which inform ethics) in science education. Matthews insists that “there is no need to overwhelm students with cutting edge questions” (p. 169), however this is exactly what educators who want to see an ethically just and sustainable future may need to do. Albeit Matthews could be said to be speaking of HPS education and not necessarily ethical engagement I still think it worth questioning both the ethos and political ramifications of this approach as it may represent a dangerously conservative stance for (science) education. Here I feel it also necessary to consider the politics of knowledge as a necessary to dimension to thinking about ethics and science education. For example, Matthews’ (2004) defense of positivism for (science) education and his views on cutting edge questions for students are worrisome when seen in light of how Henry Giroux (2011) describes the link between positivism and ethics:

The culture of positivism rejects the future by celebrating the present. By substituting what is for what should be, it represses “ethics” as a category of life and reproduces the

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6 One consideration I have begun to develop is for the consideration of ideology, in a general sense, in argumentative situations (argumentation being a huge field within science education) – that is students consider the pervasive role of ideology.
notion that society has a life of its own, independent from the will of human beings. The neutralization of ethics effectively underscores the value of historical consciousness as well public discourse on important political issues. But instead we are left with a mode of reasoning that makes it exceptionally difficult for human beings to struggle against the limitations of an oppressive society (p. 29).

Engaging ethics in science education through the tracing of an “ethical subjectivity” requires thinking about what we take for granted in ethical situations and then reworking these ethical situations in a way that is socially, politically, philosophically, and economically desirable.

David Blades’ (2006) essay, “Levinas and an ethics for science education”, makes a very critical point that I would like to follow in this analysis and discussion. Namely, that little to no attention has been given specifically to theorizing ethics for STS (Science, Technology & Society) or STSE (Science Technology Society Environment) education. Regarding the mission of STS(E) education Blades claims that the,

the nature of ethics and responsibility essential to this mission are not considered in the theorizing of an STS(E) approach; there is no discussion on how responsibility informs action, such as how to understand whether students should engage in dissection, or how to approach the natural world … from an ethical perspective (p. 648).

Blades sees an extension of Emmanuel Levinas’ (1999) concept of 'Other' as a potential basis for ethics in science education by extending it to include non-human and abiotic entities. Whether one agrees with Levinas’ ethics, or the practice of giving ethics a primary place in philosophy, Blades opens up the question of ethics in science education on a philosophical level, which works, as philosopher Slavoj Žižek (Badiou and Žižek, 2009) maintains, “to change the very concepts of the debate” (p. 51). In other words, he does not simply consider a range of ethical choices within a given framework, but reformulates ethics as radical, erotic, and terrifying relationships “to Other” - and therefore gives us a radical choice (a genuinely new alternative) for ethics in science education. One of the positive outcomes of the analysis presented here is a better picture of what kind of ethical themes are already in place in biology textbooks and how this might work to constitute a particular kind of “ethical subjectivity”. While Blades asserts correctly that ethics has not been extensively theorized for science education (STSE education specifically) I would like to show here that there still are certain ethical themes currently in science (biology) education that play a part constituting a kind of “ethical subjectivity”.

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4.2. A Methodological Note on Discursive Ethical Situations

If curriculum materials work to constitute various subjectivities then it stands to reason that all of subjectivities are involved in thinking ethically and inform an “ethical subjectivity”. *For certain the term “ethical subjectivity” is an abstraction used here to draw attention to how ethical discourses limit the possibility of thought or action, and what kind of assumptions are necessary for a students and teachers to think ethically in science education settings set up by biology textbooks.* So, while any “ethical subjectivity” in science education is informed by all the other subject positions constituted discursively through science education discourses, it is also a worthwhile task to look at how thought and actions are specifically constrained and directed when a subject (reader or participant in a textbook exercise) is overtly or directly asked to think ethically.

4.2.1 Considerations of Method for Isolating Ethical Situations

While the biology texts were perused to see what themes emerged in relation to the way discourses worked to constitute various kinds of sex(ual)/gendered, colonized/colonizer, political/economic and subjectivities, two basic patterns related to ethics began to emerge. First, the readers of the texts (students and teachers) were seldom invited to directly think/act in ethical terms. Secondly, when readers were asked to think directly about a “right course of action”, the issues, and ways of viewing them, were particular. This, for me, prompted the question of what, then, constitutes a ‘legitimate’ ethical issue as well as what informs and becomes an appropriate ethical position decision or action (ex. recommending certain forms of government policy). These initial observations led to the idea that a certain kind of ethical subjectivity could be characterized alongside other kinds of subjectivities: that is a kind of “ethical subjectivity” - how one is meant to act, think and deliberate concerning what should be done in ethical issues involving science. The four biology textbooks were then re-examined for instances where students were specifically and explicitly asked to think and act according to what should be done or a ‘correct’ course of action. It was impossible to unify all of the ethical situations in each text under singular categories, however some generalizations were made across all four the texts and these will be presented in the next section.

The discursive data from all four texts was analyzed according to the types of ethical positions and actions students were given as choices or led to consider (whether or not they were
meant to actually carry out these actions). After assigning themes to the ethical situations, a few reoccurring themes began to emerge concerning the ethical situations in the textbooks. These themes had to do with the regulation (primarily by government) of a wide variety of things from research funding to banned substances, personal lifestyle choices, and optimizing one’s health and the health of populations. The data collected from the texts centres around these reoccurring themes as well as singular themes that may function in addition to these reoccurring themes to discursively constitute a particular kind of ethical subject (these singular themes are not engaged in this thesis).

4.2.2 What is an “ethical situation” in these texts?

What comprises an ethical situation in these texts is, to be certain, complex, and will necessarily be contestable. A basic definition of ethics from the Encyclopedia of Postmodernism (Taylor and Winquist, 2003) defines ethics as “the historical inquiry into how one is to be” (p. 114). And from Miriam-Webster’s, ethics is defined firstly as “the discipline dealing with what is good and bad and with moral duty and obligation”. For the purposes of this thesis I have chosen to identify ‘ethical’ situations as ones where students are asked explicitly to think about defending and recommending right behavior or actions related to what a person or group of people ought to do or how they are to proceed based implicitly on some kind of moral duty, responsibility or obligation. A very fine line exists of course when we reach the level of everyday contact and the pragmatic decisions that students make, however if the example pertains to a right conduct based some kind of responsibility or obligation it, according to this definition, falls under the category of ethical situation. So while atypical, ‘far-fetched’, or arbitrary ethical situations can be imagined under this rubric (e.g. must I tip a waiter?), the salient point is whether these situations would actually be in the textbooks under study (and if they were they would be included!). I am also not attempting to give a precise definition of what I think ethics is or should be. This definition of ethics serves a methodological purpose by allowing one to target specific instances where students are led to think about right and wrong behavior and subsequently examine what emerges. I was met with opposition to this definition from

\[\text{7 If I were to reconceptualize ethics it would involve relations to others, the social order and self, and this would be require much space to develop philosophically. Furthermore, as Ranciere (2010) points out that, before signifying norms of morality, ethos has to do with both behavior and behavior in a particular environment. Thus, any principal of being must necessarily be related to the place one resides, and also what actions are inherent to this place.}\]
colleagues. They seem to want something very comprehensive and specific when it comes to defining ethics. For me, their suggestions seemed too entrenched in what is already present according to ethics (in science education). I made the decision to go with my methodological idea because the questions they presented were ones they already knew the answers to, such as ‘would texts from Alberta approach the tarsands differently’? The answer is here is simply a reaffirmation of parliamentary politics that are more or less already known. Such a question also privileges the author function and as such turns a ‘blind-eye’ to the curriculum itself.

Again, it is certainly the case that the text asks students to consider and evaluate matters that have ethical contexts; all sections of the text, in one way or another, inform and influence how students how students face ethical issues in science. However, to get a sense of what the limits of ethical thought and action are for students requires an analyst can look at the specific ways students are directly meant to think and act ethically, along with what kinds of outlooks and perspectives accompany these discursive limits. While some situations in the textbook have students consider the ethical implications, this is not the same as having students deliberate on what ought to be done in a given situation. It is in the latter that the student is placed in a situation of being an ethical actor, and at these moments can be said to be acting as an “ethical subject”, even by choosing a position. Again, since the entire text is involved in constituting ethical subject positions it may be said that this method of isolating specific instances where students deliberately and explicitly think/act in ethical ways limits the analysis. This may be true to some extent, however this notion of limitation is precisely the point in that the texts also, in specific ways, limit the ways students can overtly think ethically in regards to chances to do so, the types of issues offered, but also the range of ethical choices set before them. In a sense then, my restriction of only looking at directly ethical situations in the text is a means by which to expose restrictions in what can be thought and acted ethically within the discursive frame of the text. Furthermore, the basic way an ethical situation in the text is defined in this analysis, if the student is actually given a chance to decide what should be done, allows for all kinds of ethical situations (detailed/undetailed, urgent/non-urgent) situations to be included in the process of tracing a kind of “ethical subjectivity”. At this point I would like to turn back to Blades’ (2006) and a comment he makes about the good or the ‘right’ in science education and typical implicit and circular reasoning concerning STSE issues:
While a strong sense of education for the good and right pervades the concept of an STS(E) approach, there is little discussion on exactly what is meant by the ‘good’ or ‘right’ action … In the absence of such reasoning STS(E) defaults to the most superficial, circular ethical reasoning: Action on an STS(E) issue is ethical because it is ethical to act on STS(E) issues” (p. 650).

While I recognize that the entire text works to constitute certain forms of thought and action, and subjectivity I have here specifically tried to isolate exactly where students are led to ‘good’ or ‘right’ action in terms of what should be done pertaining to a sense of moral obligation, duty or responsibility. That is, I am attempting to isolate situations where students are specifically led towards actually engaging in “what should be done” or an ethical course of action to see what themes of ethics are actually present. What “should be done” has always to do with behaviours/motivations that either one person or a population can accept for diverse reasons. Moreover, just because a question or situation has an ethical dimension does not mean it necessarily engages students directly in ethical thinking or action. For example in McGraw Hill Biology 12 (p. 267) there is a discussion of the production and consumption of artificial amino acids and nucleotides along with a discussion of the social implications of this research. While this research certainly has ethical implications, it does not meet the criteria for this analysis because it does not directly solicit students to think about what should be done regarding any aspect of the topic. To be clear, I have not endeavored to define what comprises an ideal, complete, important, or rich ethical issue. I am also not claiming that a more thorough evaluation of the ethical dimensions of science textbooks needs to be done! This would be a more involved task requiring a multifaceted approach.

To reiterate, employing a very broad definition of ethical situations (there is a big difference between employing and endorsing) brings to the surface the wide-ranging capacity of ethical considerations. Accordingly, it would be wrong to assume that ethical situations in the textbook arise in the context of issues in STSE, STS, or SSI only. Ethical situations can also involve matters of personal care, governmental choices, health prescriptions, sexual mores, and even finance. Therefore, another strength of using a base definition to outline ethical issues is to precisely get away from (as much as possible) what I would wish to see as ethical situations in these textbooks (and focus on what is actually articulated). What helps define situations in the text where students are led to make ethical decisions is the use of words like “should”, which implies the presence of an often unspoken dutiful or obligatory motivator, whatever it may be, in
terms of a course of action that is to be accepted over another. It should be said that activities such as concerning extinct species and summits against environmental degradations are very worthwhile activities and have ethical dimensions that should be examined, but these situations are not chances for students to directly think and act within the discursive frame of the text about a ‘correct’, ‘right’, ‘responsible’ course of action.

Isolating ethical situations in these textbooks was sometimes difficult, but being somewhat strict about the above definition allowed quite a manageable number of occurrences (approx. 15-25 per textbook). Again, this way of isolating ethical situations in these textbooks is certainly not the only way of examining ethics or ethical subjectivity in science curriculum materials. Another way would be to isolate situations where students and teachers are asked to consider others in some way, or to outline moral/ethical assumptions wherever they appear throughout the text. These are much needed forms of analysis and are substantially different from what has been done here.

4.3 Analysis Results and Summary

After a thorough examination of four Ontario secondary school textbooks some reoccurring themes emerged. Generally when students are meant to think and act ethically in specific textbook exercises they must very often engage in terms of juridical/legal concerns, regulating practices through government, making policy recommendations, deciding whether certain research should be funded or not, ensuring personal and population health, and personal lifestyle choices. All of these themes are undoubtedly interconnected and in the next session I will attempt to discuss these aspects with respect to the (partial) constitution of a particular kind of “ethical subjectivity” through constraints on thought and action.

Reoccurring themes across textbooks, with slight variations, began to emerge after looking at the discursive data surrounding ethical situations in each textbook. I was able to describe six reoccurring themes in all four textbooks along with two reoccurring, but slightly textbook-specific, themes found in only two of the four textbooks. Table 4.1 summarizes these themes along with noteworthy singular themes from ethical situations that also may inform a discussion on ethics in these biology textbooks and science education in general (though I do not take them up in any detail here). Table 4.2 summarizes which themes occur in which textbooks.
Table 4.1. Summary of reoccurring themes in four biology textbooks related to government regulation, population health concerns, personal lifestyle, genetics and biotechnology, and regulating/controlling particular substances

<table>
<thead>
<tr>
<th>Textbook</th>
<th>Reoccurring Themes:</th>
<th>Reoccurring and Singular Themes</th>
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<tbody>
<tr>
<td>McGraw Hill Biology 12</td>
<td><strong>Reoccurring Themes:</strong></td>
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<td></td>
<td>Regulating Food safety at government level (ex. Plant growth regulators are involved in the cultivation,</td>
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<td>processing, and storage of many commercially grown fruits or vegetables. Yet, few shoppers are aware of</td>
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<td>this. Should supermarkets post signs identifying produce treated with plant growth regulators? (Give</td>
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<td>reasons for your answer.”. p. 565)</td>
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<td></td>
<td>Research funding decisions government or otherwise (ex. “Identify point not support more research</td>
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<td>into acupuncture and acupressure therapy. Identify cautions to further research into each therapy.”.</td>
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<td>p. 165).</td>
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<td></td>
<td>**Using Cost/Benefit Analysis (pros/cons) (ex. In groups, discuss the arguments for and against the</td>
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<td>use of synthetic anabolic steroids by athletes in competition.”. p. 197).</td>
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<td></td>
<td><strong>Optimizing the Health of the Population</strong> (ex. “Do you think the labels on food products should</td>
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<td>include information on the use of supplements such as hormones?”; p. 207).</td>
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<td><strong>Regulating the use of particular substances</strong> (ex. “Develop an argument to make Caffeine a controlled</td>
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<td>substance.”; p. 165)</td>
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<td></td>
<td><strong>Policy Recommendation at government level</strong> (ex. “Debate with classmates whether Canada should</td>
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<td>adopt an “opting out” policy to increase the number of cadaveric donors. What problems might this</td>
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<td>create?””; p. 119).</td>
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<td><strong>Personal habits/lifestyle choices</strong> (including hygiene and dietary guidelines (ex. Is a diet of</td>
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<td>raw food healthy for people? for dogs and cats?; p. 45.)</td>
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<td></td>
<td><strong>Appealing to/regulating government and corporate institutions</strong> (ex. “Is the school presently</td>
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<td>doing enough to protect student hearing? What kind of policies could be adopted to help protect</td>
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<td>students from hearing loss while attending noisy school functions, such as school dances?.”; p. 162)</td>
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<td><strong>Considerations of specifically regulating genetic research/biotechnology</strong> (ex. What effects might</td>
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<td>the creation of such “designer babies” have on society? Explain what laws, if any, you think the</td>
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<td>government should enact to regulate this research this area of genetic research.”. p. 329)</td>
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<td></td>
<td><strong>Noteworthy Singular Themes</strong></td>
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<td></td>
<td>Sharing information in science (“Should scientists be compelled to share information out of a spirit</td>
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<td>of fairness?”, p. 231).</td>
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<td>Rights over one’s body (ex. “Should a destitute person be allowed to sell one of his or her kidneys</td>
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<td>to avoid starvation?”; p. 119)</td>
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<td>Animal welfare question (ex. “In your opinion, should animals be used for [endocrine disease]</td>
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<td>research studies?”; p. 207)</td>
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<td>Vegetarianism (ex. Some of the people feel this means that humans should switch to a vegetarian</td>
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<td>diet; others disagree. There are, in fact, a variety of issues to consider in addition to the</td>
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<td>relatively simple one of energy transfer. Take a stand. Prepare your arguments carefully and be</td>
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<td>prepared to debate the issue in class.”. p. 450.)</td>
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<td>Nelson Biology 12</td>
<td><strong>Re-ocurring Themes:</strong></td>
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<td></td>
<td>Regulating Food safety at government level (ex. [Debate Statement]: The government should allow</td>
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<td>xenotransplants in Canada.”. p. 360.)</td>
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<td></td>
<td>Policy Recommendation at government level (ex. Nutriceuticals should be regulated as drugs under the</td>
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<td>Canada Food and Drug Act.). p. 51.)</td>
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<td>Research funding decisions, government or otherwise (ex. [Debate Statement]: “Governments should</td>
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<td>redirect some funding from organ transplant research to autologous stem cell research.”. p. 472).</td>
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<td>Regulating the use of particular substances (ex. [Debate Statement]: Not enough is being done to</td>
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<td>prevent the use of banned substances in sports.”; p. 392).</td>
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<td>Considerations of specifically regulating genetic research/biotechnology (ex. [Debate Statement]:</td>
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<td></td>
<td>International guidelines and parameters overseeing public and private recombinant DNA technology</td>
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<td>need to be established and reviewed annually.”. p. 295.)</td>
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<td><strong>Optimizing Health of Population</strong> (ex. [Debate Statement]: Women should not drink even small amounts</td>
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<td>of alcoholic beverages while pregnant., p. 120).</td>
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<td>Personal Habits/Lifestyle choices (ex. List three changes that can be made to your personal lifestyle</td>
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<td>that would reduce the odds of a mutation taking place.”. p. 263).</td>
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<td><strong>Noteworthy Singular Themes:</strong></td>
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<td>Considerations of private property come before individuals (ex. [Debate Statement]: Fossils should</td>
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<td>be donated to research Institutions because their investigations benefit everyone.”. p. 515.)</td>
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<td>Legal right of free movement even though one is sick (ex. [Debate Statement]: Individuals being</td>
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<td>treated for multi-drug resistant TB should be placed under medical house arrest to ensure complete</td>
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<td>they complete their entire treatment under medical supervision.”. p. 563.)</td>
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<td></td>
<td>Industrial practices on animals (ex. The antemordem (before death) method of tenderizing meat involves</td>
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<td>the physical injection of a solution of papain or bromelain into the living animal. Discuss ... and</td>
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<td>write a position paper on the ethics of this procedure.”. p. 77.)</td>
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<tr>
<td>Nelson Biology 11 (College Prep)</td>
<td><strong>Reoccurring Themes:</strong></td>
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<td></td>
<td>Optimizing health of population (ex. Debate statement: “Non-therapeutic use of antibiotics in farm</td>
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<td>animals should be banned ”, p. 127.)</td>
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<td></td>
<td>Personal Habits/Lifestyle Choices (ex. [preamble to question on willingness to change personal</td>
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<td>behaviour] “individuals can do little about the decisions of governments and corporations; they do</td>
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<td>however, have control of their personal lifestyle</td>
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Policy Recommendation at government level (ex. “Write a brief position paper containing your recommendations to a legislature on [the decriminalization or legalization of marijuana]”, p. 183.)

Research funding decisions, government or otherwise (Should taxpayers pay for such research, or should it be funded by the private sector? Do the benefits justify the costs? On a priority scale of 1 to 10 where does this research rank?”, p. 400.)

Using Cost/Benefit Analysis (ex. Your town council is debating whether or not to pass a resolution banning pesticide use in local parks. Compile a list of pros and cons that could be used in reaching a decision.”, p. 144.)

Regulating the use of particular substances (ex. Do you think people’s urine should ever be tested for drugs? Use a PMI chart to examine the advantages and disadvantages of urine testing…, and make recommendations on its use.”, p. 214.)

Considerations of specifically regulating genetic research/biotechnology (ex. Research the issue of labeling GMO foods. What are the advantages and disadvantages of labeling genetically modified foods? When your research is complete write a letter to the editor of your local newspaper outlining your position on this issue.”, p. 332).

Noteworthy Singular Themes:

Body Representation in the media (ex. Debate statement: The media should show bodies of different shapes not just the stereotypical ideal figures. p. 194.)

Do people have the right to sell their own body parts? (ex. In some countries, kidneys are sold for transplant. Do you believe that this practice is acceptable? Explain your answer.”, p. 265.)

Ethical treatment of animals (ex. The antemordem (before death) method of tenderizing meat involves the physical injection of a solution of papain or bromelain into the living animal. Discuss … and write a position paper on the ethics of this procedure.”, p. 55.)

Reoccurring Themes:

Regulating Food safety at government level (ex. Is a diet of raw food healthy for people? For dogs and cats? Why or Why not?”, p. 45.)

Optimizing health of the population (ex. “Given the potential benefits and risks, prepare a brief report arguing whether or not the use of artificial blood should eventually replace natural blood in all cases”, p. 298.)

Policy recommendation at government level (ex. Should labeling be required by federal and provincial governments?”, p. 574.)

Research funding Decisions, government or otherwise (ex. [In terms of treatment or prevention of a disease] What do you think the priorities for research should be?”, p. 460.)

Personal habits/lifestyle choices (One of your friends talks constantly about losing weight, while another has decided she is going to become a vegan. What advice would you give each of them, and why?, p. 366.)

Considerations of specifically regulating genetic research/biotechnology (ex. Do you think there should be more public awareness of [plant growth regulator] chemicals? “, p. 565.)

Regulating the use of particular substances, (ex. In small groups, discuss whether the use of certain drugs or all drugs should be prohibited in professional sports. How would you enforce this ruling?”, p. 366.)

Appealing to/regulating government and corporate institutions (ex. [What students can do to defend the biosphere], Take Action. Decide what issue is most important to you and pursue it. Write to politicians and corporations expressing your opinion.”, p. 608.)

Noteworthy Singular Themes:

Conservation versus economic development (ex. “Which do you think is more important: developing a better food source for hungry people, or conserving the monarch butterfly?”, p. 455.)

Should samples of smallpox virus continue to be stored? (ex. “However, one sample of [the smallpox] virus still exits at the Center for Disease Control in Atlanta, Georgia. Write a short essay outlining your feelings about this.”, p. 411.)

Proper use of antibiotics (“Why might the excessive or improper use of antibiotics eventually lead to an increase in the number of infections? How can this risk be reduced?”, p. 429.)

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<table>
<thead>
<tr>
<th>Reoccurring Theme</th>
<th>Texts where themes are found</th>
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<tbody>
<tr>
<td>2. Research funding decisions, government or otherwise</td>
<td>✔ McGraw Hill Biology 12</td>
</tr>
<tr>
<td>3. Regulating the use of particular substances</td>
<td>✔ Nelson Biology 11: College Preparation</td>
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<tr>
<td>4. Considerations of specifically regulating genetic research/biotechnology</td>
<td>✔ Nelson Biology 12</td>
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<tr>
<td>5. Optimizing Health of Population</td>
<td>✔ Nelson Biology 12</td>
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<tr>
<td>6. Personal Habits/Lifestyle choices</td>
<td>✔ Nelson Biology 12</td>
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<tr>
<td>7. Regulating Food safety at government level</td>
<td>✔ Nelson Biology 12</td>
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Table 4.2. Reoccurring themes found in direct ethical situations in Ontario Biology Textbooks.
4.4 Ethics in Secondary School Biology Textbooks: Policy for Populations

This section will attempt to discuss some of these reoccurring themes. I will introduce this section with an account from my own teaching experience to set a context for the discussion and then appeal to some of Michel Foucault’s historical analyses concerning sovereignty, governance, and population to situate some of these themes. This discussion should be understood as the way I have initially begun to think about this topic and an initial step toward further research regarding the constitution of an “ethical subjectivity” through curricula, resources, and policy.

4.4.1 Diverse Science Teachers; Same (Old) Actions

To begin discussing what these particular ethical themes could mean I want to tell a related story that has to do with “taking action” as a science educator. When I was an IB/MYP\(^8\) science teacher from 2006 to 2008 at an international school in Ukraine one of the most progressive practices being presented in IB professional development involved the mobilization of student data collection and research in science class to inform local and regional institutions. For example bacteria tests taken from all areas of the school could then be used to inform school policy regarding cleanliness and safety. This idea could be expanded to include municipal and other regional institutions of governance, for example informing these institutions about water quality in public places. The idea was to promote an integration of school science with various levels of the community and involve students in scientific research concerning issues that impact daily life (letter campaigns to corporations were also a common form of action). After being trained, I too implemented this kind of community-school science relationship with my students.

\(^8\) International Baccalaureate Middle Years Program (North American Grades 6 to 10).
We engaged in letter writing to corporations regarding their products and shared our research findings from bacteria tests with the school administration.

Upon reflection it seems apparent that these kinds of actions never consisted of any kind of transformative action pertaining to a pressing social justice issue or an environmental concern. In my case the actions we took as a class, seemed only to be aimed at the betterment of the expatriate community. Even when our action highlighted a defective product or poor water quality in one particular location, the message was simply to better optimize a product or the delivery of a public service. In this model of action, scientific research at the classroom level did not help challenge the fundamental assumptions of the community either at the level of the political order, nor how people lived their daily lives - both in the expat community or those in less privileged communities in the host country. In ethical terms, the actions, while not without value, arguably worked to maintain a specific social order.

Five years later during a session of my science education reading group a colleague recounted a very similar story of how they collected bacteria samples from school sites in their science teaching practice and presented this data to school authorities. Like before, members of the reading group considered this action exemplary. The similarities between this science teacher’s experience and mine made me think that there was certainly something constraining at work. Where was the real betterment of lives (other than those whose lives were already privileged) through/with science? Where was the disruption Blades (2006) mentions as necessary to engage cutting edge ethical questions? When my students were writing letters to corporations and school administrators it had been beyond any kind of action I had hitherto taken as a teacher; yet looking back I see that our ethical engagement was limited in ways I still cannot fully imagine. How do we then begin talking about the kind of ethical engagement in science education that meets the pressing needs of all communities? What comprises an effectual or appropriate (ethical) response to injustice within educational communities? I think it important here to first think about how we’ve come to have particular ethical themes in science curricula in the first place. This is where I begin the discussion below.
4.5 Government and Policy, Health and Population, The Individual and Lifestyle

In this section I would like to group the reoccurring themes into three interrelated groups to be discussed: Government and Policy; Health and Population; and the individual and lifestyle. I have decided to suspend a discussion on the results related to biotechnology as I feel these require a separate research study due to the different implications for subjectivity (ex. a redefinition of the body of a subject). I will also not discuss most of the singular themes found in these books or the reoccurring theme of using cost/benefit analysis (pros/cons). I hope to address these themes very soon in the context of a larger more comprehensive study and for the remainder of this chapter I will try to situate the bulk of the reoccurring themes into a context that considers some of the political realities (ex. the agenda of the state and its curriculum) that may be guiding how students are brought to ethical situations in science (biology) textbooks. What may be the most salient point about these interrelated, reoccurring themes is that by rendering ethical issues as those that revolve around health, population, regulatory and policy concern these ethical situations inevitably fall under the umbrella of state governance, and help constitute an ethical actor as someone who attempts to change, evaluate or amend largely within the bureaucracies of law and policy making. I think it important not to overlook stating the obvious. It may be that government funded education ‘wants’ students to engage in topics in a way that is productive to the wide concerns of government and also (and this is the point) in ‘no other’ ways\footnote{Larry Bencze put it succinctly: The prerogatives of government want potential citizens and scientists to think about the prerogatives of government. That is governing interests become the ethical interests of the people!}.

4.6 Government, Regulation and Policy

Each of the four textbooks have several examples of where students deliberate on what governments should do in terms of policy, regulation or enforcement of the law concerning certain issues. The primary effect or constraint on the subjectivity of students therefore seems to be that whatever the ethical situation the action taken, along with the frame of the ethical debate, \textit{it must for the most part fall within a kind of legal-juridical context}. For example, a student must consider, in a given ethical situation, what laws are (always) already in place making a legal
context a large part of the framing of the problem. Here we have an interesting literal example of what Butler (1997) discusses as the subject’s freedom being tied to subjection to the law (in the abstract). This formulation of an ethical decision being tied to the law then means that the subject must already find the orientation for their ethical decision in some attachment to the law; that is what law is already in place (Butler does not mean “law” only in the juridical sense, but here in this analysis we can coincidentally see the two overlap!). At the very least the assumption in the situation is that the law gave legitimacy to practices involved in the ethical situation prior to the student “entering” the situation in question. Once an “answer” or solution to the ethical situation has been found it must then find its embodiment again largely in a legal-juridical form.

Consider the following two examples the first from McGraw Hill Biology 11, the second from Nelson Biology 12:

1. “Should labeling be required by federal and provincial governments?” (Dunlop, 2010, p. 574).

In these examples students are asked to think what about is “right” to do in terms of labeling from a standpoint of labeling policy. The reason put forward for labeling in the first example is so consumers can make decisions about what they are purchasing (linking this particular situation with consumerism). On a basic level, since government already enforces labeling laws related to nutritional information and ingredients, the question becomes merely a debate about whether the government should extend the same types of policy to certain foods. It is not a debate about whether consumers should have a choice between organic foods or GMO foods nor is it a debate about whether GMO foods are ethical. One could say that the labeling issue could touch on these questions, and this may be true, but in the end the student is really left to decide only the issue of packaging transparency related to slightly more stringent labeling policies and laws. Besides the occlusion of more pertinent questions, such as whether GMO foods should be grown in the developed or developing world, we can ask what assumptions circulate around the ethical question. In the food labeling example the ethical dilemma centres around informing the consumer - so that they may make a better choice. Thus, market forces (exercised through consumer choice) become both integral to an ethical position and yet not an area for ethical interrogation. This represents one way personal lifestyle choices are linked to seemingly broader
ethical questions within these texts. Making the connecting between a neoliberal
capitalist/consumer subject and an ethical subject is beyond the scope of this thesis, but I am
certainly suggesting it here. Such a link needs to be made using more sources and social settings
in science education. By framing a debate of GMO foods around labeling, students and teachers
tacitly accept that a) it is still relatively unclear whether GMO foods are destructive b) the
political locus of action is at the legal level (lobbying for legislation) and the choice of the
consumer c) That agri-business and multinational food corporations as institutions are not
responsible for their practices themselves.

In the case of Xenotransplants, it is somewhat easier to see that the perspective being
taken up by ethical actors is in line with the perspectives of government. In this example the
student is led, not to examine anthropocentrism or cultural beliefs about the meaning of
(different) animal life, but to reason from the standpoint of government about a health related
issue. In this case the decision becomes tied to the concerns around livestock health, which in
turn is tied to population health concerns about disease. That is, the decision to allow
Xenotransplants involves making a decision for the good of the population. What is also
interesting is that the ethical situation, and all others in the textbooks, gives legitimacy to the
“state”, and also makes it disappear, in that there is no (ethical) argument whatsoever over the
legal-political order. This may seem banal, but what if one wanted to speak about ethical
problems by which the government was actually already implicated? These problems could
include state racism, suppression of indigenous knowledge, collusion with global capitalist,
private interests, or its open pursuit of regional economic dominance. A recent example of this is
Canadian Prime Minister Stephen Harper’s declaration of the unification of “Science and
Sovereignty” in the arctic. In this situation if one were to ask whether or not the government
should conduct its research projects (or not) it would leave to the periphery questions the
fundamental relations of government to the native peoples it attempts to govern along with the
natural environment. Thus, slightly altering the question one could say, what kinds of scientific
research should be conducted in the Arctic? How will scientific research contribute to social
justice and the wellbeing of communities? And only secondarily, what is the role of
government?

I recently asked a colleague of mine, (Michael Tan, personal communication, August
22\textsuperscript{nd} 2012), why policy recommendation would become a focus in ethical situations regarding
science. He reminded me of the extreme interconnectedness between policy and scientific research in that governmental make decisions about funding also in terms of what science offers government in relation to legitimacy, infrastructure, technology, and labour. These textbooks are not just statements taken to be “in the truth” of science but, since they, by law, must cover at least 90% of the Ontario curriculum they are also government documents. I could not help but think of Lyotard’s (1984) point that truth and the administrator have been tied in “western” societies since the time of Plato. In terms of government sanctioned texts it is easy to imagine how “truths” being spoken under the authority of government or science could then become interchangeable – especially when there is no overt author.

It is worthwhile for science educators to think about the relationship between policy, regulation, population, health, and science (education) not because this is somehow an overtly dangerous configuration for students, but rather to understand the limitations and broad motivations (ones that exceed the will of any individual or group of textbook writers) of ethical situations found within the text. To make further sense of these themes I will now turn to Michel Foucault’s lectures (Foucault, Senellart, Ewald, Fontana, 2009, Foucault and Senellart, 2010) concerning The Birth of Biopolitics and Security, Territory, and Population. Broadly speaking, we can see questions of regulation, legality, and policy - from food safety to farming practices to medical procedures - as having specific linkages to the governance of individuals and populations, and this context can be especially useful in thinking about the reoccurring theme of health and population.

4.7 Health and Population

The following three examples fall under the reoccurring theme of concern with optimization of health and the health of populations.

1. [Debate Statement]: “Women should not drink even small amounts of alcoholic beverages while pregnant.” (DiGiuseppe, 2003, p. 120).

2. “Given the potential benefits and risks, prepare a brief report arguing whether or not the use of artificial blood should eventually replace natural blood in all cases.” (Dunlop, 2010, p. 298).
3. [Debate statement]: “Non-therapeutic use of antibiotics in farm animals should be banned”, (DiGiuseppe, 2004, p. 127).

Here, we can see health concerns are interrelated to questions of regulation (bans), the use of cost/benefit analysis as a technique to make decisions, and reproductive health or concerns with population health. Ethical situations regarding health cannot be separated from legal, policy, or regulatory concerns or broader concerns of population (ex. the concern with what women do during pregnancy). Since these ethical themes are intertwined I would like to continue to develop a general context by which to think about them.

One way to think about these ethical themes is to consider the rise of modern governments historically, along with a specific “art of governing”. Foucault’s lecture series Security, Territory, and Population deals with the change from classical and later disciplinary forms of governance which were more focused on the relation of the sovereign to territory and subjects (“the people”), corporeal forms of discipline, to the rise of governing forms that use a whole range of techniques, such as law and “policy” (police), statistics, and management of goods (Foucault, Senellart, Ewald, Fontana, 2009). According to Foucault the rise of these new forms of governance occurred, in part, to manipulate and control an entirely new political problem: the population. Understanding the ethical themes of these textbooks may require taking a step back from the object of this analysis to see how “western” governments concern with populations is a historical contingency, rather than something natural.

According to Foucault, the emergence of the population in Europe as a kind of natural phenomenon in the seventeenth and eighteenth century was radically different than what came before; but more importantly it was seen as something that could be manipulated by a whole range of apparatuses, laws, and techniques of power. The population became something that had to be managed. This required concern for aspects of health, as Foucault maintains:

… the management of this population required, among other things, a health policy capable of diminishing infant mortality, preventing epidemics, and bringing down the rates of endemic diseases, of intervening in living conditions in order to alter them and impose standards on them (whether this involved, nutrition, housing, or urban planning) and of ensuring medical facilities and services (p. 367).

The management of populations is a key facet of Foucault’s notion of biopolitics, in that populations, their daily life, productivities, and even pathologies, find themselves under
mechanisms and techniques of control as well as scientific knowledges (from economics to biology) that help govern, divide, and subjectify (as well as inform). The population is seen as something that can be intervened upon through campaigns that aim to influence different modes and organization of life from the economic activities of subjects to their very “attitudes” (p. 366). The population becomes the focus of governance whereby the individual becomes somewhat subsumed:

The final objective is the population. The population is pertinent as the objective and individuals, the series of individuals, are no longer pertinent as the objective, but simply as the instrument, relay or condition for obtaining something at the level of the population (p. 42).

This population now becomes “the reality the state will have to be responsible for, rather than individuals who must be subjugated and subject to imposed rules and regulations” (p. 352). This responsibility involves managing and monitoring things like hygiene, problems of scarcity and demography. More importantly this population will be seen to be a “natural” phenomenon to be governed. And this is exactly Foucault’s not-so-subtle point, that the notion of the population that arises out of the eighteenth century is not something “natural” but a historical contingency formulated gradually through techniques of control, dispotifs, and “scientific” knowledges all working to, amongst other things, shape the conduct of subjects.

Textbooks currently written under the supervision of modern governments then can be understood, to some extent, as interventions for the management of populations. Though this statement sounds commonsensical, this idea can be extended now to the reoccurring ethical themes found in these biology textbooks. And if we consider that ethical situations in these texts (along with their many other aspects) are involved in managing populations, and we consider this management of population as a historical contingency, then the notion of the population and its management should now appear somewhat “strange” (rather than taken-for-granted). Pausing here we can now see the enormity of the context for these ethical situations, and with this enormity comes both the sense of a kind of entrenchment but also hope, as historical contingencies are always open to change.

Here the effects on the subjectivity of students are teachers are broad, but we should at least ask ourselves as educators what the significance of aligning ethical questions in science (biology) and questions of health and regulation would be (albeit this alignment is seems
unavoidable today). How does having students consider questions related to optimizing health concerns through regulation and policy change focus the students ethical concerns toward the very same goals of the state in terms of management of populations? In the case of these textbooks, we can consider part of the subjectification process as a process of repetition. As Butler (1997) puts it, “If conditions of power are to persist, they must be reiterated; the subject is precisely the site of such reiteration, a repetition that is never merely mechanical” (p. 16). Consequently, repetition of situations where students are to consider individual and population health, regulation and policy in spaces of ethical thought IU. How does this delimit what can thought and acted upon ethically? Do we accept the ethical situations presented to us in these forms of population management or do we rework them?

4.8 But where is the science in all of this!

Some (science) educators at this point may see these questions as separate from science. However for Foucault, understanding notions of biopower (the control of populations) rely heavily on knowledges that see human beings as a species, as can be seen in his description biopower given in the introduction to Security, Territory, and Population:

By this I mean a number of phenomena that seem to me to be quite significant, namely the set of mechanisms through which the basic biological features of the human species become the object of a political strategy, or a general strategy of power, or, in other words, how, starting from the eighteenth century, modern Western societies took on board the biological fact that human beings are a species (p. 1).

This is not to say the human beings are not a species, but simply to say that knowledge about human beings is tied up with techniques and practices of governance. What Foucault effectively links is the notion of the population and its root in biological facts; and it is in this way that political conceptions of the population become (irrevocably) intertwined with science: “The population is therefore everything that extends from biological rootedness through the species up to the surface that gives one a hold provided by the public” (p. 75). Using “science” in its larger sense to include discourses of objective knowledge, Foucault argues that in the eighteenth century scientific knowledge becomes entangled with governing.
So, we have a scientific knowledge indispensable from government, but it is very important to note that this is not a knowledge of government itself, its knowledge, so to speak, a knowledge internal to government. That is to say, it is not at all knowledge internal to the art of government; it is no longer simply a calculation that should arise within the practice of those who govern. You have a science which is, as it were, tête-à-tête with the art of government, a science that is external to the art of government and that one may be perfectly well found, establish, develop, and prove throughout, even though one is not governing or taken part in the art of government. But the government cannot do without the consequences, the results, of this science. So as you can see, a quite particular relationship between power and knowledge, of government and science appears (p. 351, Italics added by author).

Foucault is, for the most part, speaking of the “sciences” of both political economy and economics, but he also quite clearly is including biology. And now we come full circle to a relationship between the population and biology.

The theme of man, and the “human sciences” that analyze him as a living being, working individual and speaking subject, should be understood on the basis of the emergence of the population as the correlate of power and the object of that knowledge (p. 79).

Consequently, the discipline of biology, what we know about humans as a species is tied to a “series of specific government apparatuses “ that are intricately linked to “the development of a series of knowledges” (p. 108), all of which have the population as its target. Going back to the ethical situations in these biology textbooks, this relationship between scientific knowledge and governing can be seen in the kinds of questions being asked of students and reminds me of a conversation I recently had with a science educator who researches issues of food and justice (Erin Sperling, Personal Communication July 9th 2012). She points out that while most of the public is somewhat distrustful of corporations (which is debatable), many simply accept what the government does or tells them regarding food when there is absolutely no reason to do so. The question of subjectivity remains very relevant for future research: What kind of person (subject), then, can make ethical decision in this context, and how can we rework, expand or change the foci of these ethical situations?

4.8 The Individual and Lifestyle

Although ethics may not be often associated with lifestyle and personal choices, Foucault (2005) shows in his lectures Hermeneutics of the Subject that a key philosophico-ethical
imperative of antiquity was to endeavor to take care, in all aspects, of one’s self; which is to say that ethical concerns that have to do with personal care should not be overlooked when considering ethical situations. That is, ethics of the self may be downplayed in typical discussions of ethics and science, but that is not to say that they are entirely absent. To close off this discussion about the ethical situations in these biology textbooks I would like use three examples related to the re-occurring theme of individual lifestyle choice to highlight two key points about this ethical theme. These are: i) the importance of the individual to what Foucault calls governmentality ii) the limits on collective ethical action and activism that are related to this particular focus on the individual. Here are three examples of ethical situations related to the individual from three separate textbooks.

1) [What students can do to defend the biosphere], Take Action. Decide what issue is most important to you and pursue it. Write to politicians and corporations expressing your opinion.”, (Dunlop, 2010, p. 608.).

2) [preamble to question on willingness to change personal behaviour] “individuals can do little about the decisions of governments and corporations; they do however, have control of their personal lifestyle decisions”(DiGiuseppe, 2004, p. 423.)

3) List three changes that can be made to your personal lifestyle that would reduce the odds of a mutation taking place.” (DiGiuseppe, 2003, p. 263).

What stands out in these ethical situations is that individuals must view action through personal actions and lifestyle. This dimension is important to highlight because of the complete absence of any kind of collective action within any of the ethical situations in these textbooks including, organizing groups, petitions, and protest. This absence in relation to the examples promoting individual lifestyle choices and taking individual action underlines the central place of the individual in ethical situations.

How does the discourse of these ethical situations work to constitute the subjectivities of students? The discursive limits set by the second example assert that individuals cannot do much against governments and corporations, however the next clause has students take action individually through lifestyle. Here an “ethical subject” is one who takes action against corporations and governments through lifestyle choices. Political activism does not seem to be within the discursive choices for student (subject in science) who is meant to think ethically. It would seem that a culture of possessive individualism in school science (Bencze, 2008; Bencze
and Carter, 2011), is operating in/through/around these ethical situations. At this point, I would like to develop this link between individualism and “the art of governing” discussed in the previous section.

4.9 The Individual and the Art of Governing

Foucault’s notion of government(ality) should not be understood as only referring to structures and institutions that overtly govern but also anything that concerns itself with the conduct of others and the conduct of oneself (Lemke, 2011). In conjunction with the modern state’s concern for populations there exists the co-development of the self-governing individual (Foucault, 1978). Foucault’s lecture series, *The Birth of Bio politics*, demonstrate that with the rise of neoliberal economic thought, the market becomes the legitimizing factor for state governments. That is to say, the legitimacy of the state after 1945 rests in its obedience to market principle’s along with its ability to allow a competitive market to function while law and certain “freedoms” become less of a concern. In this new economic milieu the individual becomes not just a rational unit of liberal economic theory whose self-interest is essential for proper market functioning, but one who *must become* entrepreneurial and competitive herself. This of course requires the shaping of a new kind of individual - the production of the entrepreneurial neoliberal subject (Simons, 2006). This kind of governmentality produces a “free” subject who makes choices between alternatives, and bears the responsibility for those choices (rather than responsibility falling to the state). In this vein we must ask, are students constituted as individual autonomous actors who must see “themselves” as the sole locus of responsibility and action? If this kind of thinking is now a part of state governmentality it makes sense that it would surface in state sanctioned biology textbooks in ethical situations for example by excluding collective action of any kind. One might say there is a tiny conflict between coming to view the individual as the locus for action and while there is a clear focus on government regulation and policy change as a focus for action. However, it must be remembered that (neoliberal) governmentality *involves* the state as a partner in producing certain kind of economic conditions as a certain kind of “subject”. And as Thomas Lemke (2011) points out concerning governmentality, the individual’s “capacity for self control” (p. 204) and its role in maintaining a political order must become the target of political (and I would add, social and cultural) analysis.
4.10 Thinking about Relations to Self

Though we can see how the ethical situations in biology textbooks can work to constitute a particular kind of subject (ex. one who looks out for their own health and the health of the population as re-enforced through policy) it is worth thinking about how relationships to self come to form part of the ethical subject in science education. Foucault (1986) outlines how this relationship (exercised through practices of self) is important alongside other ethical precepts or codes (ex. In the case of environmentalism, Don’t Pollute!; Always Recycle! or Conserve Resources!):

… it is easy to conceive of moralities in which the strong and dynamic element is to be sought in the forms of subjectivization and the practices of self. In this case the system of codes may be rather rudimentary. Their relative observance may be relatively unimportant, at least compared with what is required of the individual in the relationship he has with himself, in his different actions, thoughts and feelings as he endeavors to form himself as an ethical subject (p. 30).

In the formation of an “ethical subject” through relations to self it is not as if rules and codes are not present but it is also important to consider “how the individual establishes his relation to the rule and recognizes himself as obliged to put it into practice” (p. 27). For Foucault it is this relationship to self that helps separate what may appear to be identical behaviours, but are involved in completely different modes of forming/maintaining/being an “ethical” subject.

**In the case of environmental science,** it is interesting to consider the movement of recycling industrial waste. In this fairly obvious example there could be completely different reasons for this ethical practice that range from i) satisfying the criticism of environmentalists for the good of one’s business (dealing with ones enemies) ii) Finding new value and resource/income potential in a dynamic economy (being an excellent entrepreneur) iii) Doing one’s own share to protect the environment (individual responsibility will save the world) iv) Recycling becoming a philosophy of life (only by giving back exactly what we took can we live a moral life). Self-formation as an “ethical subject” then involves a process by which the subject delimits that part of himself that will form the object of his moral practice, defines his position relative to the precept he will follow, and decides on a
certain mode of being that will serve as his moral goal...Moral action is in dissociable from these forms of self-activity” (p. 28).

For Foucault then, determining ethical behaviour in a particular period or situation would include within an examination of moral subjectification “the practices of self that are meant to insure it” (p. 29). Practices of self represent another way by which individuals are constituted as subjects and these practices must be considered in when looking at the constitution of various kinds of subjectivities in science education.

4.11 Conclusion: Beyond populations, Health and Regulation

Science educators must continually ask after the ethical possibilities already present within science education so that new configurations of ethics can come forward such as Blades’ call for an ethics of science education that privileges nature as ‘other’. This chapter does not present alternatives in the same way, but has attempted to identify and discuss themes of ethical situations in biology textbooks that may shape a kind of “ethical subject” – one who is to think and act in ethical ways in relation to science related issues. The reoccurring themes related to health, individual action, and regulation found in ethical situations in the textbooks were discussed with some reference to Foucault’s analyses related to the rise of the population as a political problem in order to provide a context for some of the ethical themes found in these textbooks. Closer examination into the complex historical, political, and social processes that have molded the discourse of ethics in science education materials needs to take place with broad policy and other curriculum resources.

Positively, this means that the foundation ethical questions we ask are malleable, and can be (re)formulated to address pressing ethical concerns, for example those that pertain to Slavoj Žižek’s (2009) four great antagonisms. Žižek identifies these antagonisms as: 1) The inappropriateness of private property in relation to intellectual property; 2) the socio-ethical implications of new techno-scientific developments (biogenetics); 3) the looming threat of ecological catastrophe; 4) New Forms of Apartheid, new walls and slums. Like Blades (2006), I feel it is time for a fundamentally different theoretical discussion of ethics in science education. We as a community (teachers, students, teacher educators, researchers) need to move away from allowing only a few experts to decide how ethics and science education are linked. For me,
questions of ethics in biology must centre around the changing notions of bodies and what it means to be a human being, which includes the way biotechnology intervenes in human life at the molecular level (Gerlach 2011), as well as permitting the freedom to ask after the not just the construction of knowledge, *but the subjective predispositions that lead to this knowledge*. In short, an ethics in science education must become also involve the *(bio)political*, Which I will discuss in the final chapters of this thesis, whereby student and teachers rework how they come to see themselves through scientific knowledge and practices.
Chapter 5: Revisiting “The Secret Identity” of Biology Textbooks: Viewing Sex/gender and Sexuality in Science Education as Integral to Reworking Subjectivity

My graduate school began with a paper written with Heather Sykes called “The Secret Identity of a Biology Textbook: Straight and Naturally Sexed” (SIBT) (Bazzul & Sykes, 2011). In this chapter I would like to revisit this paper to consolidate, question, and re-articulate the critical work that began there with further investigation into textbooks (one of which was the object of study in the previous paper). ‘Revisiting’ will comprise both an empirical look at the discourses around sex/gender and sexuality along with a reflection on this initial paper three years later. This reflection is a kind of return, almost a religious one, to the feelings I had when the first paper was being written. However as theologian Scott Eastham (1983) maintains, there is no going back, as even if one were able to trace the exact trajectory - things look different in reverse. For example in my second look at how biology texts work to constitute gender I am now more struck with the images in the text – and what they may say about subjectivities. In this chapter I will display and reflect on some images, not in terms of semiotics or preset features (what is often done in science education) but using the concepts of punctum and stadium that Barthes (1981) uses in Camera Lucida. In SIBT, Heather Sykes and I follow scholars such as Vicky Snyder & Francis Broadway (2004) as well as Julia Temple (2005) in attempting to “queer” a biology textbook. This entailed highlighting what seemed “natural” about discourses of sex/gender and sexuality in order to trace how sex/gender binaries and heteronormitivy operated in the text. This was my first in-depth encounter with a reversal of the usual understanding – whereby natural phenomena are distorted through political and historical representations – something we are ideologically ready to accept! It was this essay that moved me to study discourses of science education.

In this chapter I would like to do three things: i) attempt to shift questions of sex/gender and sexuality in terms of subjectivity; ii) present some empirical work from the biology

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10 This reflection was necessary for me to write the last chapter concerning biopolitics and science education in that I needed to continue to think about how multiple struggles may be linked together tightly. This is I think because there is no real critical movement within science education where critical science educators can find support for their work (rather it seems that science educators must justify the grounds of their work again and again and again).
textbooks in this study that speaks to the way sex/gender and sexuality are interwoven throughout and linked to discourses of race; iii) argue that the means and for re-working subjectivities in science can be found both outside discourses of science education, but also, to a large extent, within these discourses. The question at the heart of this chapter relates to this overall project that attempts to trace subjectivities partially constituted by secondary school biology texts. This questions is: given that curriculum materials maintain sex/gender binaries and work to normalize ‘heterosexuality’, how does discourse, text and images, set limits work to constitute a student as a subject of sex/gender and sexuality? That is, like Foucault (1981) asks in the *History of Sexuality Volume One*, how does a student come to see themselves as a (sex/gendered) subject through the discourses of these biology texts? Sex/gender is not just a discursive formation, it can be thought of as a regime of thought that incorporates many other discourses, religious, racial, commercial, economic, etc. It could also be thought of as a dispositif – the intersection between knowledges and power infused social relations that work to achieve effects (Agamben, 2009).

In the next section I will describe how I see sex/gender and sexuality in terms of subjectivity. After this I present some empirical fragments (text and pictures) from four secondary school biology textbooks to demonstrate that the discourse of sex/gender is a discursive formation that is pervasive throughout these texts, in other words “secret identity” is a gross understatement. Lastly I will outline ways educators can challenge discourses of sex/gender and sexuality and begin to rework subjectivities related to sex/gender and sexuality that are partially constituted through discourses of science education.

5.1 The Sex/Gendered Subject: A Struggle for Subjectivity

In SIBT Heather Sykes and I argued for equity and inclusion of those who could not conform to normative discourses concerning sex/gender and sexuality by highlighting the exclusions maintained by statements in a biology textbook. Three years later I’ve come to see oppressions related to sex/gender and sexuality as part of the larger sociopolitical and philosophical problem of the “nonneutral universal subject” (Irigaray, 1993) in science - in other words a masculine, white, heterosexual, able bodied, middle class, European subject of science. A focus on the “subject” of science and how discourses of science education work to constitute subjectivity can provide insight into a *multi-faceted site of struggle in science and education.*
One can loosely unite other critical projects, such as resistance to white supremacy and neoliberalization, by challenging the free rational subject of Descartes towards a subject formed by historical forces, technologies of power, material realities, and various overlapping discourses. Struggles over subjectivity in science education will necessarily be different in form as the subjectivities they attempt to disrupt and rework are different. I shall discuss struggles over subjectivity in science education near the end of this thesis, but at this point it is salient to note that only through the reconsideration of sex/gender and sexuality in textbooks that the idea of seeing science education as a site of struggle over multiple subjectivities seemed possible. This represents a major shift in my thinking towards trying to conceive of a larger political project in education that cannot be encapsulated by the research paradigms already set out in science education.

What I would like to problematize here is our previous focus in SIBT on inclusivity as an almost teleological goal regarding gender/sex and sexuality. Citing Kumashiro (2000) we located our critical project in the desire to break down heterosexist norms that exclude people with diverse sexualities, sexes and genders. We claimed legitimacy using public policy mandates to fight oppression from the Toronto District School Board, thereby affirming this mandate as end goal in-itself without thinking about what comes next or problems associated with this mandate. While I believe in, and advocate for, practices of inclusion I feel it pressing to ask, *into what do I advocate inclusion (and is it even possible)?* Once included, will this end-goal be any less oppressive? Are we simply advocating for the assimilation of queer, taken as a noun (people), a verb (a practice), and an adjective (a quality), into an *always already* normative, oppressive social order? These questions are naive, yet at the same time I would like to re-approach sex/gender and sexuality in a way that takes some of these questions into account. While I am not against humanistic approaches (though Foucault is the anti-humanist thinker par excellence) I think it important that we also question their assumptions. For example in our previous analysis we leave the reader with imperatives including this one:

*Any approach will require the science education community to actively engage with a large segment of society who has yet to see their humanity recognized in an objectified, categorized world (p 19).*
What exactly is this humanity that we refer to? What are its cultural underpinnings, and political motivations? Through inclusion, some may get a reprieve from oppression, but new ones will arise and more importantly what is to stop the “now included” from being oppressors?

Francis Broadway (2011) rendered a succinct critique of our previous analysis in terms of thinking about a queer way regarding both curriculum and pedagogy. However, what seems to be missing, for me, in such a treatment is a political agenda, or, a privileging of cultural and lived histories that do not find their legitimation only in the fact that curriculum theorists (ex. Madeleine Grumet) have privileged them. However, Broadway offers numerous possibilities to continue thinking critically. Immediately she highlights a major problem (in her own work and in ours) in assuming that knowledge, even “queer” knowledges, spring from stable identities (Britzman, 1995). He also stresses that the call for inclusion is not the same as calling for the dismantling of a hegemonic/elitist/privileged system, but simply to include ‘queer’ in hegemony. Not only would the excluded then become oppressors but, worse yet, we cease becoming queer (as both a noun and a verb)! Broadway advocates for a queer curriculum, one that allows spaces for self-creation, and can be thought of in Grumet’s (1989) terms as acts of interpretation within a queer pedagogy.

Educators should do more than simply admit those who are excluded into an unproblematic, privileged world, whereby those who were “formerly queer” are now unproblematically a part of an oppressive normalizing force. Broadway is useful here in describing queer pedagogy as a disruption of who/what is teaching and who/what is taught. However, this disruption must have also a political focus or we are left with a form that can easily be taken up by normalizing apparatuses of power and discourses already present in schools. Here I feel a move toward thinking about sex/gender and sexuality as part of the production, control, and maintenance of subjectivities is a useful way of framing anti-oppression struggles in education. That is, it may be constructive to move slightly away from situating the struggle over sex/gender and sexuality in terms of inclusion, humanist assumptions, and identity and instead see sex/gender and sexuality as one of many diverse revolutionary struggles. Since practices and discourses related to sex/gender and sexuality are often situated between what Foucault calls the two poles of discipline, that of the body and that of the population, these practices and discourses will likely continue to be a leading site of revolutionary action and thought. As Michael Hardt and Antonio Negri (2009) maintain, any revolutionary action (action
towards the reworking of subjectivities and material reconfigurations) must move forward like a millipede with each foot being a separate but important part of the movement towards change. In this way questions of sex/gender and sexuality need to be part of this broader movement, however without subsuming sex/gender and sexuality by some “universalized” struggle for subjectivity. In the sciences I would say that sex/gender and sexuality lead the way in terms of finding new ways to think about life and how we come to view ourselves.

5.2 Irigaray and The Sexed Subject of Science (Education)

Spaces need to remain open for the further use of theory in relation to subjectivity, and the different objects that will emerge from the use of different theories. In this section I would like to give one example of a different approach to subjectivity (different than a Foucauldian approach) using the philosopher Luce Irigaray, whose critique of the masculine subject of science, and the creation of new forms of the feminine subject have remained attractive yet elusive to me. Although I am not aware of any science educator taking up Irigaray’s ideas, they are forceful enough to reshape science education. In Irigaray’s quest to disrupt the masculine voice of science and philosophy she shows, according to Judith Butler (1993), that the feminine is the constitutive exclusion that is necessary for philosophy and science to proceed. Her way of reading texts then looks for what has been refused (to be admitted). This is a useful way of reading if one can isolate these exclusions and I think it would be productive to explore methodologies based on Irigaray’s way of reading. Certainly ‘homosexuality’ has historically been one kind of exclusion, but for Irigaray we are speaking specifically about a search for a feminine subject that is not the occupied male subject position (I recognize that I do not have the space or ability to keep terms “straight” with Irigaray and continue here to hopelessly conflate female, woman, feminine, etc). Historical binary oppositions between male and female that associate women with “material”, “bodied” and men with “rational mastery” work often not just as a dividing practice, but as an effective erasure. At this point I appeal to Butler (1993) for some understanding of Irigaray:

Irigaray wants to argue that in fact the feminine is precisely what is excluded in and by such a binary opposition. In this sense when and where are represented within this economy is precisely the site of their erasure (p. 37).

In Is the Subject of Science Sexed? Irigaray maintains that the neutrality of science is often the site for a solely masculine way of thinking and speaking. She outlines the restrictive rules of
science as a logic/language game that effectively work to set up an ostensibly “sexless” way of speaking, yet consolidates a nonetheless non-neutral way of speaking. When faced with this discourse she then asks: “How do you have an intuition outside of the language game employed? If you have one how do you translate it for the participants?” (p. 75). Part of what Irigaray is trying to say is that if science speaks with a “masculine voice” yet has rules to occlude and exclude along the lines of sex, how can we, using women as an inclusive term, speak about it? One answer she gives is to examine what science takes, or does not take, as the stakes of its research.

In this vein, I’d like to turn to what I think is an Irigaray-inspired passage from Anne Fausto-Sterling (2012) on the subject of “sex determining chromosomes” as it is a comprehensive example of what Irigaray is getting at:

Words matter. The phrase “sex determination” suggests that one is talking about both male and female development. But often in the scientific literature the term presages a discussion of male development only. For example in research papers the genetic factor in the mammalian Y chromosome is called the “sex determining factor” rather than the “male determining factor.” That is, the Y chromosome only directs male development, and itself determines nothing about female development. When this elision occurs, the writer may say something to the effect that female development happens in the absence of a male determining factor or may fail altogether to mention female development. Femaleness then becomes an absence, something that happens by default, something that does not merit the same level of scientific investigation as the more active male process (p. 16).

Erasure of the feminine is not just something described in the philosophy of Irigaray, but in the literature of biology and also within the discourses of science education. The effect of these statements, statements spoken within the “true” of science, could be wide ranging, but let’s just take the most obvious (or what is spoken plainly): When we come to think “scientifically” about sex determination we are really focusing on whether or not a male is produced – males are what is important to science. Irigaray offers a full assault on the “masculine subject”, yet it is heartening to note that Irigaray’s notion of occlusion of the feminine is not necessary to interrogate science – the actual language of science (as elaborated by Anne Fausto-Sterling) and its power effects are there to be read in the discourse of science itself! The last section of this paper will emphasize that the discourses needed to challenge and rework power relations in science education are also always already present and at play.
5.3 Secret Identity is an understatement

While SIBT dealt specifically with discourses of sex/gender and sexuality to show that that sex/gender and sexuality are discursively described in binaric, heteronormative ways, this formulation does not demonstrate enough. In the four biology textbooks under examination in this thesis, unproblematic practices of binaric sex/gender division can be found in wide ranging sections of the textbooks, making sex/gender binaries and their effects on the subjectivity of students, not just a topic for reproductive biology, but biology in general! In Table 5.1 we can see that repetition plays a distinct role in reminding students of strict categories of sex/gender and sexuality. My objective here is not to dispute the facts of the biology textbook, but to demonstrate simply that a reader of this text comes across a binaric distinction between male and female, men and women often in biology. The repetition of this discourse relates to the point made in the last chapter that, according to Judith Butler, the constitution of a heterosexual essentialized sexed/gendered subject, requires repeated constitution.

Table 5.1. Places where sex/gender binaries are mentioned in biology textbooks.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Wording in Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Respiration: Body Surface Area and Energy Expenditure (NB12, p. 111, 112)</td>
<td>“Table 2 lists the average energy expenditures for different kinds of activities for men and women in kilojoules per minute”</td>
</tr>
<tr>
<td>Cellular Respiration: Estimating VO_{2} Max (NB12, p. 131).</td>
<td>“If you are a female, enter the number 0 in column g, and if you are a male, record the number 1 in this column.”</td>
</tr>
<tr>
<td>Cellular Respiration (NB11CP, p. 218)</td>
<td>A VO_{2} max value over 35 ml/kg/min is considered good for females aged 13-19. A VO_{2} max value over 45 ml/kg/min is considered good for males aged 13-19.</td>
</tr>
<tr>
<td>Reproductive Systems (NB12, p. 398)</td>
<td>“Male characteristics result because the levels of androgens exceed the levels of estrogen. Males are ensured of maintaining low levels of female hormones by excreting them at an accelerated rate. This may explain why the urine of a stallion contains high levels of estrogen.”</td>
</tr>
<tr>
<td>Evolution (NB12, p. 642)</td>
<td>Male elephant seals often compete violently the chance to fertilize females and their injuries can serious, sometimes fatal. Explain how such behavior evolves, even though it lowers the average life expectancy of the males and reduces their chance of survival?</td>
</tr>
</tbody>
</table>
| Energy Requirements for a day (NB11CP)                               | Teenage girl 9 500 Kilojoules per day  
Teenage boy 12 000 Kilojoules per day                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Smoking and Lung Cancer (NCB11, p. 228)                             | Lung Cancer is the leading cause of cancer death in Canada for both women and men                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Reproductive Disorders (NB11CP, p. 236)                              | Prostate disorders (male), infertility (male), infertility (female), impotence (male), abnormal menstruation (female), tumours (female)                                                                                                                                                                                                                                                                                                                                                     |
| Review points: The Reproductive System (NB11CP, p. 253)              | The human reproductive systems are those organ systems in males and females that perform the functions of sexual reproduction                                                                                                                                                                                                                                                                                                                                                                      |
| Infant Development (MHB12, p. 146)                                   | Use blue dots for boys and red dots for girls. Does there seem to be a gender difference with regard to the age at which infants learn to walk?                                                                                                                                                                                                                                                                                                                                            |
| Heart Rate (MHB12, p. 147)                                           | Discuss the apparent differences, if any, in the way males and females experience the fight-or-flight reflex                                                                                                                                                                                                                                                                                                                                                                         |
| The Adrenal Cortex (MHB12, p. 185)                                   | The adrenal cortex also produces male sex hormones (androgens) and female sex hormones (estrogens).                                                                                                                                                                                                                                                                                                                                                                              |
| Testosterone and Baboon Behaviour (MHB12, p. 195)                    | The dominant males have better access to food, the best resetting spots, and the female baboons                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Steroid Use (MHB12, p. 196)                                          | Would you still want to take steroids if you knew they can result in shrunken testes, reduced...                                                                                                                                                                                                                                                                                                                                                                                                                      |
sperm count, breast enlargement and impotence in males, and menstrual irregularities, and reduction, masculine features, and sterility in females?

**Hormones (MHB11, p. 202)**
Describe the difference between hormones produced prior to the onset of puberty and after puberty in males and females.

**Sexual Selection (MHB12, p. 384)**
While one male may be able to fertilize all of his species, virtually every other male is in the same position.

**Genetics: Heredity (MHB11, p. 135)**
A couple has two children, one which is a boy. What is the probability that the other child is a girl?
A woman has a father who died of Huntington’s disease. What is the probability that she will develop the same symptoms of the disease?

**Genetics: Blood Type (MHB11, p. 146)**
Mrs. Doe and Mrs. Roe had babies at the same time. Mrs. Doe took home a girl and named her Nancy. Mrs. Roe received a boy and named him Richard. However, Mrs. Roe received a boy and named him Richard. However, Mrs. Roe was sure she had a girl and sued the hospital. Blood tests showed that Mr. Roe was type 0 and Mrs. Roe was type AB. Mr. and Mrs. Doe were both type B. Nancy was type A and Richard was type O. Had an exchange occurred? Explain your answer. (yes there was a switch).

**Sex Linked Traits, (MHB11, p. 175)**
How do you think people discovered that the inheritance of certain traits was governed by the sex of an individual?

**Gene therapy, (MHB11, p. 234)**
In 1992, a 30 year old Quebec woman made genetic history. “the woman’s liver” … “the woman’s large hepatic portal vein”

**Bioethics, (MHB11, p. 235)**
When a 38 year old father of three sons (gender has no bearing on the case)

In terms of sex/gender and biology education we can see that students encounter normative, dividing discourses in many places. As will be discussed later in this thesis, repetition is both integral to subjectification but also for intervening in this process.

### 5.4 Gender Inequity and Implications for Race

I am wary to appeal to statistics when talking about discourse, however after perusing the textbooks I began to notice that “male” and “female” pictures seemed to operate differently race was considered. When looking at the images in these texts my first response was to think that the writers had been careful to portray racial diversity by placing various peoples of colour in a wide variety of activities from professional to lay activities. From what I know about textbook writing from my colleague Joanne Nazir (personal communication, Sept 25th, 2012) they most likely did have some sort of ‘intention’ in this area (The way Joanne described it to me was that the authors saw ‘diversity’ as a kind of either/or quality. So pictures that showed people of colour, disability, etc were taken in a blanket ed way as diversity where as white able bodied pictures were not diverse. Diverse pictures were sought for inclusion seemingly irrespective of any other consideration other than the fact they were diverse). However, upon closer inspection not only were gender and racial representations in images largely skewed towards white subjects, race and gender intersected such that the representations of “gender” differed amongst racialized white people and people of colour. This is to say that there are obvious differences concerning
*intersectional identities* in these biology textbooks such that race and gender collide to *form new sites of oppression*. Going forward as a white person who performs masculinity I am wary, that “otherness” and “the fact of race” (Fanon, 1967) will now comes through an objectification process in this thesis chapter and therefore what follows should be viewed with *redoubled skepticism* since it comes from a position of privilege.

In thinking about the multidimensionality of subjects I have consulted Jennifer Nash’s (2008) comprehensive reflection concerning intersectionality. It is useful to highlight race in this re-examination of discourses of sex/gender and sexuality to further subvert binaries as well as racist discourses they may operate in ways in which people in privileged positions, such as myself, cannot see. This work should not be seen as giving voice for the racially marginalized since I do not directly share lived experiences of racial marginalization in or outside the classroom. If anything, this section is intended to show that intersectionality *must* be included when those considering lived realities, identities, and subjectivities in science. The “anticategorical” (McCall, 2005) assumption that race and gender are separate fields may not be sufficient in explaining how discourses of science education work to produce subjects (even though my thesis study has put them into separate chapters). Crenshaw (1989) highlights that often the law *forces* people to choose to make claims of discrimination based on either race or gender but *not* both. Referring back to Judith Butler (1997) then, and taking law in the broad abstract as social rules by which we are made subjects, educators must endeavor to subvert the tendency to think of one process/category of subjectification as the sole means by which we adopt a position; though I think this does not mean we cannot talk about one thing at a time for the sake of detail and dialogue. This idea represents another turning point in this thesis study in that it is becoming clear, that not only are subjectivities constituted through mutually dependent discourses, for example race and sex/gender and sexuality, but that discourses may work to constitute different subjects simultaneously – what Nancy Fraser (2003) calls differentiated subjectification.

One problematic aspect in this chapter is that I seem to position women of colour as a kind of “ideal” intersectional subject by describing the inequity of this “position” when in fact the multiplicity of women of colour is a reality that must continually be engaged with in science education (Calabrese- Barton, 1997). For critical science educators that have already decided to ask critical questions of their discipline(s), Matsuda’s (1990) technique of “asking another
question” may come in handy. For, example when declaring something sexist one could ask, where is the homophobia in this? Or when declaring something class related one could ask, where is the racism in this? There is a need for examining the lived experiences of intersectional subjects entwined in science education – if not for the very reason that curriculum materials (textbooks) portray a different reality for particular intersectional students and subjects! Students in the interstices (between identities or different subjective positions) may struggle to arrive at a meaningful synthesis amongst multiple positions and therefore curricular spaces must be created for students to explore their multiple subject positions (Asher, 2005). To foster such a space in science education, science teachers must recognize this interstitial space with their students.

I have also collected image data statistics from these textbooks. This was done with a very simple method that I will now briefly outline. It should be stated that this method and the results presented are only meant to show that there is something happening at the intersection of race and gender – they do not say what exactly is happening. This method and its results are fraught with assumptions that I as the researcher do not for the most part endorse, such as the practice of racializing people or categorizing people into binaric genders - the very thing this writing is supposed to refuse! However, these figures do affirm that race/gender differences are present within science education discourses and can ostensibly work to constitute subjectivities.

5.5 Simple Statistics Related to Sex/Gender

Each textbook was perused from front to back and images were categorized into strict gender categories of male/masculine and female/feminine as well as race categories, white and people of colour. The categorization of strict sex/gender binaries is not to say that these images are endorsed or acceptable, but can be seen here as a rough methodological tactic to survey images, that is to target the presence of maleness, privilege and whiteness. Furthermore images were categorized as pertaining to every day situations (lay) and professionalized positions in science (scientists, technicians, etc). If an image was unable to be categorized, because it was difficult to racialize, the image as white or non-white, or performative masculine or feminine, it

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11 I question underlying tendencies of white supremacy in my own categorizations as I when I recorded this data I always listed the category of white first in data tables. The structure of my tables were such that white/professionalized images were in the upper left hand corner and people of colour/lay images in the bottom right. This became apparent to me only after I had drawn the table out in two dimensions.
was not used. Historical images of scientists were included and so were graphic images (images that are not photographs) as long as they could be categorized. It is understood that I am using definitions of race and gender that are culturally imbedded and not ones that I necessarily share, however this does not make them “less real” and unqualified as the objects of (any) analysis.

Each image was counted and used to calculate overall frequencies of sex/gendered, racialized and lay or professional categories. Multiple people in a single image were counted, but only if they were in the foreground and in focus (making them subjects of the photograph). This choice to allow multiple people to be counted in one image most likely had little effect on images of professionalized workers in science as these people were usually rendered alone or sometimes in pairs. Although the context of a picture and the way it frames its subject is very important, and will be considered in the next section, none of these contextual features were considered for these statistics.

5.6 Statistical Results of Image Analysis

The statistics presented in point form support something that I feel many science educators already recognize – that science is complicit in furthering racist, colonial and white European masculine narratives and agendas. These statistics below are from the four biology textbooks combined (the remaining can be found in Appendix B).

Combined results from the textbooks showed:

- In terms of images of people in professional science positions there were 10 times as many images of “white women/females” than “women/females of colour” and 15 times as many “white males/men” than “women/females of colour”
- Women of Colour make up 3.5% of all professionalized positions
- 85% of all representations of professionalized workers in science were racialized white
- 74% of all the images in the texts (lay and professionalized) were racialized white
- There were more than 42% more “white males/men” than “white women/females” in professional positions related to science
- There were 160% more “males/men of colour” than “women/females of colour” in professional positions related to science
The last two points here demonstrate the need not to just advocate for a shift in representation, but that there is clearly a need to think of the intersectionality of sex/gender and sexuality and race within science education. Not only do we see clear hierarchies in how different groups are represented concerning science work, but also in gendered representations of people of colour. That is gender equity matters less when we are talking about people of colour! A sound conclusion is that the racialized and sex/gendered thinking and practices involved in producing representations in biology textbooks, from the decisions of writers/editors to the already existing network of images, is very different across racial lines. For me the urgent response is not to seek to flood the text with images of people of colour, as Rodriquez (1996) basically sums up regarding the images of people of colour in the American National Science Education Standards, as this does not change fundamental systemic problems related to science and minorities. The urgency here consists in recognizing that oppressions related sex/gender and sexuality and race not only have points of intersection that affirm each other’s existence (science is heterosexist, male and white) but to deal with the reality that many in science education live. If students of science must use these textbooks to “learn their trade” then how are they (their subjectivities) differentially positioned (constituted) by these images? Science educators can distil these micropractices of subjection in science education (Kamberelis and Wehunt, 2012) related to race, sex/gender and sexuality and how they relate to other aspects of subjectivity. I want to now address race and sex/gender in terms of the actual images displayed in these textbooks in a different way. In the following section I would like the reader to consider some of these images through my reflections that draw the work of Roland Barthes.

5.7 Some Images in school Science: A Reflection

As I was going through the textbooks looking for instances of sex/gender and sexuality some images (not all) began to strike me. The first was Moira (see Figure 5.13) and the ‘playful’ connotation made visible by the use of space. I realized that it would have been difficult to not include these images as discourse and proceed to speak of them. This is also the case in the way race is represented in images in that at first these images seem quite “diverse”, but on closer inspection white people are largely over represented. I think it very significant that I, as a white person, felt that the book was “diverse” when it was only diverse compared to a complete ‘white wash’! Generally speaking, photographs and images are important to examine because they tell us things; as Barthes (1977) says, they are meant to inform.
In light of this, it is worthwhile to examining specific images that represent sex/gender and sexuality. Instead of a detailed semiotic analysis, I would like to follow Roland Barthes (1981) in Camera Lucida in his attempt to speak of “a” photograph instead of “the photo” (p. 4). That is, instead of trying to analyze large swaths of pictures for an already decided upon feature of representation, for example what do these images say about “what a scientist is”, it may be also be useful to consider a “collection” without the burden of any ‘presence or absence’, and considering photographs in deitic contexts is another way that science educators can begin to engage discourse in science education. Here I employ, though most often not openly, Barthes’ notion of the punctum and studium. The punctum represents that wounding detail that attaches a person to a photo or image. Many of these images have such a detail which brought me into close relation with the photograph. The studium is to be thought of as the cultural interpretation of the photograph. The studium and punctum then function in tandem to bring the viewer into a particular deitic relationship with photographs.

It seemed to me that a productive way to display these images would be the way Barthes’ (1981; 1977) displays pictures with text in his autobiography Roland Barthes by Roland Barthes and Camera Lucida. I also feel I have approached these photographs and images in a way consistent with Foucault’s endeavor to privilege the surface of texts. As Roland Barthes states: “I cannot penetrate, cannot reach into the photograph. I can only sweep it with my glance, like a smooth surface. The photograph is flat, platitudinous in the true sense of the word, that is what I must acknowledge” (Barthes, 1981, p. 106). And just like a subject, “a photograph cannot be transformed (spoken) philosophically, it is wholly ballasted by the contingency of which it is the weightless, transparent envelope” (p. 6).

The following images were chosen for reflection because of their association to sex/gender and sexuality and race. I cannot fully answer the question of why I selected these images and not others, and the selection process remains open for interpretation and criticism. What follows can be seen as a critique and perhaps the beginnings of a method by which students and teachers can arrange and look at images in science. I do not call of the removal or inclusion of these images, only that they be thought about and experienced. My reflections for the images appear beside the image.
5.8 The “Gendered” Photograph Repeats …

The incapacity to name is a good symptom of disturbance. – (Barthes, 1981, p. 51)

Something about the Edmonton Protocol is school like - its members are spatially arranged. The three span the nine. I cannot tell who is who except by the fact that it is extremely unlikely that any of the front three are graduate students or technicians. The back row has not been fitted according to dress code. These are scientists.

Figure 4
Members of the Edmonton Prot at the University of Alberta

Figure 5.1 The Protocol
This image is not a photograph, but a construction from mind (from language?) and is thus open to thesis instead of the physis of photos. I see masculine and I see feminine in symmetry – its most powerful feature. Do I see race? Yes. Do students? And, is there exaggeration? Why is the skater’s torso less than half the length of her legs? I think of Plato’s halves. Unisex is given its location between male and female (Between Asian and Black? Is it the space of whiteness, of universality?). Is there such a thing as reversal (I think not)? On the periphery, the nightmares for the two halves, bigger breasts, smaller breasts, facial hair and small balls.

Figure 5.2. The effects of Steroid
Symmetry again, brown is the father-son, blonde and blue the mother-daughter. A family question is unclear. But comes to mind anyway. I imagine a heterosexual union. Nothing is out of the ordinary.

Natural dietary sources of folic acid include fresh fruits and vegetables.

Figure 5.3. Blonde and Brown

Colourblindness follows the male while the female is protected by chromosomal circumstances, her yellowness and her dress. I think about parent and child, male or female.

Figure 5.4. Colourblindness
What makes the image stand out, for me, is the “blackness” of the sickle cell family, and their middle-class clothes, as racialized black people are found in very few images. Could it be imagined that another gender would find their way into the position of the four identical children? Would four feminine figures arouse questions? Is sickle cell a racialized trait?

Figure 5.5. Sickle Cell

Figure 5.6. Elementary Shopping Lessons

Who is concerned with counters?
Figure 5.7. They are close

My scan has cut the older child’s face off. How could she be similar in appearance? Is there a reason for “Asian-ness” being included here? Does race play a different function in this photo, than it would if the family were white (I can’t imagine a white family in this text - what would be obvious about this photo ‘in white’ – and what does this photo achieve for the universal?

Figure 5.8. A planted image

Struck by the proximity of Henry and Douglas who died years before this picture was published. Though there is no mention of it, I imagine someone planting homosexuality.
This is a representation of a certain Cindy B - A subject: Writing in cursive with loopy letters. Who is Cindy B?

Figure 5.9. Who is Cindy B?

Here the old trope is played, “man moves”. It reminds me that movement in the world (by the scientist) has always seemed unitary and full of purpose.

Figure 5.10. ATP and Man
Body stereotypes are old and new, male and female. What has remained invisible? Do these pictures really represent divergence or a common distinct set of ideals? Are ideal bodies always white and cisgendered? Are they presented (now in capitalism) like the connotations of fashion? Always against a backdrop of the old.

Figure 5.11. White Bodies

The warm virtue of the face lands - the (racialized) black woman as strength. I think of this form and wonder if a racialized white woman would have the same effect - or how would the story of the face change? Staring at the picture for fifteen minutes or so I realize that her blackness comprises the studium (the overall interest of the photo). A hope in medicine exists, her watery look is undeniable - but how is blackness part of this image? - especially since there are so few pictures of women of colour in these texts.

Figure 5.12. Where is the punctum?
Moira Brown sparked this photo reflection. Why is she tucking under; scooping her legs up to her chest? The punctum (the detail that breaks the aura of the photo), is her toothy grin. And who is she in her pose? She’s posing as a woman in science, to the photographer and herself, perhaps even to convince herself of who she is.

Dr. Moira Brown

His face is warm; a smiling thinker. Like Moira he is being the scientist he thinks he is - he thinks we want to see. Unlike Rodin’s thinker there is a vacancy of thought. Could Moira place her hand on her chin? Could she think? Would she? I am wonder about his smile; his freedom in the world to think.

Professor Michael Smith

Figure 5.13. Moira

Figure 5.14. Michael
5.8.1. The Juxtapositioning of Text to Image

The text beside each image represents a gap between image and text as well as reflection and interpretation. I would like to now speak about what I feel went into making each reflection: that is the thoughts, feelings, and fragments of language that came to mind when looking at these images. These images represent a necessary layer in analyses of text(books) as they can represent what is not spoken (e.g. ‘males’ are thinkers, more important; white is a universal colour); ironically, representing what is absent by their very presence. These images connote a great many things and my reflections above were not my first conscious thoughts as these images first seemed banal. In a sense then, I am recalling my second thoughts. These thoughts come after already making the decision to read these images through the lenses of sex/gender and sexuality and race. First thoughts could be said to be at the level of ideology in the sense of Barthes’ mythologies in the very connotative concepts that land first or what fills the form of the picture. Second thoughts or asking after myth, connotation, ideology cannot undo the fact that the concept has been received and the form (image) ‘has been communicated’. In a sense then I am working both for and against ‘first’ thoughts or connotations. In writing my reflections I am taking my secondary thoughts literally as they come, which is paying attention to the surface of

Figure 5.15. Joseph

Joseph is the last image. I notice him because he is the only racialized black person in a professionalized position in one entire text. He is being shot performing a task, an obvious simulation. The punctum, his multicoloured pen pocket, strikes me as too loud to be fake. He uses those pens. He does not face the camera, he is one of a handful of scientists who are photographed “at work”. We should ask, who can be positioned as ‘the thinker’.

Dr. Joseph Odumeru
the text, such as Moira’s arm tuck and a sex/gendered meaning of such a pose – yet to make such a thought I have had to ‘ignore’ that a “female/woman” scientist is quite natural in any pose not typically seen as ‘intellectual’. That is, reflecting on these images seems a process of ‘letting the connotation’ land, but then disrupting it by rendering the connotation visible.

Staying with the idea that the discourse in texts operate through what is there to be read on the surface as well as Barthes notion that photographs strangely render a reproduction of “what is/was”, we can think of images as exposing the surfaces in a way that wounds. In this thesis, the surface connotations were informed with the way the discourse separates sex/gender and sexuality into distinct and oppressive categories (a topic of this chapter). Relevant here is how Barthes (1981) claims a picture most often seems discreet at first, but once a person chooses to engage the photo it is at once indiscreet – the image takes on personal (deitic) meaning if studied. When looking at the images above I asked myself: How does the image render sex/gender and sexuality into something normative? What is captured in real-time and space but also what cannot be located here (e.g. the pose of the thinker)? What is attributed to some subjects and not others? Though I would have the reflection text speak as an creative text, it is worthwhile to also speak about the connections from image to reflection.

It must be said that after coding images for the frequency of representations of race/sex/gender, images of people of colour such as Joseph (the last figure) became much more ‘visible’. How is Joseph, who is ostensibly at work, being framed by the camera in a way that a racialized white scientist would not? Joseph is not (to be) represented (or has more difficulty being presented as) the universal scientist/thinker. Neither can Moira whose ‘femininity’ is permitted to be (or is) represented in her photo. Again, none of this can make much sense unless attention is paid to the ‘whiteness’ of these texts as well as an analysis of sex/gender. So for example, in the first image, the Edmonton protocol, we can see the allocation of space that has been made for ‘white male subjects’; but the problem does not lie with the cramped, secondary, subordinate-suggesting position of the ‘female/women’ in the back row. Rather it is in the relations between the two and the power differentials these relations signify – which is also to say there is no problem with Moira yet for her relation to Michael. The point here is less the racializations and sex/gendering of subjects than the differential, unjust, nature of these representations.
The racialized black male jogger and Asian roller-blader in figure 5.2 are given comic book proportions, and these proportions match the statistical findings that were not included in the thesis (I cannot find the terms and the means to engage in further racializations!). That is there seems to be an under-representation of racialized Asian males and black females in these texts. Again, intersectionality is important in that for people of colour equitable representations of binaric gender/sex seem to matter less. With this lens in place (the idea that representations across race and gender lines are not the same for people of colour and racialized white people) the comic proportions of these racialized issues makes some sense. That is, they racialized representations can be inscribed with stereotypical, hyper-masculine and feminine features as these representations of race are already seen by textbook writers subconsciously (or consciously) as racialized (through skewed representations).

Thinking again about what is permitted in some images and not others, the racialized ‘woman of colour’ in figure 5.15 becomes striking. Notice how her face is again away from the camera and how her mouth is half open. It seems as if she is in a state of emotive reflection or more succinctly, she seems to photographed as a subject ‘acting’. Here I asked the question, could a racialized white person be photographed in the same position –in the middle of an emotive response? As it turns out, I did not see this type of image in the texts involving racialized white people. Going further, there seems to be the connotation of strength – almost a kind of human warmth – but here I ask(ed), is this the same representation of humanity that stems from Michael (the thinker)? Is one representation the humanity of warmth and feeling, and the other intelligence and confidence? How are these images racialized-sexed/gendered and even open to sexual desire? Now that it seems to be the case that race matters in these texts when it comes to gender, is it not also noteworthy that all of the representations of ‘male and female’ beauty in Fig. 5.11 are white? What would the disruption be if this image contained a person of colour? It is reasonable to think at this point that such an inclusion would break the universal and invite the question of race into a space where it is not allowed – where the universal (in this case white) prevails.

If these images are a series with a studium – an overall message - I think we could also say that the series as a whole has a punctum – an image that orders the rest, or also, disorders. This image (which would be different for every viewer) makes an analysis like this possible because it provides a break from the white, masculine, realist, seamless order of the images. The
image that I think breaks the series or works to reconstitute the heteronormative order of these images is figure 5.8. These two people are also clearly representing love – something not represented in the other images. These two people can be seen readily as queer and so the question remains: why use this image? As it stands, these horticulturalists are quite known in the field, and here practical application of biology meets some kind of queer awareness. This image becomes the punctum of the image series because if this image can ‘exist’ then the whole of the series is moveable. That is, the whole of the series and its universality are offset by the particular. But what is the particular? Again, I would say that it is both queerness and love, or that love is doing the queering; and love is always queer. Once things are queered (loved?) then we can see a new studium. The loving family in fig 5.7. is what it says it is, a loving family. And reading this image through a context of race, sex/gender creates a surplus by which to read love. This is to say, that a new way of reading critically leads also to positive forms (love) and new beginnings.

Lastly, the juxtaposed text is curiously similar to what already exists in the text in that it is a rewriting of the caption. Derived from the Italian, capito, a caption is ‘a catching or seizure’ Redesigning captions then is a reformulation of how these images are meant to seize – it can also hopefully be a reconfiguration of how these images work to delimit what is normative. By denoting the visible, a rupture is created whereby what has not been attributed to these images through language (yet is represented in the image) is sayable. Referring back to the basic aims of Foucauldian archaeology this exercise works to form negative relations between the visible and the sayable.

While this exercise may seem like a foray away from the critical discourse analysis methodology used here, it is also quite in line with its principles in the following ways: 1) reflecting on images involves reading the surfaces (details); 2) it is a process of asking after how these images normalize and work to constitute what is commonsensical about ‘becoming a subject’ in science; 3) It is a means by which to rework what is given towards new kinds of subjectivity. In terms of the last point, it seems to me that by selecting and arranging images, as well as contextualizing them with new captions (reflections; seizures), offers a reformulation of what is sensible, normal, and definitive of the various subjectivities related to science and science education.
5.8.2 A Final Word About These Images and Analysis

When encountering these photographs in texts I found I first had the tendency to at first be very interested in what the picture was trying to relay. Using the work of Barthes, I tried to give attention to the parts of discourse that cannot be tied down, what escapes obvious situatedness or systemization. Roland Barthes develops this attention to nuance *A Lover’s Discourse* (1978) and *Camera Lucida* (1981), and in a similar way these images show do exceed their intended illustrations and have an ability to wound (as Moira first wounded me and began the display of images). Semiotic or “preconfigured” analyses of images may in fact temper this ability to wound by introduced a pre-known signified. Instead it should be remembered that these images are not “memoryless” language and signs, but instead have the power to authenticate themselves, outside of themselves (as Barthes (1977) states in *Roland Barthes*). Unlike language a photograph is self-authenticating, and exudes “this has been”.

In trying to think about sex/gender and sexuality along with race in these science education texts the statistics given above, while helpful to see the intersection of race and sex/gender and sexuality also work to reify traditional categories of sex/gender and race, whereas reflecting on some of these pictures allows us to ask (better) questions. Science educators must not forget that strict categories of race, sex/gender, and sexuality still govern us, even though such categories of sex/gender and sexuality have been largely “debunked” in many areas of academia. For students repetitively bombarded by similar arrays of images, ones that discursively form specific relations of gender/sex and sexuality and race, the question remains of what effects such images in constituting sex/gender and sexuality and race through science and education? We are flooded with images in science education, and a question that remains for me is: what are we to think of how these images are sexed/gendered and racialized? Is this not also a process of (re)constituting my own sexing and racialization?

5.9 Subjectivities of sex/gender and sexuality are integral to struggles for freedom

Like other struggles for liberation, different ways of living with/out gender should not be thought of as strictly an emancipation of various gender identities but instead would seek, albeit always constrained terms, the undermining of fixed identities. In terms of identity we can think
of liberation as the “production of singularities” (Hardt and Negri, 2009). Hardt and Negri recognize that the emancipation of identities and identity politics will and should continue as an entry point for resistance against control; but while identities can be emancipated “only singularities can liberate themselves” (p. 339). In science education this means making the space for *n* sexualities (as opposed to zero, two, or twenty). Clearing such a space means setting conditions for freedom, to subvert the forces of biopower (Rabinow and Rose, 2006), that are integrally apart of science education. This context for science education will be discussed in chapter 9. The self founded in identity may have to be (inevitably?) sacrificed in the same way Butler (1997) maintains that anyone who offers a forceful critique of the law must be prepared to be undone. Politically, it will mean recognizing that singularities can only be recognized within a context of multiplicity from within and without, they cannot be imagined on their own. For Hardt and Negri (2009) it is this attention to multiplicity and singularities, which can be thought of as placing subjectivity at the heart of political revolution, and forms a broad base for all kinds of critical, political assaults which can shake modernity’s problematic foundational tenets, such as the hyper focus on private property.

Foucault maintains that the discourses that circulate also contain the discursive means for their own subversion. This is also where Butler’s ideas of freedom and subjection can come into play:

Subjection is, literally, the making of a subject, the principal of regulation according to which a subject is formulated or produced. Hence, subjection is neither simply the domination of a subject nor its production, but designates a certain kind of restriction in production, a restriction without which the production of the subject cannot take place, a restriction through which that production takes place (p. 84).

As Butler maintains the subordination and production of the subject are *one*. The implications are thus that, for better and for worse, our freedom to act, to choose a course of action is, at least initially, formulated (with)in the production of our own subjectivity. Science students, teachers, and scientists are not *just* made into subjects but in their perceived freedom of thought are the very *principle* of their subjection! Realistically then, we must *also* realize that when we act we act as a contingency of various processes of subjectification. Following these Foucauldian notions of subjection, Butler distils two basic ways resistance and subversion occurs, of which I will put into the context of science education:
a) Subjectification will exceed its normalizing aims, for example discourses of the
universality of scientists can be used as a backdrop in the history of science to clearly
show that scientists and practices of science are far from universal.

b) Through convergence with other discursive regimes, for example how discourses of
brain research and genetics inform psychological theories of gender identity
formation (in science education see Kamberelis and Wehunt’s (2012) work with
hybrid discourses).

Thus power exercised through discourse also contains the possibilities for resistance, its self-
subversion. Disruption occurs in the repeated process of the subject’s production. In table 6 we
can see that gender/sex statements regarding male and female exist all over biology (repeatedly),
and it is in the disruption of this repetition that opens the space for a counter-discourse.
Furthermore if the same subversion can then repeatedly be enacted, for example in many the
spaces of where strict “male” and “female” statements exist, then we have an example of a
normalizing discourse/practice that is now turning back on itself with new understandings of
these objects/terms. In addition to these processes of resistance we can also think about
(mis)recognition (Althusser, 1998), which subverts the interpellation process by which the
subject is hailed and thus becomes the very subject that is named12. That is to say, there is
always the potential for misrecognition, which, in a case such as sex/gender and sexuality, can
occur in several ways. First, misrecognition could involve knowing that this discourse has not to
do with you - for example those science students who have already encountered personally the
normalizing forces of sex/gender and sexuality or race. However, there is also misrecognition in
the refusal to be addressed this way because the discourse on sex/gender and sexuality (race) has
now been deemed unjust, erroneous and outside ‘the true’. Butler (1997) sees this reliance on
repetition as evidence of the subject’s incomplete character and subjection; an ever presence of
disciplinary incoherence. What makes this more complex is that there are passionate attachments

12 Althusser gives the abstract example of the policeman hailing someone on the street by a “hey, you there!” . The
person subsequently turns around completing his subjection to the law, power, institution that gave the hail. The
point here is what if the person fails or refuses to turn around? In science education, what if we refuse to be (or
better yet if we misrecognize the process of) hailed, refuse to respond to problematic or erroneous conceptions of
sex/gender and sexuality.
to the identities of our constituted selves, for example many find comfort and solace in “hard truths” about females and males.

If biology (education) is partially responsible for providing the truth/power discourse for constituting individuals according strict sex/gender and sexual categories then it makes sense that in this subjection, in the violations of these categories, a locus of resistance can form. As Foucault states in the *History of Sexuality Volume One*, homosexual identity arises around this very normative pejorative term in the nineteenth century. The Victorian era category of the homosexual, meant for the most part to repress, has given rise to new ways of thinking about sexuality and sex/gender. In terms of personal freedom Butler (in her essay, What is critique: On the virtues of Foucault) describes Foucault’s aim of a stylization of the self, in relation to the rules imposed, as a kind of *critical praxis*. Specifically related to sex/gender Butler (1993) asks in *Gender Trouble*, how then do we ask after gender in such a way that disrupts a given notion of a pre-existing sex/gender - recalling that sex is “always already gender” (Butler 1993, p. 9)?

Coming back full circle I fully accept my work with Heather Sykes because we succeeded in occupying and queering sites by which we find “subjecthood” in order to affect a reformulation. As Butler concludes about undoing fixed gender binaries,

If identities were no longer fixed as the premises of a political syllogism, and politics no longer understood as a set of practices derived from the alleged interests that belong to a set of ready made subjects, a new configuration of politics would surely emerge from the ruins of the old. Cultural configurations of sex and gender might then proliferate or, rather, their present proliferation might then become articulable within the discourse that establish intelligible cultural life confounding the very binaries of sex, and exposing its fundamental unnaturalness (Butler, 1993, p. 190).

Butler (2004) claims that exposing a discourses fundamental unnaturalness we must trace the places where this knowledge/power coupling fails to remain coherent, where it contradicts itself and therefore cannot stand the way it did before. The intersection of power/knowledge and power relations is precisely what Agamben (2009) clarifies as a Foucauldian apparatus. Thus in a sense we are tracing apparatuses, and in doing so we risk the very foundations by which we have come to know ourselves as a subject, and this, to Butler, is what gives the act of reworking subjectivity a kind of “virtue”.

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5.10 Freedom through the Discourses of Biology and Science Education!

In this last section I want to draw from Foucault’s notion that resistance to binaric views of sex/gender and sexuality is already inherent in power relations, and emphasize that the means to resist is already present within the many discourses at play in science education. That is to say that the tools and more importantly the ideas and discourse needed to resist oppressive biological and educational discourses can be found within these discourses! Although it depends on where we set the boundaries for what counts as discourses already in play, educators do not necessarily need to necessarily go to other disciplinary knowledges to engage in critique. To conclude this chapter I would like to underline a couple of textbook examples to show that there will always be possibilities for students and teachers.

5.10.1 Switched at birth?

In McGraw Hill biology 11 there is a question regarding blood types and a hospital baby switch that reads as follows:

Mrs. Doe and Mrs. Roe had babies at the same time. Mrs. Doe took home a girl and named her Nancy. Mrs. Roe received a boy and named him Richard. However, Mrs. Roe received a boy and named him Richard. However, Mrs. Roe was sure she had a girl and sued the hospital. Blood tests showed that Mr. Roe was type 0 and Mrs. Roe was type AB. Mr. and Mrs. Doe were both type B. Nancy was type A and Richard was type O. Had an exchange occurred? Explain your answer.

By the blood test data given, students would conclude that yes, there was a switch! But, what else could have happened (what is perhaps even more likely considering that both parents were comfortable enough with their babies to name them!)? For example, what if the genitalia of the children, let’s say both, were ambiguous? As Anne Fausto Sterling (2012) maintains,

… all that needs to happen is that something out of the ordinary switches or derails the process of sexual development at one of the levels from chromosomal to genital sex. For example, rarely an XY child is conceived who carries a genetic mutation that prevents the body’s cells from “seeing” or binding testosterone ... Such androgen insensitive XY babies are born with highly feminized genitalia and are often identified as girls at birth, even though they are chromosomally and gonadally male (p. 25)
Here we do not necessarily need to draw from radical feminist or critical scholarship. The U.S. National Library of medicine has readily available information about sex/gender studies, a resource intersecting at least two regimes of truth/power (state government and science):

If the process that causes this fetal tissue to become "male" or "female" is disrupted, ambiguous genitalia can develop. The genitalia makes it difficult to easily identify the infant as male or female. The extend of the ambiguity varies. In very rare instances, the physical appearance may be fully developed as the opposite of the genetic sex. For example, a genetic male may have developed the appearance of a normal female … Ambiguous genitalia is usually not life threatening (see Causes section for exceptions), but it can create social problems for the child and family. For this reason, a team of experienced specialists, including neonatologists, geneticists, endocrinologists, and psychiatrists or social workers will be involved in the child's care.

What is most interesting here for students and teachers are the kinds of questions that can be asked about sex/gender, but also questions that lead back to the original text/discourse. What assumptions about sex are implicit in the textbook question? What values are students meant to take for granted and how are they then to look at gender? Ironically here we can see that Butler’s theoretical considerations regarding gender and the law are a very useful way forward as the example literally embodies sex/gender within (custody) law and the proper identities of Nancy and Richard within the field of genetics!

5.10.2 Risking the provocative!

How do sexual acts begin? What drives them? What is the definitive moment? Nelson Biology 11 College Preparation has one answer: “Sexual intercourse begins with sexual stimulation that causes blood to flow into the spongy tissue of the male’s penis, causing it to become relatively rigid and erect” (DiGiuseppe, 2004, p. 234). But is this how the sex act begins if you don’t have a penis (or if you have one?). Must a penis be rigid and erect for sexual intercourse? Here we can see how a masculine or male imaginary is the neutral subject of science education, and a useful exercise would be to reword this as a class exercise (e.g. in the Lacanian: sex begins ultimately in the ‘lack of the other – or desiring the other’s desire for you – which I think is often biologically true!). In another example Nelson Biology 12 states that males and females play specific roles in the process of reproduction. It would be interesting to ask what roles these may be and what if any of these roles is actually necessary for the process of reproduction. Where do
these roles begin and end? How does biotechnology augment or negate these roles? Where, why, how and when do organisms actually change gender, for example plants and certain fish species?

5.10.3 Teachers to discuss a world of winners and losers

The last example I would like to discuss does not come from the texts in question, but the teacher’s guide for Nelson biology 12. To support teachers’ discussion on sexual selection the book sets a contexts for teachers:

Students naturally find the topic of sexual selection fascinating. It is a good opportunity for students to consider some of the ways in which behavior may be influenced by evolutionary forces (DiGuisepppe, 2003, p. 274).

For teachers, we can see at the outset a context which they must accept evolutionary processes and students’ ‘natural affinity’ for sexual selection (sex) as described in the discourses of biology. The text now takes a turn towards humans:

Although you should avoid implying that human courtship and/or gender differences are a result of strict Darwinian evolution, students can be encouraged to speculate about what role selective pressures may have played in molding our sex drive and associated behaviours (p. 274).

Teacher’s questioning the assumptions of their textbooks will notice two things: first teachers are told to avoid relating “human courtship” and gender differences to strict Darwinian evolution instead of stating outright the problematic nature of this assertion. In the next sentence the teacher’s guide then encourages students to speculate on associated behaviours related to human sex drive! The point being that there is a kind of double speak; on one hand there is a light prohibition to relate human courtship and gender differences to evolutionary pressures, but in the next breath teachers are encouraged to have students speculate. Rather than see this as simply a mistake, it may make more sense to see this as the merging of two discourses that are sometimes in conflict (evolutionary biology and discourses of public education related to sexuality).

Lastly, I’d like to quote this last paragraph from the teacher’s guide regarding the biological success of males. Again, the task for the teacher and student is to call into question assumptions (and in this case the task is directly for the teacher as ostensibly they are the only ones with access to the teacher’s guide).
Those individuals that produce the greatest number of viable fit offspring are most successful (as are their genes). For this reason, the sexes are not equivalent and are often under very different pressures. In most species male success is extremely variable. Some males are able to fertilize many females and have very large numbers of offspring while other males are never able to fertilize even a single female. As a direct result, males can be big winners or complete losers in the sex game. In sharp contrast, females are almost always “winners”. Almost all females have one or more opportunities to reproduce within their lifetimes and unlike males, they are rarely in competition with other females for reproductive success. The disadvantage to females is that although they are almost guaranteed reproductive success it is not possible for them to have as many offspring as a single highly successful male (p. 274).

This passage contains details about what it is to be male and female. A teacher who engages students with this sort of heteronormativity can work to shape a student’s subjectivity towards sex/gender and sexuality within the frame of a truth discourse. While I am not necessarily out to dispute the science behind sexual selection, theories teachers need to see and engage the context by which such statements are uttered. The statement directly before it (above) pushes teachers to encourage students to consider the evolutionary basis for sex drive and behaviour, then the next paragraphs relates male and female success in completely heteronormative terms, success for “males and females”, and in terms of big winners and losers. Here we can take the teacher’s text at its word and ask the question: are animals deemed ‘male’ big losers if the don’t even fertilized one female? How does this work in the human world?

5.11 Concluding a Revisit to SIBT and the What was Found

Revisiting the SIBT has not necessarily meant a move away from concepts like identity, inclusion and distinctly defined sexualities (ex. homosexuality), but instead has meant finding a context for my queering project (my endeavor to be queer) within a context of struggles over subjectivity. While I have tried to use Judith Butler’s work in some detail to elucidate subjectivity I recognize that science education scholars may access a whole range of theories and practices related to subjectivity, such as hybrid discourses or Donna Haraway’s (1991), at least somewhat urgent, thought regarding cyborg subjectivity.

To conclude I would like to mention the work of few in science education that I think are inspiring examples of rethinking our general approach to sex/gender and sexuality in science education. The first is Deboleena Roy’s essay about asking different questions in the natural
sciences. Here, she advocates for a more feminist approach to science and science education for the scientist or educator in terms of resistance:

She must also learn to resist, for example, the sexist and racist biases that run rampant within the theories, paradigms, and language used to produce scientific knowledge. She is used to “resistance-building.” But to be “effective in opposition,” the feminist scientist must also have a way to express her “differential consciousness” in the space where she resist (p. 146).

Roy’s work draws from the work Chela Sandoval (2000) who calls for a differential consciousness in Althusserian terms, that is a way to speak from within ideology and ideological apparatuses (as we always already do) against these ideologies. Roy maintains that this differential consciousness is needed to question in a meaningful and potentially altering way the research agendas of institutions of science. As she puts it,

… the expression of her differential consciousness can guide the feminist scientist through the practice of research agenda choice, allowing her to politicize her engagement within the processes of the scientific method and to embed her knowledge practices within a community of marginalized knowers (p. 146).

Subjectivity and asking after its constitution, then becomes especially important for those marginalized in science and science education. The intersection of race and sex/gender in science has been empirically shown to be a new site of oppression in terms of inequitable representation and *science educators need to ask after the effects on the subjectivities of science students who do not see themselves as a legitimate subject of science!*

As I move towards the next chapter to think about the way science and science education frames those who are “other”, I want to end with a few thoughts from Elizabeth McKinley (2008) who calls for a focus on the subject of science using Indigenous women as a site of focus. First, McKinley raises a key point about the subject as a construction and ultimately the site of multiple subjectivities. For McKinley, the subject “is a necessary fiction—a (re)construction of something that has gone before—opens up the possibility of several narratives being told by the subject about herself. That is ‘multiple subjectivities’ or multiple positions and their strategic use” (p. 965). It is here that I want to end my revisit to SIBT and begin to think more about the colonized/colonial subject of science education.
Chapter 6: Constituting the Colonizer and the Colonized

Following chapter five’s treatment of race/sex/gender intersectionality, this chapter continues to consider the theme of ‘other’ in these four secondary school biology textbooks by investigating how these discourses may work to constitute both a ‘colonizer/colonized’ subjectivity. That is, how discourses may work to delimit a subjectivity that takes on elements of a ‘colonizing’ outlook, but also works to constitute those who are ‘colonized’. Other ways of phrasing this could be: the subject of science|the subject of non-science or the universalized subject as privileged social position|de-privileged social position. This chapter shall employ the postcolonial theory of Homi Bhabha and other theorists, to think about how the colonizer/colonized may be constituted together in science education texts - more specifically, how these texts work to discursively set limits concerning ‘who’ is legitimately on the ‘side of science’, who is not ‘scientific’, as well as who’s knowledges do not count. Postcolonialism is a historical and political term that is highly contested, and does not simply refer to postimperialism, but also (neo)colonial structures of power and networks of governance. One of the conclusions this chapter makes is that a radical reworking of a theoretical framework is needed before a substantial postcolonial critique can be launched on these textbooks. This framework must endeavor to move beyond the confines of a certain forms modern epistemology to trouble science’s taken-for-granted assumption and expose its propensity to, in Edward Said’s terms, create the other as object.

The emergence of modernity was co-extensive with the rise of imperial, colonial powers that endeavored to control almost every part of the Earth. The reduction in complex forms of life, biodiversity and social relationships are all outcomes of these powers. As shall be discussed later in this thesis, the expansion of this colonial power is part of what Hardt and Negri (2009) deem the controlling aspect of modernity – one at odds with its immanent power. In this chapter I suggest that the discourse of these biology texts works to constitute both a ‘colonized’ and ‘colonizer’ subjectivity – that is the discourse works to define how we can know something in science and thereby divides those who know and can make claims over others and those who cannot know. It may come as no surprise that official scientific discourses trivialize and delegitimize indigenous or “traditional/alternative” knowledges – those that do not fit within the purview of science. Evidence presented here for example will demonstrate how the discourses of these texts work to position those who take up ‘scientific’ viewpoints in terms of global north,
Eurocentric ("western") ways of thinking. Educators must consider the political and social effects of these discourses for students, but also what could they mean for the lives of people spread over the globe.

6.1 How I came to this Chapter – How it came to me

At the National Association for Science Teaching Conference (NARST) of 2012, I had the opportunity to present a paper on the “neoliberal subject of science education” alongside three critical scholars. While two presentations involved postcolonial considerations, senior, white scholars and the topic of neoliberalism dominated the subsequent conversation. This experience confirmed to me that even though topics like (post)colonialism, anti-racism, can be acknowledged, detailed discussions, that would inevitably force science educators to face colonial/postcolonial realities, seem much more difficult to broach amongst (white) critical science educators. I would say that the prime reason for this is that critical science educators are mostly white, European and heterosexual, and able bodied. This experience has underlined the need work towards a critical project which does not occlude questions of colonizing knowledges, white supremacy, or the systematic delegitimization of other ways of knowing (following those who have already begun this work, see Carter, 2011; Aikenhead, 2001). While I endeavor to subvert colonizing discourses in this chapter by promoting spaces to challenge and rework subjectivities, I will also undoubtedly work to reproduce colonial discourses and their effects - but I take Gayatri Spivak’s (1988) criticism of Foucault seriously: *it is not enough just to insist that the subaltern must speak for themselves!*

6.2 Constituting the Colonized/Colonizer

Describing how secondary school biology textbooks work to constitute a certain kind of colonial subjectivity begins with a reminder that the colonizing/colonizer subject labels are only *abstractions* by which we can imagine normalizing and dividing practices in relation to eurocentrism, western hegemony, white supremacy, and the delegitimization (destruction) of local knowledges. As I attempt to frame the work in this chapter within postcolonial theory I first
would like to stress the importance of examining colonial discourses. As Edward Said\textsuperscript{13} (1978) famously declares in/about *Orientalism*,

My contention is that without examining Orientalism as a discourse one cannot possibly understand the enormously systematic discipline by which European culture was able to manage – even produce- the Orient politically, sociologically, militarily, ideologically, scientifically, and imaginatively during the post-Enlightenment era (p. 3).

Edward Said has become a starting point for much postcolonial work, and his positive and negative relations to Michel Foucault form a necessary side conversation for those looking to make use of Foucault’s theory. Said makes the highly relevant point that colonial discourses, like many oppressive discourses related to science, involve a kind of radical realism. Said explains:

Philosophically, then, the kind of language, thought and vision I have been calling orientalism very generally is a form of radical realism; anyone employing orientalism, which is the habit for dealing with questions, objects, qualities and regions deemed Oriental, will designate, name, point to fix, what he is talking or thinking about with a word or phrase (p. 72).

This provides science educators with an interesting starting point for dealing with discourses of “other”/Self, the global south, colonialism, and indigenous knowledges. When discourses designate, name, and fix, the objects, knowledges and practices of the colonialized a radical realism is employed and at play. Said’s realism bears a resemblance to the very definition of evil described by philosopher Alain Badiou (2005), that is *the will to name at any price*. Unlike the other chapters of this thesis I intend not to highlight a survey of empirical data from these texts, in the form of a table, but to focus on examples that need explication. A reliance of “tabled” data ends up, I have found, tying the study to categorizations and quantifications.

In the last chapter I tried to demonstrate that sex/gender and sexuality is conflated with race/racialization through images found in these texts. Though this thesis has tried to (artificially) separate different aspects of subjectivity, it is becoming clearer to me through the course of this thesis that single “abstract categories” of subjectivity, ex. a subject of sexuality, cannot suffice to

\textsuperscript{13} I recognize that Said distanced himself from Foucault’s work later in his career, namely the notion of discourse, claiming it was a vacuous, limiting and masochistic. Nichols (2010) maintains that this misunderstanding is due to the lack of attention given to his later work - which Said never seems to cite or remark upon. Bhabha (1994) also criticizes some of Said’s more simplistic conceptions of discourse.
remain isolated categories of how subjectivity is constituted through discourses of (science) education. The dual nature of a colonized/colonizer subject constituted through discourse follows the same ‘move’ I take in the previous chapters but exposes a double-working of discourse or what Nancy Fraser (2005) calls differentiated subjectification. Multiple subjectivities are constituted in an almost de facto way, which we can see when discourses of heterosexuality also constitute queer sexualities as Foucault shows in the History of Sexuality Vol 1. However sometimes it is more subtle, for example, the constitution of the ethically and “scientifically” responsible individual also works to constitute those who are not. That is to say, for any discourse there are simultaneous effects (subjectifications) that are wide ranging, sometimes conflicting. For example, Fraser (2005) discusses how societies of control (Deleuze, 1992) constitute both the entrepreneurial self-governing subject along with the marginalized subaltern who must continue to sell their surplus labour. All of this is to say that discourses of science education may work to constitute, in a similarly differentiated way, both the colonizer, as scientist, science student, who gains freedom in becoming the subject of science (e.g. white, male, and heterosexual), as well as the colonized student of science – those who cannot see themselves within the operative positions of science and science education where they can function as subjects of science. In terms of science education this means that subjectification processes constitute those who are either forced to “flee” science or undergo processes of subjectification so they are able to engage in science (ironically, often believing they are freely researching). In this way the discourses of science education may succeed constituting science students and teachers along both colonizing/colonizer lines.

This chapter is consistent with the goals of this thesis in that in attempts to do two basic things. First to be an examination of how discourses of these biology textbooks work to constitute colonizer/colonized subjectivities; and second, to engage some of the needed theoretical considerations for postcolonial examinations in science education.

6.3 Engaging Postcolonial Theory

I want to start this section with a couple of points from Gayatri Spivak. First that the knowledges of non-Europeans are often only given importance only insofar as they follow western scripts. In science education the valuing of non-western medicine for example is mostly
valued or respected in ways that can be described in the language of “western science” is an example of this basic point. Part of the project of the colonizer, to Spivak (1988), is not simply to label the colonized as “other”, but to destroy the subjectivity of the other. As Spivak stresses, “the education of colonial subjects compliments their production in law”. This formulation fits quite well with how John Fiske (1998) elaborates Althusser’s work concerning the production of subjects through Ideological state apparatuses in that, “the education system cannot tell a different story than the law” (p. 307).

Taking a basic postcolonial approach can include placing a kind of “colonial grid” of exploitation onto science education. Subjectivities constituted through science education must recognize the heterogeneous colonizer/colonized nature of modern science – where the formation of modern (scientific) subjectivities is always already co-extensive with the colonial project of modernity (Hardt and Negri, 2009). In terms of the role of theory Homi Bhabha (1994) asks “what the function of a committed theoretical perspective might be once the cultural and historical hybridity of the postcolonial world is taken as the paradigmatic place of departure” (p. 21). That is, once we grant the hybridity of colonized/colonizer subjectivities (which includes people who have been constituted “mostly” as colonizer subjects - white, middle-class, able-bodied, male-performative how do we then think about how this hybrid subjectivity is constituted through science (education)? Hardt and Negri (2000) are very critical of Bhabha’s notions of hybridity stating plainly that the proliferation of difference is one of the substrates for the new empire. However, through his postcolonial theorizing Bhabha’s notions of hybrid subjects, in my opinion, becomes a situation/theoretical point that can no longer be ignored. Indeed this has become one of the realizations through my work with subjectivity even while trying to keep an analysis of different kinds of subjectifications separate! What we need to recognize are the third spaces – but as Richardson Bruna (2009) argues, in her analysis of how science education can “proletarianize” students, not in an uncritical way! As Hardt and Negri (2000) point out, achieving hybridity in an uncritical sense (for them a global capitalist sense) may be what the colonizers (the elite) want anyway! Furthermore, educators must be careful not to reduce Bhabha’s hybrid notion of colonizer/colonized to a binary (though it is admittedly done here as an analytical abstraction), as this misses both the complexity of what is happening and also possibilities for change and transformation (Shumar, 2010). Indeed the reason for keeping such binaries (colonized/colonizer) tacitly in place is that these are the basis of current forms of
global wealth as well as hegemonic organization. However, Bhabha advocates locating both the colonizer and colonized in discursive practices and stresses the need to consider both the “colonized” and “colonizer” subject together; “it is difficult to conceive of the process of subjectification as a placing within Orientalist or colonial discourse for the dominated subject without the dominant being strategically placed within it too”. (p. 72)

What seems particularly attractive about Bhabha’s (1994) position is his defense of the place of theory and textual/discursive forms of resistance alongside taking “visceral and material” actions to oppressive conditions. He puts it this way:

It is a sign of political maturity to accept that there are many forms of political writing whose different effects are obscured when they are divided between ‘theoretical’ and the ‘activity. It is not as if the leaflet involved in the organization of a strike is short on theory, while a speculative article on the theory of ideology ought to have more practical examples or applications. They are both forms of discourse and to that extent they produce rather than reflect their objects of reference… The latter does not justify the former nor does it necessarily precede it. It exists side by side with it – the one as an enabling part of the other (p. 21).

For Bhabha activism or action must respect writing as a productive matrix, which defines the social, and makes it a resource for action. Politically this means that:

A knowledge can only become political through an agnostic process: dissensus, alterity and otherness are discursive conditions for the circulation and recognition of a politicized subject and a public truth. The language of critique opens up new spaces for hybridity and overcoming traditional oppositions, in this case. Writing and critique disrupts our own system of referents and reminds us that they are not “primordial” or natural.

Bhabha further stresses that social movements need to be theorized because no one group of people have some radical historicity or emit the ‘right’ signs. Thinking about colonization involves continually ‘turning it over’ theoretically.

Developing an approach to colonizer/colonized subjectivities is a necessarily incomplete, unfinished project. Following Frantz Fanon (2008) and Foucault we should be careful about reification of the historic, material, and economic exploitation and social oppression of (neo)colonialisms. That is to say, locating the colonial project in mere material relations while ignoring the symbolic or psychic dimensions and effects, or accepting one interpretation of what
(neo)colonialism entails, is to lose fertile space by which to reconceptualize colonialism. Following Fanon, Bhabha warns against historicizing colonial experiments:

There is no master narrative or realist perspective that provides a background of social or historical facts against which emerge the problems of the individual or collective psyche. In short the colonized or colonial subject must always remain in question, articulated through fantastic images and representations (p. 42).

In this vein, and much like Foucault, Homi Bhabha (1994) advocates for a suspension of final judgment on the power exercised through colonial discourses but rather to trace a network whereby “truths” become part of a colonial regime. Part of this regime involves desire and the intersection between the racial and the sexual. He maintains that, “In order to understand the productivity of colonial power it is crucial to construct its regime of truth, not to subject its representations to a normalizing judgment” (p. 67). Race and sex/gender and sexuality here become linked in the constitution of a colonial subject and the exercise of power in colonial discourse. The construction of the colonial subject in discourse, and the exercise of colonial power through discourse, demands an articulation of forms of difference – racial and sexual.

Concerning the discursive statements found in biology textbooks, there is then a need for examining closely processes of subjectification when reading colonial discourse through science education curriculum materials. Bhabha (1994) calls for such an interrogation explicitly in lieu of stereotypical discourses in terms of the processes of subjectification they enable. He highlights the stereotype as a discursive device that at once fixes the colonial subject, along a racial-sexual dimension, and “connotes rigidity”, disorder and degeneracy, and one that must continually be repeated (remembering again that repetition according to Althusser and Butler is key to processes of subjectification). Psychoanalytic aspects aside, Bhabha agrees along the lines of Butler and Althusser that repetition is integrally involved in the constitution of postcolonial subjections. To him, these stories, in various forms, “must be told (compulsively) again and a fresh, and differently gratifying and terrifying each time.” (p. 77). Furthermore, knowing “the native” in stereotypical forms makes colonial rule appropriate, the colonized population is then both the cause and the effect of the system. As Fanon (2008) states, “There is on one hand a culture in which qualities of dynamism, of growth, of depth can be recognized. As against this, [in colonial cultures] we find characteristics, curiosities, things, never a structure” (p. 35).

However for Bhabha it is more than looking past the binaries and into hybridity – subjects must look into “the interstices” of identity to find new ways of being. A focus on
interstitial existence would allow subjects to both exist in relation to and in spite of those discourses, practices, and material conditions that constitute them. More importantly hybridity may be a more fitting basis for analysis in a world where we are now constituted by networks of social relations and capital – rather than just the twentieth century institutions of the “Fordist” era (factory, school, hospital, state ministry, etc.). These broad postcolonial considerations are intended to open up questions and not provide some definitive perspective on colonialism and science education. (Neo)colonialism in science education is a visible and ongoing phenomenon and therefore calls on (science) educators to address these discourses in different ways.

6.4 Postcolonial Work and Science Education

I think it is important to recognize some research in science education that has already cleared space for postcolonial analysis in terms of discourse and subjectivity. Elizabeth McKinley (2008) engages post-structural subjectivity from the perspective of the multiple subjectivities of Maori women in science. She criticizes poststructuralist notions of the subject as being somewhat inadequate for dealing with the subjectivities of those who have been colonized as these approaches attempt to displace a “taken-for-granted” rational subject and there-in take for granted that a displaced “new” (a reworked subjectivity) is possible (McKinley, 2008). Such a view of subjectivity potentially, “sits uncomfortably with indigenous peoples because of the rupture and violation that has already occurred through the globalizing process of colonization” (p. 960). She makes the vital point that “fragmented” subjectivities do not mean the same thing for different peoples – especially in the spaces of science (education) – which in the past “intervened at the level of subjectivity” and made people of colour the objects of knowledge (p. 961). McKinley maintains that hybrid subjectivities of Maori women in science can play different strategic roles at various moments in spaces of science. In asking after how subjectivities have been constituted do we take for granted that, at one point, we were some coherent whole? And is this experience the same for everyone? What about “a subject that has never experienced such a coherency (p. 965)? McKinley asks the important question of what it means to be a hybrid carrier (subject) in terms of race, sex/gender and language in science education. Gloria Anzaldua’s (1999) work in Borderlands/La Frontera showed how subjectivities can arise on the border in terms of both language and national(ized) cultures. She stresses the
need to allow for multiple subjectivities and their subsequent engagement with the multiple subjectivities of others. I think it useful to consider Bhabha’s use of an “unhomely” presence, which can be experienced on “both” sides of a colonized/colony subject’s reality. Existing within the world of the colonizer, the colonized never quite feels at home – though they may love and have only known that home! Simultaneously, the world of the colonized can never be the same after colonization and therefore becomes unhomely. This idea of the unhomely can be a backdrop for critical science educators to ask: How might a student feel *unhome* in and amongst the discourses and worlds of science and science education?

### 6.4.1 Postcolonial Work and Foucault

My project with science education texts takes a Foucauldian notion of subjectivity and the constitution of subjects discursively as a point of departure, and in light of this I think it worthwhile to discuss Foucault’s possible relations to postcolonial work. Foucault’s work is useful as it attempts to attack natural and static formulations of knowledge and recast them as contingent and localized. As Nichols (2010) states of discourse analysis related to colonial discourses:

> For Said, and much of ‘Colonial Discourse Analysis’ to follow from him, Foucault thus represents a major conceptual and methodological innovation that allows one to study colonialism through the repetition of a set of linguistic and textual referents that draw their effective force from the authority of the system of textual representation itself rather than the actuality it purportedly describes (p. 120).

Nichols makes the key point that Foucault has even become a *discourse in itself*. One can be “for” or “against” Foucault, however one must try and differentiate if one is for or against Foucault as Said, Bhabha, Spivak, and other postcolonial theorists use him, or his texts. It was interesting for me to approach postcolonial aspects of these biology textbooks having already affirmed Foucault’s work in this thesis. I do not feel as beholden to critiques of Foucault’s work, however already accepting a Foucauldian approach to these texts constrains me as I am not able to fully “follow” many critiques of Foucault found in postcolonial studies - for example, Spivak’s (1988) criticism that Foucault and Deleuze do not do enough to speak against colonialism and are content to let the subaltern ‘speak for herself’.

not deal with colonial subjects directly by having the reader imagine biopolitics, the development of science, notions of race and sexuality within a colonial frame. Stoler is useful in relating race thinking and colonialism to the logic of the biopolitical state, whereby discourses of race were also counter-discourses to a particular formulation of sovereignty and used to secure power. As Stoler points out, for Foucault racism is an incessant social war driven by the biopolitical technologies of purification. Racism is internal to the biopolitical state, rather than just something that happens in the colonies; as Foucault states “racism is revolutionary discourse put in reverse”, as the same techniques and juridical weapons transported to the colonies were also used in the “occident” after the seventeenth century. Colonialism makes it possible to solve the problem of the transition of the disciplinary to a regulatory society. In the regulatory society the right to kill is at odds with the goal of fostering life. This does not mean the right to kill is dispensed with (indeed it still serves a disciplinary function in the biopolitical state), and therefore racism becomes a discourse to decide who must die. Furthermore, racism serves a political function as it not only decides “who” must die, but “establishes a positive relation between the right to kill and the assurance of life” (p. 84). That is, if particular (subaltern) people die, the more you (privileged subjects) live. Again, racism becomes a way for the biopolitical state to retain its disciplinary power while fostering the life of the population. In this way it may be useful to consider how certain indigenous knowledges are also ‘being killed’. It seems likely that scientific knowledge, besides being a conveyer of racist colonial discourses, might be also, in some ways, be the epistemological and ontological manifestations of the “right to kill”.

Encountering Stoler’s work helps bring postcolonial realities, racism, as well as struggles in identity politics closer to a notion of biopolitics (Hardt and Negri, 2009).

In order to consider how the discourses of these textbooks could work to constitute a colonizer/colonized subjectivity the textbooks were perused in a similar way as in other parts of this study. However, in both preceding content chapters results were collected systematically, with the ethics chapter in themes and with the sex/gender and sexuality in a collection of discursive instances. Here I want to limit the discussion to a focus of four discursive selections. The intent then is not to catalogue a neo-colonial theme throughout each text, but to bring to the surface its potential presence in various forms. My goal here is to intentionally de-emphasize the need for “frequencies” of statements and instead discuss four examples. The background drop to
all of these examples remains the basic question related to subjectivity: How does the discourse of these biology textbooks limit the possibilities for thought and action?

The following sections deal with three sub-topics from the four textbooks under study: Nutriceuticals/Functional Foods; The discourse on Human Populations; and Rainforests and the Global South. The goal here is to try and place a kind of ‘postcolonial grid’ on these texts by looking at how they can work constitute someone who thinks scientifically at the expense of an ‘other’ who does/can not. These examples are meant to be read dialogically, and are intended to open up a discussion of how textbook discourses may work to constitute colonizer/colonized subjectivities.

6.5 Nutriceuticals/Functional Foods

The first example involves “nutriceuticals” and “functional foods”. These terms are used to describe a wide range of typical food stuffs (tea, juice, fruit drinks, herbal supplements) that are said to have medicinal benefits, often in the prevention or treatment of a chronic condition or disease (see figure 6.1).

![Table 1 Common Functional Foods](image)

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product name</th>
<th>Nutriceutical Ingredient(s)</th>
<th>Claimed health benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple &amp; Eve “Tribal Tonics”</td>
<td>Energy Elixir</td>
<td>guarana-seed extract, ginseng</td>
<td>enhances energy, stamina, and endurance</td>
</tr>
<tr>
<td>Arizona “Rx Elixirs”</td>
<td>Rx Stress</td>
<td>kava kava</td>
<td>relieves stress</td>
</tr>
<tr>
<td>Fresh Samantha “Body Zoomers”</td>
<td>Super Juice (beverage)</td>
<td>echinacea</td>
<td>keeps colds at bay</td>
</tr>
<tr>
<td>Golden Temple Cereals</td>
<td>Mango Passion Crisp</td>
<td>St. John’s wort, kava kava</td>
<td>supports emotional and mental balance</td>
</tr>
<tr>
<td>Hansen’s Beverage Co. “Healthy Start”</td>
<td>Immune-ox Juice</td>
<td>echinacea</td>
<td>stimulates the body's production of interferon, a cell-protecting protein</td>
</tr>
<tr>
<td>Odwalla</td>
<td>Femme Vitale</td>
<td>vitex, nettles, dong quai</td>
<td>strongly supports women's cyclical nutritional needs</td>
</tr>
<tr>
<td>Snapple</td>
<td>Earth</td>
<td>grape-seed extract, ginseng</td>
<td>helps provide your body with the balance it needs</td>
</tr>
</tbody>
</table>

Figure 6.1. Skepticism for “Functional Foods”, but what else is assumed?

In this example (see also Appendix C) the discourse on nutriceuticals is openly antagonistic towards knowledges that do not fit within the purview of western scientific knowledge. However
globally, many human societies rely on these foods and medicines in empirically based ways, and have done so for centuries. The above example (table 6.1 and appendix C) come from Nelson Biology 11 College Prep (DiGiuseppe, 2004, p. 40-42), and a smaller version of this section can be found on p. 51 of Nelson Biology 12 with very similar arguments. To introduce functional foods and nutriceuticals the text starts out by stating that a pharmacy counter and a delicatessen counter have little in common but that researchers in the food industry have begun to “claim” health benefits beyond the nutritional value of food. The text specifically states:

The delicatessen counter in a grocery store and the prescription counter in a drug store have little in common. One provides food, the other medicines. Lately, however, researchers in the food and beverage industry have begun to develop new products that claim to provide health benefits beyond the nutrition value of food (DiGiuseppe, 2004, p. 40).

Already the text has begun to set up a normative frame for thinking about nutrition, prescription drugs, and functional foods/nutriceuticals. A binary is drawn between the functions of medicine and food before introducing functional foods, “Lately, however … researchers have claimed that their products can provide health benefits beyond the nutritional value of food” (p 40). Notice how a definitive, unproblematic statement about the role of food is made and then a statement disrupting this role is stated using the word “claim” (claim being a statement that is not fact – unlike the clear separation set up in the first emergence of medicine and food) and “beyond”, (beyond meaning both in addition to and also outside of the scope of something). What is most salient in this text is that the reader is told already (before a discussion or debates that follow in the text) that the claims of functional foods are “beyond” the scope of food and that medicine is something else altogether. The text defines nutriceuticals “as foods that claim to prevent or control disease and improve physical and mental performance”. However the text does not give “extra” space for nutriceuticals to be something ‘other’ than food and medicine, just foods that “claim” to do the job of medicine. While there is often no experimental evidence for “claims” of some nutriceuticals and functional foods it is notable that the textbook lumps all of these holistic medicinal substances together – there is a massive difference, for example, between the ginseng and Snapple ™. Here, we can see that anything that does not fit within the totality of science education, both herbal medicine and fruit drink, becomes delegitimized. The point here is this essential opposition - an opposition that is made more visible by the simultaneous questioning of
corporate motives (in this example we can see a mistrust of corporate motives and the role of science to mediate the claims of large companies).

Looking at the table in Figure 1 we see a range of functional foods/nutriceuticals with a wide range of ingredients. Many of these ingredients are also found in traditional medicines and some widely accepted in medical circles, for example St. John’s wort. However, the text takes a definitive stand on these nutriceuticals when it claims: “In many cases the health claims made on the packages of functional foods may be exaggerated and confusing to the consumer” (p. 41). The text also gives the example of green tea’s cancer prevention properties as having no basis in current research trials and seeks the warrant for its claim in legally defending consumers: “While there is no legal definition for the term functional food or nutriceutical, laws are in place to protect consumers.” Here is another instance, as in the ethical situations in chapter 4, where there is an alliance between government (Ministry of health) and the “scientific” view of the text – which reads something like: consumers need protection from these foods and medicines (which include traditional medicines) that are not sanctioned by the practices and knowledges already legitimated science.

6.5.1 Going Further into Ideology

The ideological\textsuperscript{14} character of the text’s stance can be seen when the text claims that “if functional foods live up to their claims, there is growing concern that consumers could get too much of a good thing” (p. 41). Not only are we not informed about who is concerned, an authoritative group kept secret in the “objective” text, but we see that even if the foods “work”, they will automatically be declared “too much of a good thing”. Part of the ideology in this biology education discourse is that nutriceuticals and functional foods are dubious and should be avoided – even if they work. For example, in the text’s treatment of Ginkgo biloba it ironically claims that the substance can act as a blood-thinning agent, and then goes on to state that people who are already taking blood-thinning drugs may be at risk, exposing a predisposed approval of pharmaceuticals over natural medicine. The text reads:

\textsuperscript{14} Ideological in the sense that now that the text has created a socially constructed fabric of reality for students which is adhered to in many instances of the text (even, as we shall see, when contradictory). I think the use of the term ideology here is specific for this discourse as we can see its contours specifically in the course of two pages of text!
Nutriceutical producers would like to adorn their labels with health claims, but dieticians worry that consumption of these products might actually aggravate certain health problems. For example, *Ginkgo biloba* contains ingredients that may act as blood-thinning agents. People who are presently taking blood-thinning drugs, such as aspirin, to control a heart condition could experience additional heart problems if their blood becomes too thin after taking *Ginkgo*. Taking aspirin and *Ginkgo* at the same time could lead to increased bleeding – there have been reports of bleeding behind the eye or bleeding in the brain in patients who take both a blood-thinning drug and *Ginkgo biloba* (p. 41).

These statements are particular alarming as the discourse openly contradicts itself in that the texts focus on side affects reveals a double standard. What is not mentioned (and interestingly not noticed by me on an initial reading) is that there are *a plethora of side effects caused by pharmaceutical drugs*!

The effects of such an ideology, this vitriolic stance towards ‘nutriceuticals’, functional foods and traditional medicines, may not tell us anything of great importance on its own, instead, as Foucault (1972) states, we should look to the effects. In this case, the text associates a scientific approach and governmental legitimacy alongside *one* orientation to medicine. That is to say the discourse works to constrain and set limits on thought and action concerning how students and teachers can engage both food and medical treatment. While I appreciate the text’s questioning of industry and corporate interests, this example allows us to see how discourses of science education frame other knowledges that cannot be subsumed into the language of science: ideologically “other”. In the final exercise to this section (Figure 2.) the text depicts the promoters of functional foods as being against scientific testing and regulation as this would make the foods too expensive for people who need or want them. The consumers and producers of nutriceuticals are positioned against science thereby designating ‘who’ can be scientific and ‘who’ cannot.
Fig. 6.2. How does the debate on Functional Foods set limits on how science approaches this issue?

We have the conflation of those who would support nutraceuticals for their own merit with those who think the testing would make these products too expensive – thereby “sacrificing” health concerns. In this way, the discourse sets up an easy choice for students “Stay scientific and move away from the promotion of alternative/complimentary medicine” or “sacrifice health and remain on the ‘side’ of advertising and unsubstantiated claims about health”. McGraw Hill Biology 11 (p. 165, 206) also downplays natural medicine/nutraceuticals in comparison to pharmaceuticals and calls for more research and caution around these therapies.

There are two important points I want to make here before moving on. First, in this example we can see the way authoritative (biological and educational) discourses can work to constitute specific courses of thought and action – a subjectivity. To move onward in a scientific way - to engage in discussion in a scientific way in the example - one is led to take a stance against nutraceuticals and functional foods. A subject then finds her “scientific” identity, or the grounds by which to make further choices in the spaces of science in this particular stance. We can see that to act and think in “scientific ways” we must always already first adopt particular views in relation to the objects we study. In Nelson Biology 11 College Prep we have a science
education discourse that can be seen to align itself with a colonizer mentality - seeking to destroy that which it cannot assimilate, ‘traditional’ practices/knowledge of medicine.

However, those students who are already imbedded in cultures that value these approaches to medicine and nutrition (e.g. aboriginal, particular Chinese communities) perhaps go through a somewhat different process of subjectification than those in more “Eurocentric” cultures. How does this discourse also interpellate students who already use, for example, herbal medicines? The discourse positions the local and indigenous knowledges of other cultures as not “measuring up” or being “outside” of science, thus reaffirming the superiority of Eurocentric culture and western science. This represents a simple, but traceable example of differentiated subjection along colonizer/colonized lines, highlighting Bhabha’s point that one cannot constitute the colonized without the constituting the colonizer.

I think it is worth mentioning that this vitriolic stance towards alternative medicine may be symptomatic of a situation that goes beyond epistemic blindness or discrimination of all that does not fit within the purview of science. That is to say, a discourse that delimits the side of science may also be seen as a strategy of what Foucault outline’s roughly as biopower, in this case employed through the state, whereby individuals are brought into a particular regime of population health, managed through partnerships with pharmaceutical sciences and modern global capitalist structures, institutions of scientific research, and educational institutions that support them. The suppression or positioning of alternative health can be seen as entwined in the exercising of biopower. However, this discourse’s opposition to both alternative forms of medicine (those that do not fit within the purview of science) and corporate interests attempting to capitalize of these products demonstrates the messy complexity of science’s entanglement with capitalism and ‘colonialisms’ and disallows us from making easy blanket statements about the discourses science.¹ For example, is it not the case that multinational companies are also exploiting the knowledge and labour of indigenous societies in their quest for a profit margin? The simultaneous anti-corporate–anti-indigenous knowledge stance is something to be engaged with and teased apart rather than rejected altogether. For me, a key question from this example remains, how is scientific ‘proof’ tied to political comments of governmental, scientific, medicinal, pharmaceutical, epistemic importance?
6.6 The Discourse on Human Populations

During my time in school biology (from grade 11, through teaching, and into graduate school) I have noticed that substantial sections on human biology are often included in biology textbooks. NB12 and MHB12 have such sections under the heading of Human populations. Both chapters proceed with a progress-oriented narrative where hunter-gatherer societies develop steadily toward large industrial societies. Such a narrative often piggybacks on quasi-evolutionary views of Homo sapiens, equating hunter-gatherer societies with less evolved forms. In NB12 we have an example of this in the second page of the unit, which states, “The geographic distribution of suitable wild plants and animals largely determined the regions in which agriculture would arise and where human societies would follow” (p. 700). Although the statement might seem banal at first glance, here we can look to the surface of the text and take its literal meaning: In societies where there is no agriculture there is no human society. There is no “soft” reading here. At the very least we can see that societies that live as hunter-gatherer groups are occluded from the definition of “society”.

What is also alarming from a postcolonial perspective is the unproblematic adoption of the general argument of Jared Diamond’s (1999) Guns, Germs, and Steel. This popular book maintains that global power and human development varied around the globe due to the veritable distribution of plant and animal species capable of being domesticated. This argument is a reasonable addition to biological anthropology, however the dangers of a “strong” view of Diamond’s thesis is that it explains the domination of some parts of the world by others as a natural outcome of “geobiological” destiny. While there is no extensive explanation of this kind in any of the textbooks, it is noteworthy that significant elements of the thesis are present, for example how the text compares one views hunter-gatherer society compared to others (modern industrial). The clear hierarchal implications can be seen in this summary statement: “Thus, the geographic distribution of suitable plant and animal species largely determined which human populations had the opportunity to switch to an agricultural lifestyle” (p. 701). Again, the statement may seem banal at first glance, but we can see the language of inevitability with the use of the word “opportunity”, which indicates a direct value judgment about societies. This is confirmed on the next page in summary format:

Not surprisingly those human populations that experienced rapid growth based on large agricultural food surpluses began to spread out across the globe. In most cases they
brought their domesticated plants and animals and their technological innovations with them. A striking example of this was seen in North America where wheat, barely, and other crops, as well as cattle and pigs, arrived from Europe and became the dominant food sources for future generations. Often this was not to the benefit of indigenous human populations, which were often displaced, or worse, by the invaders who brought not only assorted plants and animals, but also guns, steel, and germs (p. 702).

The colonization of North America is not a simple phenomenon of the “spread” of human populations across the globe. Such biological determinism masks the historical, political, and historical context surrounding colonization of North America.

A differentiated constitution of subjectivity in terms of colonized/colonizer has also to do with establishing a relationship between two. Here, colonizers (white, European settlers) are given a kind of “natural mandate”, for the resettling of North America; and those that would be the “colonized” find also a “natural justification” for their domination. The most pressing concern of the above quotation is that the colonization of North America, in terms of cultural obliteration and land appropriation is rendered acceptable through statement of fact and inoculating phrase that settlers also brought “guns, steel, and germs” (p. 702). While the chapter on human populations is a useful part of these textbooks, the above examples, just to name a few give it a distinctly (neo)colonial orientation.

6.7 Rain Forests

The text in Figure 6.3 is of concern in the way it depicts global south versus the global north. Or to put it another way, “science” versus “other”.
Here we have a situation where the reader is automatically assumed to be a global northerner, which can be seen in the following ways. The first sentence of the text sets up an unambiguous situation whereby destruction, extinctions are real threats and scientists are associated with “concerned” citizens, protecting the social and economic interests through the preservation of tropical rainforests and slowing global warming. The use of, “Others disagree” works to literally set up a group of people that are “other” to science, concerned citizenship and social/economic wellbeing. These people are said to consider environmental concerns such as flooding, soil erosion, and deforestation as non-serious - I wonder who “these people” could possibly be? The text declares that “For some…” the incentive to clear land for agriculture and industrialization is concomitant with the right of developing countries to self-determine, and intervention by developed countries is seen as an infringement. **The discourse in this example sets up not only two positions, but also two peoples.** The first are ‘concerned citizens’, scientists, and environmentalists (holders of expertise). They are motivated by social interests to avoid destruction, extinctions and environmental threats. The second, “some”, are motivated by the “incentives” of industrialization and agriculture. They are not said to be motivated by the
concerns of the above group, do not see environmental problems as serious, and view the “scientific and environmental” concerns of outsiders as an infringement - read: they are not thinking rationally, but selfishly and defensively. Thus we have the establishment of two peoples – the global “rational”, “concerned” north and the “incentive”, “selfish”, “unconcerned” people of the global south.

The effects of establishing two such “peoples” in biological, educational discourse can be wide ranging and unpredictable. To take up the “side of science” requires that one care about social and economic wellbeing as well as environmental threats, but also that one be a ‘concerned citizen’ not influenced by “incentives” of industrialization. Indeed one group is forward thinking – almost “from the future” – while the other is stuck in the past, not having the gift of foresight. Here, an ideological analysis that traces this social fabric and its contradictions would be useful: is it not almost uncanny that the global north would not be seen as being motivated by incentives and industrialization?

More importantly, we can call such a discursive formulation a “micro-practice” of subjectification in that students must adopt a certain position to be considered scientific (and conscientious). Nuances between and outside of these positions abound, and this is where resistance to such a dichotomous and “global north” positioning of science can be of use. Students and teachers may very well ask the practical question; how can we take up social, economic, and environmental concerns in a way that does not characterize the thinking or attitudes of those who live in the global south in oppressive (selfish, unscientific) ways?

6.8 Re-enforcement of colonial discourse in Biology Texts

Like discourses of sex/gender and sexuality colonial discourses re-enforce themselves regularly throughout the text. I would like to highlight examples of how a colonial discourse can manifest in a constellation of tiny points. For example, in a discussion of disease such as the one on p. 141 of NB11CP, which describes people from poorer countries of the global south as “carriers” (p.95) of disease. Interesting that the global south is often portrayed as the fear over population growth, while factors are listed there is often an implicit moral decision that is implied (NBC11, p. 410). Another example is that Latin and Greek languages are not only
described as providing a common language for all scientists, but also as having a distinct advantage over other languages (p. 98, 101). While NBCP11 asks students to consider treatments for diseases not based on Western medical tradition, it does so only in terms of their effectiveness, cost and “why they may work” - the same questions are not asked of western medicines – they are assumed to work without question. Overtures are made to indigenous knowledges, but these are only done when these knowledges align with western science. While it represents a start, the basic assumption that indigenous knowledge is only useful when it can be incorporated into epistemological structures of western science becomes very evident, for example in this description of Mayan Bush doctors found in NB12:

Among the most revered members of the Maya village are the bush doctors. Bush doctors have a vast knowledge of the medicinal uses of native plants. For example they use bark from the gumbolimbo tree to treat the severe chemical burns that result from accidental contact with sap from the poisonwood tree (p. 270).

However, this example leads the reader to believe that indigenous people only have some practical knowledge about their local system or isolated factoids. As Franz Fanon maintains – never a system or a structure. So for example, while horsetails are mentioned as being used in traditional Native medicine (p. 279), while important, we must ask if students perceive merely a scattered use of factoids compared with a “systemic” knowledge of science.

NB11CP may not be able to make many sweeping statements about humans without western, Eurocentric generalizations. For example on p. 355 it reads,

At one time, many people thought that humans had the right to be dominant over all other living things and over Earth itself. Although this way of thinking may have changed, in many ways human behavior has not. We use natural resources without regard for the fact that they are in limited supply; we pollute the very land, air, and water that we and other organisms have to live in; and we do this because we are either unable or unwilling to see and think beyond our own life span.

What is especially striking about this passage is the moralist tone and its desire for human consciousness raising whilst being Eurocentric, western, colonial. The seemingly monotheistic narrative attached to all human beings at the beginning neglects those human groups who never expressed or saw the need to be dominant over all the earth. Human behavior in terms of environmental destruction is not a universal phenomenon yet it is treated as such both in the past
and the future. Simple declarations of humanity such as this one *clearly define who is to be included within humanity and who is excluded*. The silence on indigenous knowledges has much greater “reinforcing” effect in the text than may be realized after the first reading. That is, by giving a specifically Eurocentric modern narrative to human beings, even in deriding them as unable and unwilling to change, it *sets the limits* on what it means to be a human being, *both in the past and in the present*. Humanity clearly does not include groups of people that have and still live in relative harmony with their natural surroundings. A similar example is the way NB11CP introduces ecology:

> Although ecology was not formally recognized as a science until the 1920’s people have been studying the environment forever. Early humans depended on their observations of the environment for their survival. Even in more recent times, the early inhabitants and settlers of Canada depended on their observations of nature for their livelihood and for their survival. Hunters, fishers, and farmers developed an understanding of the natural environment from their own observations. This understanding was not based on scientific research as we know it today, but was just as valid and important.

The text then goes on to talk about the scientific method and how we know what “we know”. Concerning the above text, the first statement simultaneously places importance on the observations of humans concerning their environment (it has been going on forever), however subsumes all of human observation under the teleological category of ecology (Here I am reminded of Spivak’s comment that colonized knowledges are only recognized when they fit into modern paradigms). The importance of non-western-scientific knowledges are acknowledged only in the past, in the term “early humans” and also in the term “early inhabitants and settlers of Canada” indicating that previous observations were uniform – which we know from a cursory glance at history that the detail of knowledge was clearly *not* equal as many European settlers died trying to survive. The final statement declares these knowledges as “just as important” in a historico-instrumental kind of way, but at the same time declares them unscientific, thereby demarking them as “other”. In summary, what we have in the statement is a subsuming of all knowledges until/into the discipline of ecology, thereby rendering this other knowledge as a thing of the past, not meeting the current standards of science.

In terms of choice then, there are clear alternatives: modern western science (the science of ecology) stands for knowledge in the present and any alternatives belong in the past or cannot be included in science today. Students of science have but one choice to be scientific according
to the text - to accept “other” knowledges about the world as belonging to the past or outside of science. To be scientific requires a categorical and an almost complete rejection of indigenous or “alternative” ways of knowing. The text goes on to define the epistemology and character of science in terms of decision making: “In order to make informed decisions we need valid and reliable information – scientific facts. Without this scientific information our decisions can be based only on personal opinion, beliefs, or emotions” (p. 361). Here we have the tight regulation of decision making (environmental) whereby decisions must be based on one type of knowledge system. Though the opinions of other stakeholders are recognized they are only required to be “considered”, and can therefore be subsequently rejected as selfish, unobjective statements (I have heard anecdotal reports of those who have worked with the ministry of the environment in Ontario. Here the government has field workers consult with community aboriginal leaders, but their concerns and knowledges are often seen as being inferior and sometimes held in contempt. The point of this chapter is to look past token language and see what exists on the surface in terms of what is actually being said (and done as well).

6.9 Challenging a Colonial Paradigm may be the Most Difficult

Amongst the five content chapters in this thesis this chapter’s attempt to isolate how the discourse in four biology textbooks can work to constitute a colonizer/colonized subjectivities is perhaps the only one where one chapter does not seem to be adequate space to deal with such a project. I think this is because the scope of the analysis needs to shift in terms of basic epistemological assumptions. For example, unlike the next two chapters on neoliberal global capitalist subjectivity and the constitution of humans as capital, in the case of (neo)colonial discourses a radical repositioning of epistemological assumptions needs to occur simultaneously with a refocus on a new series of textual questions. Bhabha’s conception of ‘stereotype’ for example would allow for a different way to treat wide ranging aspects of the text of colonial subjects in the text. The following text example (figure 6.4) demonstrates what I mean.
Figure 6.4. A series of questions in NB12 (DiGiuseppe, 2003, p. 564) that brings up the African sickle cell example as a biological phenomenon.

In figure 6.4 we can see that question 8, brings up the sickle-cell allele phenomena. As a former student of biology, a biology teacher, and now a researcher in science education what I find highly conspicuous yet seemingly impossible to engage with here is the recurrence of African populations as research objects unlike “other” populations such as European ones. I have read enough textbooks at the secondary school and undergraduate level to recognize this discourse, yet I have not cleared the proper space to be able to theoretically and empirically deal with this
discourse (for instance There are other parts of the discourse such as a general discourse of fear regarding “outsiders”. For example in McGraw Hill Biology 11 there is a provocative description of loosestrife as an invader species (p. 594)). In the example of figure 3, all instances of groupings of peoples would have to be analyzed systematically to see if different treatment is given to particular populations, within specific contexts. Again, I think grouping these under the Bhabha’s notion of “stereotype” would be most productive. For example, David Stinson (2010) has used the notion of stereotype to attack the myth of the white male math student by opening up identity construction for students of colour; it is precisely this kind of reworking that can guide work in science education (where stereotypes often operate unnoticed due to science’s perceived universality). In the previous chapter a similar approach was taken where disproportionate “ratios” of “sex/gender” (binaric ones) were accounted for, however this technique of sorting images was rather limited due to the “ubiquity” of sex/gender in images and the end goal of such a tabulation (which ends up re-inscribing binaries). New categories of research would have to be devised, for example along the lines of desire and sex; that is, how is sexuality and desire a key element in the subjectification of students and educators as both the colonizer and the colonized?

6.10 A Way Forward: Towards a Postcolonial Ethics in Science Education

Besides continuing with micro-analyses of colonial discourses in science, a path forward in science education might consider a postcolonial ethics of self along the lines that Foucault (1986) suggests. David Scott (1999) argues that this can happen only if subjects consider how to best manipulate the productivity of power and considering how to fit themselves within games of truth. Scott asks the questions: what are the practices of self-formation in which the colonized/colonizer subject must engaged and how do these practices operate in relation to colonial/postcolonial power. Two basic modes of resistance to (neo)colonial subjectification may be: i) an ethics of self as outlined by Scott in postcolonial terms, ii) asking after the modes of subjectification by which subjectivity is constituted.

There are some science educators those who are looking for ways to change approaches to approaches deemed outside the scope of modern science (Carter; 2006; Carter, 2004). However as Kidman, Abrams, and McCrae (2011) caution against the superficial inclusion of
indigenous knowledge in science classrooms and warn that, “saying something in an indigenous language does not automatically mean that an indigenous world-view is being drawn upon, nor does it necessarily reflect indigenous knowledge or even something that is culturally relevant to the speaker” (p. 216). Kidman et al, are clear that the inclusion of indigenous knowledges, in their case Maori, may have less to do with indigenous priorities, but enhanced science education or curricular development. To offer a comprehensive analysis this work must consider what prevents local knowledges in science education from being deployed even by the very same groups that create this knowledge, that is what hinders the incorporation of indigenous knowledges into scientific practices, such as the patenting of plants and the prevention of agricultural practices by large multinational corporations (Regmi and Fleming, 2012).
Chapter 7: The Constitution of Neoliberal/global capitalist Subjectivity and Humans as Capital, Part One: A Subject in Line with Neoliberal/global capitalism?

In the first part of this final chapter I want to set the theoretical context for considerations of neoliberal global capitalist subjectivity in the broad terms of biopolitics. Following this, the next chapter considers science education, and the discourses found in its textbooks, as one entangled in both global orders of economic domination, what Hardt and Negri (2000) call ‘Empire,’ in the context of biopolitical struggle against biopower. However, for any change in the broad contexts of which science education is situated, such as its domination by capital, there must be accompanying microanalyses by which subjective attachments are constituted through apparatuses, which include discourses formal education.

7.1 Neoliberal/global capitalism as Discourse

The next two chapters combine a focus on political economy with the poststructuralist perspectives that give shape to this thesis. Viewing neoliberal/global capitalism as discourse allows us to include the broad economic perspectives that flow out of political economy with micro-practices, such as the constitution of subjectivities in science education. Simon Springer (2012) advocates for poststructuralist thinking, which involves an engagement with social and political discursive practices, to supplement Marxist views of macro-economic structures and imperatives. As Michael Peters (2001) notes, poststructuralism advocates going beyond the “telos” of any superstructure or view of history, adding a much needed dimension to Marxism or political economy in general.

To be sure, neoliberal global capitalism is a complex economic and social phenomenon that deserves specific consideration in the diverse contexts in which it manifests. In a general sense, neoliberal global capitalism embodies the idea that well being can best be advanced by freeing up entrepreneurial initiatives, private interests, and free markets (Harvey, 2005). It must also be said that neoliberalism can use regulation through various forms of government to meet
its strategic goals (McMurty, 1999). Neoliberalism as a political project also comprises a complex political process for re-arranging and re-structuring social relations for the unfettered demands of global capitalism (Bourdieu, 1998) — this linkage is the reason why I have grouped these two terms. As Wendy Brown (2005) maintains, it is the sociopolitical aspects of neoliberalism, deployed as governmentality, that reach and claim the soul of the citizen subject. As Brown says, “through discourse and policy promulgating its criteria, neoliberalism produces rational actors and imposes a market rationale for decision making in all spheres” (p. 40).

Through a governmentality that is applied to all aspects of life, neoliberal global capitalism produces a ‘free’ subject who makes choices between alternatives, and ultimately bears the responsibility for those choices (rather than responsibility falling to the state or some organization) — its specific rationality often presents itself as achieved and normative. As far as political interests and the neoliberal subject is concerned, Brown (2006) explains, “Neoliberal de-democratization produces a subject who may have no such interests, who may be more desirous of its own subjection and complicit in its subordination than any democratic subject could be said to be” (p. 702).

In education, we are seeing the effects of neoliberal global capitalist reforms, such as the insinuation of advertising in formerly ad-free zones, a significantly increased focus on standards and individualism, private funding options, as well as interschool competitions which ‘punish’ schools that don’t ‘perform’, as in the case of No Child Left Behind (NCLB) legislation and Race to the Top (RTTT) in the United States (Norris, 2011). More and more, the goals, structures, and cultures of schooling seem to be oriented to the needs of global capitalism rather than democratic engagement (McLaren, 2000). It is vital for science educators who wish to push back and problematize neoliberal global capitalism in educational settings to think about the discourses of science education, how they may operate and recruit all of us on a general level.

What has become a major topic for some is the role of neo-conservatism in the neoliberalism. I am undecided on the issue, however my particular view is that neoliberalism cannot only operate without neoconservatism (the union of which may be a particularly north American stance) but is of much larger concern. In addition (neo)conservatism in all its forms can often act as a counter discourse to market-based neoliberal global capitalism — whether one supports this discourse or not.
Ward and England (2007) define four areas of neoliberalism: i) Neoliberal/global capitalism as a system that circulates ideologies and images for the benefit of certain global classes; ii) Neoliberalism as a policy that shifts responsibility from public interests to private, corporate interests in the form of deregulation, depoliticization and the provision of choices; iii) Neoliberalism as national or multi-nation form of government whose purpose is to stay competitive by scaling back services yet simultaneously increasing government intervention in the production of competition; iv) Neoliberalism as governmentality, which has to do with the interpellation of subjects under the grid of *Homo economicus* to produce self-investing individuals. This analysis concerns all four of these aspects.

Springer (2012) echoes the approach taken in this thesis in terms of the constitution of neoliberal/global capitalist subjectivity and the possibilities of freedom:

Thus, the productive power of neoliberal/global capitalist ideology constitutes and constrains, but does not determine. Instead as a process of becoming through which one simultaneously obtains the constitution of a subjectivity (Foucault 1988) and undergoes subjection (Butler, 1997), neoliberal/global capitalist subjectivation works on individuals who are render as subjects and subjected to relations of power and discourse (Foucault, 1982).

Patti Lather (2012) claims that particular neoliberal global capitalist ways of thinking make us effectively ‘fish in water.’ She explains: “We cannot see how ideas that Foucault termed governmentality have been taken over by the logic of capital in the production of the subject-citizen as consumer of neoliberal/global capitalism” (p. 4). Looking at how subjectivity is constituted in discourses of science education then is vital to resisting neoliberal/global capitalist practices. Again, this research attends to what Rabinow and Rose (2006) call micropractices of subjection, that is at the level of science education we find the constitution of neoliberal subjectivity.

(Re)politicizing and (re)historicizing understandings of neoliberal global capitalism as a set of practices needs to include examining the rise of (economic) liberalism. Foucault’s historical work concerning the art and rationality of governing led to an examination of the specific rationality of liberalism in the context of emerging notions of the modern nation state and the role of government (Foucault & Senellart, 2008, p. 31). Foucault shows historically how the concerns of those who govern and the basis of their legitimacy change from the middle ages into
the twentieth century, to the point where market logic, and adherence to its rules and procedures, encompasses the key function of government. For Foucault, the government of a modern nation state is less concerned with, and gains less legitimacy from, how lawfully it behaves or how much freedom it gives its citizens (for they are not allowed to do anything they want!) but rather how well the market functions and how well the government concedes to the rules and functioning of a market economy—a mode of governing that accelerated after 1945. Foucault notes that, while today we associate the market with a ‘true’ price based on supply and demand, historically the market was also seen as the site of justice or just prices (Foucault & Senellart, 2008, p. 31). Plainly put, today the market becomes “a new domain of truth, a domain which provides new criteria by which to assess the rightness of government as well as a new model of the subject” (Dean, 2010, p. 8). In this way, liberalism (and its newer ‘neo’ forms) becomes one of the ways Foucault develops the notion of biopolitics— that is, a way of thinking about the subtle management of citizens in areas not previously thought of as economic, including government institutions and education policy (it also entails the politics around this governance such as struggles for rights, etc). These notions of rationality, biopolitics, and management become part of Foucault’s notion of governmentality (Foucault 1991). Today, not only do we find ourselves in particular rationales of government(ality), but the way we understand ourselves is contingent on a particular vision of human life — *Homo aeconomicus*. Homo aeconomicus essentially refers to the economico-political subject that passes as a kind of anthropology. This subject is seen as rational economic actor who will seek entrepreneurship and its own self-interest; it is also subject by which all areas of social life can be understood economically. It is precisely on this broad point that science educators and policy makers must be ready to challenge *taken for granted* neoliberal global capitalist rationales that come from government or their corporate partners in the name of freedom, competition, innovation, or even well being. In the case of liberalism, is our freedom only based on whether we can buy and sell or set up the conditions for (re)production or consumption? How are we governed or regulated in order that ‘liberal’ freedoms, or illusion of freedom, can be sustained (opening up the paradox of liberalism, political interference to promote ‘freedom’)? Foucault makes the point that any crisis of capitalism (such as the economic crisis of 2008) is linked to crises of liberalism, questions of how to specifically govern in relation to market rules (e.g., the question of too little or too much regulation). Foucault’s analysis is useful for educators because it shows the political and historical specificity of (neo)liberalism as it is connected with governance. Since neoliberal
global capitalism is fast becoming part of the larger context for education we should take the following warning by Foucault as both inspiration and a cause for pause:

[W]e should guard against thinking that at a given moment there was the literal and simple economic reality of capitalism, or of capital and the accumulation of capital, which by its own necessity would have come up against old rules of right, and then created, in accordance with its own logic and requirements and somehow by pressure from below, new and more favourable rules of right, whether property rights, legislation on joint stock companies, patent law, and so on (Foucault & Senellart, 2008, p. 164).

Positively, we can see this particular socioeconomic, political and cultural context of neoliberal global capitalism for science and science education as anything but inevitable and thus open to change.

**Neoliberal Global Capitalism and Science Education**

Before moving ahead it is important to mention two broad contexts for science education related to the acceleration of capitalism under neoliberal governance. The first has to do with radical changes in scientific research that are transforming science into an investment/driver of economic and market growth. What is sometimes called the shift from mode I science research to mode II (Ziman, 2000). Here the purposes of science become enslaved to a particular rationality that legitimizes science only in so far as it leads to economic returns and gains in the short term. Such as science is problematic if just for the reason that placing other areas of importance as the driver of science research, such as sustainable agriculture or alternative energy becomes increasingly difficult.

The second broad context is that neoliberal education reforms in science education now tend to be geared toward extracting (bio)value from students as surplus labour (Pierce, 2013). That is to say that science education reforms that support the reconfiguration of science for biocapitalist exploitation involve instilling a certain kind of self-investing subjectivity whereby students are already geared towards the kind of science that produces unsustainable material and social conditions. Students come to understand science along a kind of hyper-mode II model in that science and profit are two sides of the same coin. Although I do not directly discuss these two broad contexts in this chapter, educators must also think about the micropractices that constitute and reproduce the subjectivities that allow these over-arching contexts to operate unproblematically. Analyzing these micropractices can assist educators in reconstituting
subjectivities away from the needs of the market (and the elite) towards sustainable community living as well as social and economic justice.

7.2 Neoliberal/global capitalist Discourse in Textbooks

There is evidence within these four biology textbooks to suggest that there does exists a discourse that naturalizes certain choices and values, e.g., the market and competitiveness. To demonstrate this, I discuss several instances, from each textbook, of how the discourse in these texts works to constitute a particular range of possibility for thought and action. Again, the assumption here is that these texts all represent larger discourses’ or discursive regimes at play (e.g., education policy, science, capitalism). These examples help illustrate two basic points about the influence of neoliberal global capitalism. First, neoliberal global capitalist ideologies and discourses may already be present in taken-for-granted ways, that is to say, it may seem quite natural to speak within the discourses of neoliberal global capitalism. Secondly, that resistance to market logic and consumerism may be more complicated than educators may perceive. For example, exercises that are intended to question the role of corporations in science education, an exercise that is deserving of pedagogical praise, can also leave such relations unchallenged thereby re-enforcing corporate involvement in science as natural or to-be-expected. Science cannot be dislodged from the general cultures in which it is practiced (Feyerabend 1987), and it is perhaps easiest to see this when sociopolitical, economic, cultural, and ethical topics are openly discussed in science education, as is the case with the excerpts presented here. If nothing else, these examples, simply by their existence, positively exhibit the potential reach of neoliberal/global capitalist norms into science education.

7.3 Analysis: Neoliberal Global Capitalist Discourses

This section will highlight several neoliberal global capitalist themes and their relation to subjectivity in the four textbooks. Taken together as samples of larger discourses at work they appear to embody key aspects of neoliberal global capitalist discourses. The themes that will be discussed with examples in this section relate to: competition; the role of private property; Consumers and Individuals as the Locus of Concern; and how these delimit thought and action concerning “subjects” in science.

Figure 7.1 comes from an Explore an Issue box (DiGiuseppe, 2003, p. 212) that is intended
to frame, support or refute the statement: *Competition is the key driving force behind science, followed by collaboration.* The first thing to note is the main caption: “competition drives science” (p. 212). This phrase or cliché is a cornerstone of the business world usually seen in the form, *competition drives innovation.* Note the title is not given as a question or statement of debate, but a statement of fact or assertion thus rendering the building of arguments for and against somewhat moot. Such a position is confirmed in the teacher’s manual (Carr, 2003) preamble to the exercise that notes, “most students are not aware that competition drives science” (p. 143). Thus, from the very beginning, this textbook exercise has an overt purposeful message, which is to emphasize ‘the fact’ that competition is a key aspect of science. Adoption of the language of competition by science, and indeed it is a far-reaching discourse, may be seen as a barrier for people taking governance into their own hands, for this point I turn to Jodi Dean (2010):

Both liberalism and neoliberalism, however, present a certain version of the economy, one first focused on the market and then on competition, as a barrier to governance, a limit of what government can know and do. In each instance it is a limiting of the people. And it’s a limiting of the people that turns them from active agents of power into a passive population. They can observe and monitor the economy but they cannot know it or change its laws (p. 11).

I cannot help but wonder if this same logic is at work here: that somehow competition is given access to forces far beyond the reach of humans and should be left to operate on its own. If in neoliberalism, the state is subjected to market forces and not the other way around can we then think the same of science?

Individualism as an organizing theme contributes to a particular perspective for this exercise, not only in the way scientists are described as individuals, but also in the examples given for students to research as the viewpoint of each scenario centers around the personal story of a single person, leaving peripheral the socio-cultural, communal, and political aspects of science. Possible research topics for students are framed in such a way as to place political and sociocultural dimensions of science as inhibitors or facilitators to the truth, or as simply circumstances external to the ‘real’ scientific work at hand (examples include, if there had been no communist bias, Pauling may have had access to high quality X-ray diffraction photographs, or if we did not have private research we would be behind in genomic research).
Figure 7.1. Competition drives science.

However, this example directly broaches the sociopolitical (albeit in a very specific way) and can be used to persuade students and teachers to think about the specific character/nature of science. In terms of subjectivity, one could ask how such an exercise works to constrain how students come to see typical behaviour and relations with between science and society. More broadly, educators and students can consider how this type of exercise can initiate questions related to the alignment of the values of competition and individuality with a ‘good’ consumer, free market oriented citizen or subject.

For science educators who stress the collaborative and social aspects of science, critique of such an example will perhaps come easily. However, for science educators who see competition as a natural and necessary component of science what may be interesting to consider is the nature of competition in relation to ‘free’ markets. Competition in this sense, often taken for granted as a natural outcome of ‘free’ enterprise, is linked with specific historical processes and is not in itself, in any way, a natural component of economy. Here we can turn back to Foucault’s tracing of liberalism and his description of the contrived role competition plays:

For what in fact is competition? It is absolutely not a given in nature. The game, mechanisms, and effects of competition which we identify and enhance are not at all natural phenomena; competition is not the result of a natural interplay of appetites, instincts, behaviour, and so on. In reality, the effects of competition are due only to the character that
constitutes it (Foucault & Senellart, 2008, p. 120).

For Foucault, competition is something that requires constant active policy and a particular kind of governmental art in order to promote a type of market based on formal inequality. Competition is a mechanism itself, which creates specific effects. In other words, “pure competition, which has become a prominent feature of the market since the nineteenth century, can only appear if it is produced and if it is produced by an active governmentality” (p. 121). This governmentality involves, more and more disciplinary institutions, such as schools, as well as other areas of life not hither-to influenced by market logic. Thus, for Foucault, neoliberal global capitalism not only involves the spread of market logic into other spheres of life but an intensified and constantly active governance to maintain competition, surplus labour, and relative inequality. How did it come to be that competition is seen as a key component, something taken for granted, in a biology textbook? ‘Who’ then, is required to take up positions in science, but those who are keen to compete against others first, and collaborate second.

Figure 7.2 is another “Explore An Issue” segment from NB12 (DiGiuseppe, 2003) that deals with corporate realities and science. Here, students are asked to consider the question of what belongs to the public domain when it comes to scientific research; a very worthwhile exercise. What is also of interest here is how far such an exercise actually encourages students to question the role of private interests in scientific institutions.

Fig. 7.2 The economics of fossil study.
Reading closely the debate statement from which students are meant to develop supporting points and counterpoint (“Fossils should be donated to research institutions because their investigations help everyone”), it is worth noting the central importance of the private party. Even if one argues that fossils should be donated to research institutions the word, “‘donation’” implies that it was once the legitimate property of the private individual or group and was rendered as a gift. In other words, the statement at its fundamental level maintains that private parties should be allowed to keep, sell or donate whatever material comes into their possession. The furthest the ‘opposite’ position can go is that private interests ‘should’ give these materials up as a donation or gift rather than be legally or communally obligated to turn over the material to public scientific institutions. In essence, the example sets up a very limited choice, either public institutions do not have the right to expect the donation of artifacts of scientific importance found by private individuals that benefit the common good, or they do; but, either way, they are still at the mercy of private parties and donations. The example also sets up the simple narrative of good corporations (Ronald McDonald House™ and Walt Disney™) and bad (Sotheby’s™), thereby displaying clearly the common place binary logic of good company/bad company in today’s consumer society of corporate (ir)responsibility; which does not involve challenging socioeconomic systems and structures themselves. The statement concerning how research institutions ‘‘must bear’’ a wide range of costs also works to set up a taken for granted scenario in which public research institutions have limited budgets. The notion that they be well funded is not considered in the initial context of the example. In such a scenario, how will students come critically to view corporate involvement in, and more importantly the range of possibilities for, public institutions?

In order to think about challenging the taken-for-granted capitalist, neoliberal/global capitalist, and/or corporatist discourse in this example, we can roughly adapt Jennifer Sandlin’s (2004) three level model for criticizing consumerism in schools. Sandlin identifies three stages from a favourable approach (how to be an effective consumer), to one where consumer rights and solutions through consuming are championed, to a more critical one that critiques consumerism as something socially, culturally and historically situated. In this textbook exercise we can employ roughly the same three stages of critique. First, students and educators can engage a debate about corporations and public institutions in terms of the framework provided asking whether corporations and private parties can contribute to public scientific knowledge or
if they procure materials or knowledge for their own gain. Second, students can also start to ask questions about what kind of priorities we, as citizens, put on public spending and the public investments that our governments make in scientific research. In this second level, alternative funding solutions may be considered which would break with the parameters of the exercise. Third, students can be encouraged to fundamentally question the nature of the socio-political realities, often idiosyncratic rather than inevitable or natural, that give shape to scientific research, thought, products, and practices - and indeed the textbook example. Students and teachers do not have to take for granted the nature or material realities of present day global capitalism, consumerism and corporate involvement in science and science (their) education. Questions such as, “How did it come to be that we openly allow corporations, with well-known private commitments, to regulate issues of public concern (both positively and negatively)?” can be asked. Such questions allow for the (re) politicization and (re) historicization of the contexts in which science is practiced. Without critical engagement these pedagogical moments can easily re-enforce the status quo and can work, along with other aspects of education institutions, to help form subjectivities (the range of what can be thought or acted upon) contained well within the confines of a neoliberal/global capitalist agenda, a subject position that is potentially constituted by the narrative there are merely “good” and “bad” corporations and the supremacy of private property over the public good. Without critical engagement with discourses found within science educational communities, student subjectivities will be such that they will not be able imagine something fundamentally different from the status quo.

The next example is on p. 40-41 of NB11CP, and involves the nutriceutical issue (Appendix C) that I have mentioned in other chapters of this thesis. Here scientific research attempts to insert itself as point of resistance against companies and their lax advertising regulations, by claiming that functional food labels should be more explicit. The limits of this critique are therefore tied up in consumer rights, and the limit of the discussion is that students are to decide if consumer rights are violated with more or less labeling. In this case we can inquire as to the possibilities of offering radical choices on both sides, so while increased labeling may “give more information”, what is in fact owed to consumers? That is, what else are consumers entitled to know (ex. where ingredients come from, what workers are paid, what profits of companies are)? Furthermore, if testing and subsequent labeling is too expensive why must the cost automatically fall to the consumer? In terms of neoliberalism and global capitalism
we have a situation where the ‘unit of justice’ is on the individual and the choices they can make in terms of products. Here would it not be moving in a radical (new) direction to make the corporation and/or the government the unit by which to consider this issue? Instead we have a situation where the discursive frame of the issue is rendered in terms of the individual and choices – hallmarks of current neoliberal global capitalist discourse. Students then come to see themselves and a neoliberal capitalist system as the primary locus of socioscientific and ethical issues.

The next example comes from a section that talks about careers in landscape design, turf management, and horticulture (DiGiuseppe, 2004, p. 339, 340). I would like to present two images associated with these jobs (Figures 7.3, 7.4). In examining the placement of a golf course in the textbook we might ask what normative message is being sent by placing both figures back to back. That is to say, a giant suburban house and golf course pertain to a certain group of people and they normalize a specific use of land - which not only requires much private money to maintain, but can only be used by a fraction of the population. What also must be considered is how these images frame not only what a typical home may be, something where the landscaping itself would cost more than an average Canadian annual salary, but also this privilege in relation to a student’s future employment. That is, we must ask how these images frame the world of work, property and what is normative when work is associated with lavish property owned by the world’s elite (top 1-5%). What do images such as these do for students both from public housing and the suburbs? Here it is interesting to consider that the images may work to constitution of subjectivity in a differentiated way. Someone who is wealthy might for example see work related to science as superfluous with a “natural” home setting and thereby make the connection that science and their lived world fit quite well. A student who in different socioeconomic circumstances may see this example as working to constituting the relation between wealth and science and her exclusion from such a relation. In any case these images work to normalize a middle class home setting.
DID YOU KNOW?

The Grass of Greens
Most putting greens are planted with creeping bent grass. This unusual variety of grass likes cool temperatures and must be mowed and watered every 1 to 3 days. Construction of a single putting green can cost more than $100,000.

Figure 7.3. Picture of a golf course associated with Turf Management employment

Maintaining high-quality lawns requires careful attention to drainage, irrigation, fertilizer application, mowing, and pest management. Turf managers have training in plant and soil science, irrigation systems, and pest control.

The design and construction of ornamental gardens is a major task. Many gardens are now designed using computer-assisted-drawing (CAD) software. This technology enables designers to provide their clients with a realistic image of the finished garden before work begins (Figure 6). The technology can even show how the appearance of the plants will change in winter, spring, summer, and fall.

Figure 7.4. Example of landscape design using CAD software
In terms of constituting a global capitalist neoliberal outlook it is interesting how the discourse of the text in the example below both identifies environmental problems but does so under a discourse of personal responsibility within institutions of governments and major corporations.

Humans need to take responsibility for their actions, whether on a local scale or on a global scale. The wealthiest 20% of people on Earth are presently enjoying a much higher quality of life than the remaining 80%, while imposing a far greater share of the stress on the planets life support systems. Individuals can do little about the decisions of governments or major corporations; they do, however, have control of their personal lifestyle decisions (DiGiuseppe, 2004, p. 423).

This text, found in the lifestyles and sustainability section near the back of the text, is remarkable in the way it reifies an economic order where the individual is seen as the locus of change. This social order: a) recognizes a global wealth inequity; b) a differential responsibility for global destruction between the global south and the global north; c) corporations and governments are out of the reach of individuals to influence; d) individuals do have control over their personal lifestyle decisions. Here we see a reliance on neoliberal ideology even in the face of environmental destruction. More importantly how does this limit the thought and action students can take concerning global inequity and destruction? Could students conceive that they could join grassroots organizations such as *Idle No More! to challenge both corporations and governments? Or rather are they inclined to think they must focus on their daily habits?*

The fullness of individualistic ideology of neoliberalism and global capitalism comes into full view when the text states, “Solving these problems may seem to be a monumental or hopeless task. However if every individual contributes to the problem, then every individual can contribute to the solution” (p. 424). The text urges students, among other things to “Recognize that no one can do everything. Focus on things you can do something about.” (p. 424). However does this mean that students only do things in the realm of personal behavior thereby keeping structural inequities in tact? Concerning these global problems the text reminds students to “Remember there is no single correct or best solution. There are many solutions, all of which work to some degree” (p. 424). This statement works to neutralize any major action taken, such as protest, demonstration, disobedience. Indeed all equally work and simultaneously none are correct.
I would like to now highlight a few examples of neoliberal global capitalist discourse that discuss genetically modified plants (GMP). I would like to cite the way the text opens discussion of the issue:

The public debate over genetically modified crops has created a fear among Canadian consumers that the food they eat may harm them. At the same time, Canadian farmers are concerned that their crops may not be saleable. Newspaper headlines and magazine covers are beginning to highlight the issue of genetically modified crops. Questions include: Should farmers plant seeds that have been genetically manipulated? Will consumers buy these products? Are consumers entitled to explicit labeling on products that contain genetically modified organisms? Do consumers have enough knowledge to make an informed decision? What are the consequences to human health and the environment? Are there genuine food safety and ecological issues? By examining the risks and benefits of this new technology you will be able to decide for yourself (Dunlop, 2010, p. 574).

I want to draw attention to a number of ways the debate is framed. First, questions of human health, ecological issues and the environmental and food safety are secondary while the debate centres around the consumer as the “unit” or focus. What is conspicuously missing is any emphasis on the centrality of corporate involvement and government control around the issue. Instead, for students, consumer rights become the way they are brought the debate. Action taken or ethical decisions made will take for granted the centrality of the consumer and the individual and will downplay any focused action on systemic change (as the sustainability example from NB11CP does).

Another example involves defense of the biosphere and it again is representative of the subtleness, and sometimes ambiguous, neoliberal global capitalist approach in science and science education. The following are four suggestions outlined by the text (Dunlop, 2010, p. 608) as to what students can do to defend the biosphere.

- *Continue to educate yourself:* You do not need an advanced degree to stay informed about issues relating to biology and technology
- *What does media communicate?* Are issues chosen based on their “shock value”? Think about whether these media companies are in business to disseminate accurate information and well considered opinion, or whether they just want to sell more advertising space or commercial time.
• **Develop a healthy skepticism.** Beware of easy answers to your questions. Consider whether the data you access so easily on the internet are products of research or opinion. Try to find information about the author.

• **Recognize the limitations of science.** Scientific knowledge can help us solve problems such as the ones discussed in this chapter, but science cannot always give a definite answer.

• **Take action.** Decide what issue is most important to you and pursue it. Write to politicians and corporations expressing your opinion.

This list has several aspects that are worthy of discussion. There is a focus on educating *yourself* (not others), as well as individual actions such as writing letters to corporations, which ironically would do little good according to NB11CP (discussed above). Here, I also question the depoliticization of scientific knowledge in the push for a “healthy” skepticism and being skeptical of “shock” environmental news. *What would a skepticism towards “sensational” environmental news achieve?* Here the text is critical of media news companies for putting out sensational news, instead of not enough news, about environmental issues! Secondly, why are news corporations targeted here for being guided by profit margins, but corporations destroying the earth get a free ride?

However, I continue on the note that discourse in these books (neoliberal, global capitalist) is always a confluence of both forces for change and those that maintain the status quo and oppressive conditions. The following example appears as a question in MHB12 and works to present a very important issue to students, of course with particular constraints:

8. Some companies that produce transgenic crop plants forbid farmers from saving the seeds from their crops in order to replant the transgenic organisms. Instead, the farmers must purchase new seeds each year. Write a brief report explaining some the advantages and disadvantages of this policy. If you were a researcher working for one of these companies, what policy would you recommend?” (Blake, 2011, p. 311).

The question outlines the situation whereby Monsanto™ forbids farmers from saving seeds but effectively monopolizes the sale of genomes as private property (see Shiva (2000) for an extensive discussion on the cultural and “global internationalized” politics concerning). Again, the text positions students as having to give a position from the perspective of the company
rather than actually opposing Monsanto. *In other words, as employees of Monsanto, what range of choices remain open for students?*

The last example I will discuss is a kind of culminating task by which the students re-formulate a UN Earth summit. There are a few aspects of this exercise I discuss, partially fuelled by the recent activist movement *Idle No More!* This exercise can be found in Appendix F. The activity models itself after the 1992 Earth Summit in Rio De Janeiro and the text describes its main theme in this way: “The goal of the Earth Summit was to promote the idea of sustainable development; that is, allowing present human generations to maintain or improve their quality of life without compromising that of future generations” (Blake, 2011, p. 538). I find this opening interesting, since it places first the imperative of maintaining quality of life without major (radical) changes to the way we, at least in the global north, live our lives (in unsustainable ways). Assuming “quality of life” to be a variable concept, the discourse here constrains students’ ability to think and act in ways that would promote sustainability while radically altering our “quality of life”. From the beginning, then, a radical conception of what it may mean to live sustainably is constrained by the imperative to maintain a way of life (read: the standards of the global north). This is not to say, that such an arrangement will be possible in the future — but it is quite understood in environmentalist circles that our current modes of life in North America, with a reliance on fossil fuels and processed materials, may be *de facto* the problem. Therefore, the discourse here may severely limit this idea entering the forum of the summit.

The text also works, in the beginning, to set equal responsibility to the global north and south for potential environmental concerns — a claim that is highly questionable as the global north through the spread of global capitalism has been at the helm of most of the world’s environmental breaking-points, such as the impending problem of climate change (Harding, 2004; Shiva, 2000). The text uses population increase as a counter balance to the excessive consumption: “Delegates recognized that the relationship between overpopulation and environmental degradation is not simple, since the conditions and practices associated with poverty often place as much stress on the environment as the excessive consumption of richer populations (Blake, 2011, p. 538).” What is immediately left out is the way practices of consumption in the global North *drive* the conditions and practices of environmental degradation and poverty in the South. Instead a kind of 50-50, depoliticized scenario is set up that assigns culpability to the global south for over-population. Over-population, (a re-current theme in these
texts and is often used as a way to erase the culpability of the global north, but also the problems associated with global capitalism. It is not that a concern with over-population is a neoliberal or global capitalist, is simply the locus by which another discourse is made visible – a differentiation between global north and global south and a discourse that delimits a particular view of North and South and what solutions should entail (as well as the place of science and its “subject”). This framing of the issue is reinforced in the next passage:

One of the basic issues related to quality of life is the availability of food; while some people have an abundance others are starving. Although more equitable distribution of available food might help solve the issue, some researchers believe our current supply of food cannot keep up with the demands of a growing global population. And the more the population grows the greater the potential for environmental damage (Blake, 2011, p. 538).

The textbook exercise continues to place over-population as a problem equal to and greater than over-consumption. Here the possibility of critiquing the political project of neoliberal global capitalism seems far out of reach – out of reach even when issues such as poverty and environmental destruction are the topic of discussion. This is not to say that the example isn’t useful, but the framing of the debate effects how students proceed with their analysis of the task. For example when students are explaining bias in their work, in the sources they collect, will they attempt to go back to a ‘neutral’ position — that is, the discursive frame of the exercise itself? This example opens many possibilities for students and teachers to talk about social and economic justice, even if students are initially led to depoliticize global contexts and see the ravages of the planet as an ‘equal’ problem.

I think it important also to mention the silence around supra-national organizations in these textbooks. That is to say that there are other entities that play a role in the propagation and neoliberal structural reforms, ideologies, and discourses such as International Monetary Fund, the World Bank and Pharmaceutical Lobby groups. In discussions about environmental degradation it is not simply that there exists a solution say amongst the public, the government, private institutions. There is also a network of institutions that intersect with what is typically deemed private and public to bend both toward market-oriented policies that benefit the economic elite. In science education this means including these institutions as part of the conversation in terms of the way these institutions contribute to the constitution of subjectivities that promote subjectivities (homo economics) through the reproduction of “common-sense”
policies that require nations to have their citizens self-invest rather than promote an ethic of common care.

7.3.1 There is Hope; Science as Resistance to Neoliberal Global Capitalism

A friend of mine (Alex Means, personal communication, Jan 4th 2013) recently stated that he felt science was 'like a cypher', something that could be used with/in various neoliberal and global capitalist forms of governance, or as a form of resistance. That is, whatever 'truth' science ‘deals in,’ its complexities render it as (always already) a site of antagonism and struggle (this includes a range of contestations from sex/gender to traditional understandings of class struggle). While science education already shows evidence of being susceptible to neoliberal forms of governance (see also Ken Tobin’s (2011) description of neoliberal school restructuring and Larry Bencze’s (2008) analysis of consumerism and hypercapitalism in pedagogical structures), this analysis also reveals a discourse that can potentially resist ‘hyper-capitalist’ ways of discussing commodities, and modes of communication inherent in the way Frederic Jameson (1994) describes postmodern market realities. I am encouraged by the presence of a false advertising example in NB11CP (DiGiuseppe, 2004, p. 125). In this way, I question whether science and science education will not very soon find themselves in a struggle with those who reject the market as a site of truth.
Chapter 8: The Constitution of Neoliberal Subjectivity and Humans as Capital, Part Two: A Discourse on Careers and the Function of Repetition in Laboratory activities.

In this final chapter I want to merge another theme of a more Marxist (Althusserian) line into this thesis, which is the constitution of human beings, through discourses of careers, as human capital, and the notion of repetitive lab activities as the site of this constitution. That is, I suggest the constitution of a subjectivity whereby students come to see themselves as human capital. To do this I consider the long list of investigation/lab/performance task exercises as a ‘series of practices’ that can work to constitute subjectivity. This chapter draws on Judith Butler’s and Louis Althusser’s ideas about the role of repetition in subjection – where a break in this series of repetition can be seen as a break in the chain of subjectifying practices. After a build up to engaging this role of repetition I have finally engaged it thoughtfully in this chapter. What kind of repetition exists in school science that is more constituting than laboratory investigations and activities? Theoretically this focus draws from different but supporting notions of subjection, the first “poststructural”, the second more structural or Marxist.

In line with the neoliberal global capitalist context given in the previous chapter, we can see the career choices of students as constitutive of a kind of “entrepreneurial self”. As Jodi Dean (2010) states:

Neoliberalism’s emphasis on education as preparation for work similarly targets the worker as an ‘abilities machine.’ Rather than producing critical humanists or responsible citizens, the theory of human capital treats education as a means for instilling in the worker those specific capacities that render him sufficiently competent, competitive, and flexible (p. 11).

Concerning state education systems we can consider Maarten Simons’ (2006) point that, “the entrepreneurial self, and not the state, is regarded to be having the first responsibility for social inclusion” (p. 533). Following this line of thought we could also say that students are now expected to include themselves into a work force. As Wendy Brown (2005) states:

neoliberalism normatively constructs and interpellates individuals as entrepreneurial actors in every sphere of life. It figures individuals as rational, calculating creatures whose moral autonomy is measured by their capacity for “self-care” - the ability provide for their own needs and service their own ambitions (p. 42).
As Brown (2006) also states: “Foucault theorized a subject at once required to make its own life and heavily regulated in this making-this is what biopower and discipline together accomplish, and what neoliberal governmentality achieves” (p. 705). Thinking about the discourse of careers in science education and its possible ‘neoliberalization’, “the model neoliberal citizen is one who strategizes for her- or himself among various social, political, and economic options, not one who strives with others to alter or organize these options” (Brown, 2005, p. 43).

8.1 Rikowski’s Capitorg: Education’s project of constituting humans as capital

Although I do not have the space to develop this topic in great detail the constitution of humans as capital or subjects that invest in themselves as capital, is one aspect of subjectivity that needs to be thought about in science education as a micro-analysis if any politico-economic change is to be made in this sphere of education. So far a literature review reveals nothing on the topic of how science education works specifically to produce human capital - though there is an excellent article by Skordoulis (2008) which explains philosophical bridges between Marxist ontologies and scientific ones and argues for science’s space of autonomy from the social consciousness. Although I disagree with the need for this kind of realism, I see Skordoulis’ endeavor to bring Marx’s thought into the typical worldviews or ontologies of science and scientific thinking as needed. The theoretical background for this section will draw primarily from the work of Glenn Rikowski (2011) to set a theoretical background for seeing these texts as producing humans as capital - subjects that are meant to think of themselves as capital and/or invest in their own human capital.

Rikowski identifies Adam Smith as one of the first to recognize education as an investment in the self, however also notes that it takes roughly 200 years for this investment to become systematized in education (see Marginson, 1997). One reason for this may be the unpalatable thought of human beings as capital as this has ‘slavish connotations’ (Hardt and Negri (2009) describe slavery as counter to the modern project and one reason why the Haitian revolution still goes largely ignored. Slavery runs counter to the modern project and as such must be denied). Theodore Shultz (1971) outlines this basic modern moral argument: “Free men are first and foremost the end to be served by economic endeavor; they are not properly
marketable assets… our values and beliefs inhibit us from looking upon human beings as capital and goods, except in slavery, and this we abhor” (p. 25). However Shultz himself over-turns this moral dilemma by arguing that investing in our ‘selves’ opens up more choices, higher earning potential and increased opportunity. Sympathy for the investment of human capital is described by Rikowski as the result of modernization theory which states that nations can become modern and capitalist through investment in human capital via education and training, and, as Marginson (1997) notes, this view since has become integral to broad schemes of economic growth since the 1960’s (I am compelled to think that places like OISE/UT really exist for this reason, any subversion of this practice being an unforeseen outcome of massive government investment!).

In thinking about the prospect of education apparatuses constituting humans as capital, Rikowski turns to Marx’s (1848) prediction of the erosion of all other forms of life to the reality of capitalism: “All that is solid melts into air, all that is holy is profaned, and man is at last compelled to face with sober senses, his real conditions of life” (p. 83). In a similar way Rikowski recognizes that today this condition, of humans constituted as human capital, is not just a metaphor but also a form of human life:

One of these “conditions of life” that humans have to face is that they are a form of capital. But at this stage in the argument the full horror of this predicament has not been uncovered…Human Capital is not just a fancy theory spawned from mainstream economics: it is a crucial part of life in capitalist society, more, it is part of us (Rikowski, 2011, p. 4).

The urgency for (science) educators is that the requisite cognitive abilities, knowledges, skills, and know-how involved in the construction of human capital (Johnson, 2000) gives educational institutions, practices, discourses tremendous power and importance in the (re)production of humans as capital. In an all encompassing way knowledge, if we take Lyotard (1985) seriously, would always be something that is taken up into service of the market economy; humans investing in themselves would also do so in relation to knowledge that only fits the “system” – or it may be made to be something that disappears as suggested in the previous chapter. Moreover, schools are involved in (re)producing the attitudes required for working in capitalist labour markets (the most famous study is likely Bowles & Gintis’ (1976) Schooling in Capitalist America). Science education and its involvement in the integral production of a skilled work force can be (re)considered along the lines of this (re)production (Pierce, 2013).
This investment in human capital by educational institutions and governments is in fact a very specific one that places: “responsibility for the productivity of labour on the individual employee, and on education programmes, and diminishes the responsibility of employers and work organizations, thus protecting negative freedom and managerial prerogatives” (Margison, 1997, p. 118). A site of struggle then subsequently exists in labour along with the energies, skills, knowledge and attitudes by which labour becomes possible (the generation of labour power). According to Marx, labour has the power to create value and transform (Marx, 1858, p. 361), and it is the gearing of this labour (and labour power) that is at stake in education and training. Because value (in the Marxist sense) is a kind of field that holds the capitalist social world together, and labour is necessary to produce value (as it produces commodities), education becomes vital in the (re)production of capitalist relations – in the formation of labour (power) – but also in the struggle against the subsuming of all social relations by capital(ism). This double point can be seen both in the hope placed in education and the anxiety attached to it, and also in the re-production of education by representatives of capital who seek to define labour power in specific ways (which ultimately serve the interests of capital). Schooling in capitalist societies is precisely capitalist, Rikowski argues, because labour is what’s needed to produce the substance of the social world of capital: value. Therefore, it is in the field of education that we can push against the barriers of these relations and disrupt what keeps the constant production of the social world of capital intact – in the context of my work with textbooks the analysis the constitution of humans as capital.

Science education, and its involvement in the production of human capital, is therefore implicated in a contest over the (value) form of human labour and the production of social life subsumed by capital. At this point in this analysis of biology textbooks I think it more pertinent to turn this lens towards how these discourses require subjects to invest in themselves as capital. How do science education discourses and texts require students to invest in themselves (take personal responsibility for success)? What are the forms of labour that are being (re)produced? What is the social world by which this labour (power) is expected to thrive? What attitudes must a subject or individual have (already) to engage the world of work? And then, what are possible alternatives?

What turned my attention towards Rikowski’s argument however, was not just its importance as a mode of analysis for science education, but also what it means for resistance in
terms of subjectivity. Human capital is incorporated with the ‘human’ itself, and lies within (Rikowski, 1999). Therefore,

The implosion and dissolution of the capitalist form (human capital) of the explosive commodity (labour power) necessarily involves changing us, our 'selves'. This occurs as we change simultaneously the social relations that maintain us as this horrific life form (i.e. the social relations nurturing and sustaining us as the capitalized life form that we have become). Education for human liberation of necessity includes educating ourselves regarding what we have become. (Rikowski, 2011, p. 12).

For me this is not far off from what Foucault is generally calling for through critique – an asking after what we’ve become as a kind of politics of refusal. While Rikowski, along the lines of McLaren (2000), calls for revolutionary pedagogy, the question will remain about how this is done and of course to what end. However it seems probable that one aspect of this resistance pertains to the control of labour forms and labour power as far as they produce surplus value. Surplus value is what drives the capitalist economy and also what goes back into producing the forms of labour that produce value, as well as the tools for labour power. Suffice it to say, there is a vicious circle here as the labour power in all of us becomes reliant on the production of this surplus value. Again, Rikowski, rightly singles out education, particularly national programs, as seizing this reality and making it a prime area of investment in order to compete in a global economy. In other words, nation states are in a (mad) race to create as much surplus value as possible – for which labour, that which produces value, is absolutely necessary. This fact makes an analysis of human capital, along with Marxist abstractions, useful when thinking about subjectivity and changing our ‘selves’ as a way of resisting.

The rather playful term capitorg, coined by Soowook Kim (2006), can be thought of as an organism of capital - which includes us – we are all composed of capital. Capitorg is coined much like Donna Haraway’s cyborgs. Kim demonstrates the convergence of human capital concerns and neoliberalism when he claims that educational discourses of neoliberalism, promoting literacy for job opportunities, economic advancement and individual success are paramount to producing human capital rather than human beings (Kim, 2006, p. 2). Rikowski (2011) insists however in the distinction between human existence as both labour and capital and it is the former that embodies our capacity for resistance. Thus, even though human beings are continually being represented as capital, this formation does not have to hold. The class struggle there exists within each student, and is between ourselves as capital and/or labour –
Rikowski (2011) stresses that humans constituted as capital need to be recognized as entangled within social relations, not as something that is somehow a part of who we fundamentally are or something that can be easily removed. Rikowski sees our existence as labour as a site of resistance where we can collectively realize our powers of creation and free association with others. What the following chapter details is how biology textbooks in Ontario can work to produce humans as capital through self investment and specific forms of labour. The next section will outline some methodological approaches as well as points of method.

8.2 Careers in Biology: Humans as Capital

I only got here, because number one, I decided to... that's what I decided to do with my life, and then number two I worked at it for my whole life. So I really want to remind all of the Hadfield Hawks to think about that. What are you going to do with your life? You're going to grow up to be something, why don't you choose what you might want to grow up to be and then make yourself into that person. You can do it slowly day by day and with that i't's amazing, one day at a time, one step at a time, it is amazing where life can lead you. And Jeremy Hansen there with you, and me here in the space station, we are both evidence of that. – (Chris Hadfield speaking from the International Space Station to a School Assembly at Chris Hadfield Elementary School in Milton, Ontario – January 17th, 2013 – NASA TV Expedition 34 – Educational Event.)

My approach to thinking about capital and its constitution through a discourse of “careers” I feel is significantly different than other approaches taken in this thesis. For example a very recent publication in the philosophically oriented science education journal, *Science Education*, contained an article that attempted to use Bourdieu’s notion of cultural capital for identifying “worth” in science education which was then intended to spark an interest in students realizing the capital involved in studying science and building their own cultural capital (Claussen and Osborne, 2013). While such an application of capital is consistent with Bourdieu’s basic conception of cultural capital it fails to understand that education as capital is not antithetical to the goals of capital. That is to say, getting students to realize their potential to accumulate their own capital is very similar to the neoliberal discourse of appreciating self opportunity, employment prospects, and the realities of the job market - thus the paper embarrassingly misses Bourdieu’s larger point of class domination. In short such a perspective,
at best, has students maximize their potential in the current neoliberal, global capitalist order. At worst, this kind of thinking perpetuates structural inequity and does nothing to challenge the neoliberal structures and discourses that require students to invest in themselves with a ‘scientific’ education. Admittedly students must survive in this world and therefore need employment, however transformative education, must risk this kind of disruption of doing what is best for the current socioeconomic order. This is another example of the reticence of science education to go deeper with ideas and most importantly politics. A superficial application of the ‘habitus’ onto science education must, if we are to take Bourdieu’s radical message, produce a realization of class (hegemonic) antagonism/inequity/cultural difference. Furthermore I do not see how this antagonism cannot be apart of any analysis! In this chapter I suggest that the discourse on careers in these textbooks, however brief, at least partially succeeds in its ‘governmental’ function as both a discourse of state education and science education, to constitute a subjectivity of self-investment along with other aspects. In the next section, I will elaborate on some methodological points I felt were necessary to demonstrate this.

8.3 Considerations of Method when Considering the Discourse on Careers in Biology

I have chosen to focus on the specific discourse of careers in biology and its role in the constitution of humans as capital in these texts for similar reasons that I gave in the ethics chapter. That is, this career discourse contains a certain kind of specificity about careers/work/labour which may be obscured in more general discourses where the motives of other discourses (ex. texts showing that scientists are involved in the rational advancement of history in vignettes about the history of science work) override and conflate images about what a scientist (amateur or professional) does and how they operate in the production of knowledge. Like all of these chapters a thorough investigation of the synergistic effects and contradictory messages requires more study, however, through a collection of specific career oriented discourses from the four textbooks, (Appendix D lists these occurrences) some specific themes were observed and form the basis of a discussion around the constitution of individuals as human capital or subjects who come to invest in themselves as capital.
8.4 Career Connections and Biology at Work

In this section I will give a detailed description of the specificity of the discourse of careers along with some interpretation of these specifics. Afterwards I will engage briefly with the ideology of liberalism as one way to understand the specific discourse of careers. The types of careers described in these texts are listed in Appendix D. In future studies it would be interesting to compare the careers outlined and the skills obtained through laboratory/investigation activities (discussed at the end of this chapter) to see possible connections; however this is not the focus of my analysis as such an alignment would have to be contextualized and properly situated in terms of more focused research goals.

8.4.1 Responsibility of Students

What was initially striking about the discourse of careers (Appendix D) was that students were expected to gage the education, strengths and skills they needed for a certain career and to explore what job opportunities existed for a particular biology related job (this was most clear in Nelson Biology 11 College Preparation). I think it very important to highlight what the object of focus is: the student (what they must do to be ready for a job) and the (job) market (what opportunities already exist). This may seem commonsensical, but noticed how the attention is not on the conditions and social circumstances that give shape to both the student being able to obtain work or the conditions by which these jobs (some of which are rare and elite such as becoming a cytologist) are made available (contradicting Chris Hadfield’s statement to the students in Milton, Ontario!) Again, a productive way of thinking about this is to consider what is foregrounded; the student-self and all of the self-investment needed in order to work and the opportunities afforded by the market. What disappears is the social reality and the market itself that is perhaps so taken-for-granted it does not need mentioning. This emphasis can be seen even more explicitly where the text requests students to find out about, not only the training required, but the programs offered at Canadian colleges (ex. NB11CP, DiGiuseppe, 2003, p. 47, 135), in conjunction with the texts asking students to investigate the opportunities available (p. 103, 192).

An example in MHB11 (Dunlop, 2010, p. 266) suggests a discourse of individualism when describing the career of a perfusionist: “Imagine knowing that without you, the operations that save people with heart attacks or lung cancer would not be possible”. Here, the individual is given such an important position that the student-subject is to imagine they themselves stand
between life and death of patients! This sense of individualism also plays out in the description of personal satisfaction attributed to careers. In the example of the naturalist artist found in MHB11 it states that students can gain great satisfaction simply by learning the names of plants. What I want to suggest here is the emphasis on workers ‘loving’ their job, even when it is highly demanding and destructive of their social lives as found in the example of a food industry manager in MHB12 (Blake, 2011, p. 51). In addition, the presentation structure or profile genre of “Canadians in Biology” and “Biology at work” in the McGraw Hill texts emphasize the narrative of having arrived at their success in the professional world. The profile genre matches the singularity of the professional being profiled with the singularity of the student - which means the text reads like it is addressing someone specific thus matching one individual with one job. Going back to the statement by Chris Hadfield at the beginning of this section, we can see that certainly the appearance of a choice is set up for the student irrespective of the fact that what appears in these boxes is socio-politically and economically determined. For example, even the career of ecological policy maker given within a frame of “Biology at Work” must frame community work in individualist terms by asking the question: “What community services could you perform to help prepare yourself for a career that interests you?” – that is, instead of discussing the importance for people the emphasis is on preparing themselves for a career that interests them.

8.4.2 Education, Qualification, and Certification

Along with this discourse of self-investment there is also a strong emphasis on credentials, qualifications, and education achievements usually in the form of requisite degrees and diplomas. Certainly there are many pragmatic reasons for this emphasis, students need to prepare to undertake these specialized degrees if they want to participate in science work NB11CP (DiGiuseppe, 2004, p. 216, 227). However, the high frequency of their mention deserves some attention. One outcome of the frequent mention of degree requirements is that it works to differentiate experts from lay person (student); the highly or prestigiously trained from the locally and moderately trained; and the professional from the worker. The latter distinction is made in the text associated with some careers (for example in NB11CP, (DiGiuseppe, p. 181, 203), in designating the difference between a pharmacist technician and a pharmacist - one
works alongside the other and not the other way around). *Therefore the question arises of how disciplinary knowledges are used to qualify how one comes to think of themselves and others as having a “career”*. One function seems rather obvious, that these discreet units of knowledge – ex. a masters degree in plant science – breaks knowledge up into disciplinary units for control. Another dimension along these lines is the fact that it is often stated *where* particular career-featured scientists obtained their degrees (ex. Verena Tunnicliffe studied at McMaster University and Yale, MHB11, Dunlop, 2010, p. 416). Students cannot be constituted as capital or see themselves as a (professionalized) worker any other way – thus knowledge in its disciplinary form is very valuable - coming full circle to Foucault’s earlier thought, that knowledge is most valuable in reference to its disciplinary form! What is also interesting is quite often the text examples emphasize that students must master multiple disciplinary forms either in stating that they need a broad understanding of the life sciences or combined expertise, for example in the case of a Medical laboratory technologist MHB11, (p. 438):

Medical Laboratory Technologists must also be competent in examining and analyzing samples of various types in other fields, including the following: biochemistry (chemical analysis), hematology (blood cells), histology (preparation and analysis of tissue), immunochemistry (blood transfusions), bacteriology (infections and microorganisms), mycology (fungi), virology (viruses), cytology (cancer screening), molecular genetics (molecular basis of disease), and cytogenetics (chromosome abnormalities).

Here, it is not so much the tasks that the technologists must do (transfusions; preparation of tissue), but the disciplinary importance and organization given to these tasks. Here also, the link between the Ontario ministry of education and training’s oversight of both elementary, secondary, and higher education means that there likely will be an effort to locate human capital into Canadian universities. In Nelson Biology 12 (Appendix D, Table 2) there is a general formula which is more noticeable than in other texts (though it exists there too): a four year degree is mentioned followed by a general discussion of accreditation and a discussion of where students can work afterward. In general, students subjectivities concerning work and careers comes to be constrained through the discussion of what they need to do (education, training, discipline, finding opportunities) and also in terms of silences what is not be discussed, for example why can’t everyone in low-socioeconomic neighbourhoods choose to become astronauts?
Job descriptions sometimes displayed a strong interest in private or large-scale economic enterprise (ex. pest management for the purposes of real estate, NB11CP (DiGiuseppe, 2004, p. 336) or the maintenance of healthy forests for the purposes of harvest (p. 424). The career example of Michael Smith describes a scientist who is not only a successful scientist in a university but also a “successful” businessman (reference). In a career example of a naturalist artist it is interesting to note the underlying framework by which their career is discussed along personal economic lines. The natural artist in question taught art in a secondary school in Ontario however, the text states, “by the time he was 40 he was able to earn his living solely through artistic endeavours” (MHB11, Dunlop, 2010, p. 529).

8.4.3 What the Texts ‘Want’ People to want to do

In longer descriptions of careers in textbooks (MGH11, MG12, NB12) there are also instances where the professional under focus claims to enjoy their job very much (which I mentioned above). It brings to mind Butler’s (1993) point about the performativity of texts. That is they say what they do – people love doing their jobs - jobs are loved. When the discourse concerning a particular career is given more space quite often a narrative is created (including themes such as “the glory and excitement of discovery”, challenge, and personal adversity) where individual scientists come to a particular problem. These two themes, job satisfaction and challenge, are interwoven such as in the description of Jagdish Butany’s work in pathology combines the theme of job fulfillment and satisfaction “I love my work” with challenge: “Doing the work he likes, doing it well and doing it on time are among Dr. Butany’s biggest challenges” (MHB11, p. 310). A similar example can be seen with Elaine de Rooy’s profile as can be seen in the description of her career:

Managing a cheese factory makes heavy demands on de Rooy’s time. The factory operates 24 hours a day, seven days a week. “If everything is running well, you’ve got a really nice mix between home life and work, she explains. ‘When there are problems, it’s a huge demand on your time. During the past month, I have been here everyday. I have been here in the middle of the night and gone home to catch a few hours sleep and come back to work again. That’s my biggest challenge.” However, de Rooy enjoys solving the variety of problems she encounters on the job. For instance, any day might involve dealing with equipment failure, bacteriological problems, or safety issues (MHB12, Blake, 2011, p. 51).
Here we can see plainly, a mix of themes such as challenge, the love one’s work (even solving safety issue problems), and a demand on time (similar to the pathologist example above).

The discourse on careers also situates personal likes and dislikes as the basis of why someone chooses a particular career (sometimes it’s a personal circumstance), and never social circumstances. However there is one notable instance where it is actually mentioned that the scientist, Michael Smith, came from a working class family – however the narrative being that it was personal perseverance that led this scientist to (his own) success. Here Smith’s genius wins out in the end:

Michael Smith was born in England in 1932 to a working class family. He did so well in elementary school that he earned a scholarship to a private secondary school. He was encouraged by his secondary school chemistry teacher, and went on to study chemistry in University (MHB11, Dunlop, 2010, p. 202).

I think it is likely that this story is not something that the text writer researched and included, although it is very possible, rather it is being reported by the writer after a direct communication with the scientist. However in terms of thinking about discourse and texts in a Foucauldian sense, this aspect is not given as much attention. What matters is the surfaces where discourse appears and how they order reality and work to constitute subjectivity. It is perhaps easy to notice the inherent hierarchy of schools here concerning public and private and the meritocracy upon which opportunity for working class children often have no choice in accepting. This narrative is also given in the example of Irene Uchida (MHB11, Dunlop, 2010, p. 228), who had to overcome internment due to her Japanese background - the point here is that the focus is on her perseverance and not conditions that might have prevented thousands such as Uchida access to careers. What is irresistible to point to mention here is that Uchida’s advice to students pursue a career in science involves “letting the creative power of random chance help shape the course of one’s life”. For whatever, wisdom this affords here again we have a focus on one’s life amidst social circumstances one can do nothing about! However, do these examples not provide educators with a window within the discursive frame of careers to break with the discourse – an opportunity perhaps not intended by the discourse – to talk about social injustice and inequality (A chance strengthened by the texts’ highlighting of, for example, Smith’s commitment to supporting the Society for Canadian Women in Science and Technology)? Thus a combined
discussion of social justice and equity can proceed in a discursive space where it may be unexpected.

8.5 Considerations of Liberal Ideology, Lab Investigations and the Discourse on Careers

A critique does not consist in saying that things aren’t good the way they are. It consists in seeing on just what type of assumptions, of familiar notions, of established and unexamined ways of thinking the accepted practices are based. (Foucault, 1981)

I would like to take a slight detour and elaborate a little bit about how an ideology of liberalism may be operating in the discourse around careers in these biology texts. Although Foucault maintained that the question of ideology in science was best engaged in terms of describing the effects of power, the work of Michel Pecheux, following Althusser (1998), may provide one way to consider the topic of ideology in relation to science and the discourse on careers. Pecheux (1994), using Žižek,’s (1994) interpretation, essentially claims that a key strategy of ideology is to essentially say “Look, you can see for yourself how things are!” – that is, to make a claim to the self-evident, something Barthes (1972) also assigns to the ideological rhetorical strategies of the right. Disregarding the veracity of truth claims in science, can we not also say that even within science any statement that uses this rhetorical strategy declares something in an ideological way? As Žižek (1994) elaborates – “facts never ‘speak for themselves’ but are always made to speak by a network of discursive devices” (p. 11).

Žižek (1994) gives the point of the ‘ecological problematic’ in that the very definition of this scientific field/phenomenon is up for grabs by the many authoritarian approaches (socialist, global capitalist, activist, corporate, governmental science body) that give it authority. At the same time, as Bourdieu argues, all educational academic institutions are also ideological institutions for maintenance of class divisions in terms of the distribution of personal capital (Eagleton and Bourdieu, 1992). Bourdieu makes the rather counter-intuitive claim that,

the further you go down the social scale the more they believe in natural talents or gifts – the more they believe that those who are successful are naturally endowed with intellectual capacities. And the more they accept their own exclusion, the more they believe they are stupid, the more they say ‘Yes, I was no good at English, I was no good at French, I was no good at mathematics’” (p. 114).
One notion found within the work of Althusser which I feel has been relatively unexplored in science education is the notion that it is *not one's inner self* that primarily causes us to act, but it is the *acting with retroactively constitutes us as ideological subjects*. For example, the act of kneeling and praying does not necessarily originate with an inner conviction but starts with a practice that “creates” or constitutes the inner conviction in that if one kneels and prays one is often always already made to think that they’ve done so simply by some inner conviction (Although the two most certainly do reinforce each other). The external manifestations (often found in ideological apparatuses such as the school where bodies are ordered) also *produce their ideological foundation*. *Is it not also of pressing concern to consider what this may mean for lab practices and investigation in science education?* Here we have a situation where students act in a repetitive manner. As science educators have we considered what kinds of ideological subjects this constitutes in a repeated, retroactive manner? The advantage in switching to Foucault’s predecessor Althusser, is that in this regard we can also begin to imagine a top-down approach to the constitution of subjects – while in Foucault we often remain in the bottom-up.

### 8.5.1 Liberalism as Ideology

It seems to me that one ideology (not to be understood as false consciousness but an ordering of the social fabric) coming out of the science education texts pertains to the ideology of liberalism (which includes forms of neoliberalism). Here I specifically mean the maintenance and illusion of choice – that is – that we are all free to decide particular choices such as consumer and career choice – the associated subject of this ideology being the rational consumer or economic subject – *homo economicus*. Liberalism as ideology is found both in the materialized (ideological) apparatuses of the state sanctioned education but also in the everyday “self-evident” experience of students. Considering some aspects of liberalism as an ideology according to how it is portrayed in science textbooks can shed some light on the discourse of careers found in these textbooks. In terms of the discourse of careers, liberal ideology critique would entail recognizing that “*no choice is in fact a free choice*” in that options are highly constrained concerning the *choices available* for careers (see Appendix A). Slavoj Žižek (2005), in his essay *Against Human Rights*, outlines the liberal “attitude” of the professions in that “the modern notion of profession implies that I experience myself as an individual who is not directly ‘born into’ his social role. What I will become depends on the interplay between contingent social circumstances and my free choice” (p. 119). But as Žižek (2005) maintains “a choice is
always a meta-choice, a choice of the modality of choice itself” (p. 118). It may be interesting to expand here the ideology of choice as it may be that students do not choose a career in science for a circumstantial reason (which exposes some of the ideology of choice) but also what if students effectively reject the modality of “career choice”. Žižek makes the point here that in medieval times it would be odd to claim that a serf would have a profession – or a king for that matter. Can we imagine people today not “choosing” careers? And if they do not make this choice are they not in some way rejecting the entire modality of choice or are they seen as “not having made a choice”? In this way, through science education career considerations, we can start to see the cracks of the (neo)liberal edifice of our society. Students who want to live their lives outside of producing or exercising capital (in volunteer or community positions) would effectively then have rejected this choice. To offer this option in a repeated manner, say as an activist, religious community member, or a stay-at-home family member does not exist in the textbooks I have examined (but can we imagine it existing?). What we have taken for the rational actor is instead an actor that is intended to pursue happiness through the pursuit of work (through capital or labour); in fact it is her duty, leaving little room for other kinds of sacrifices or duties.

These ideological considerations tie into what Rikowski’s (2011) thesis that schools nowadays have the function of producing human capital (humans as capital), where “the ruling ideology endeavors to sell us the very insecurities caused by the dismantling of the welfare state as the opportunities for new freedoms” (Žižek, 2005, p. 118) (see recently, the movie “won’t back down”). Going back to the discourse on careers and thinking about all the skills, personality traits, and expectations science textbooks attribute to the “selves we must be” we can take Žižek’s (2005) point that today we view changes in our choices of financial investment as the outcome of a particular type of personality (the tendency to escape from financial planning or in the case of careers in science, having the proper dispositions to “be a doctor”). In other words – a centering of self as a central rational actor - instead of adherence to the almighty market and its driven priorities which in turn describe labour realities for most people in the world. Fredric Jameson (1994) gives us clear terms for our perhaps the most taken-for-granted ideology of our times: “‘the market is in human nature’ is the proposition that cannot be allowed to stand unchallenged; in my opinion it is the most crucial terrain of ideological struggle in our time” (p. 98).
8.6 Considerations of Method when considering Lab Activities as a Series of Practices

In this section I would like to focus on discourses that specifically orient students toward lab activities/investigations/performance tasks. While this methodological aspect is related to practices in science education, it is through discourse that we can come to know what these practices entail as well as their potential effects. Science education research, more than ever is finding itself beholden to the imperative of producing a work force in the sciences, a citizenry, that is scientifically literate (Hodson, 2011). The consideration of lab activities/investigations/performance tasks as a series of repetitive practices in this thesis is informed by the idea that subjectification through ideology occurs within practices – to put it another way, “this is the location of ideology”.

In order to analyze activities that students engage in repetitively, I have isolated lab investigations, activities, and performance tasks in all of the textbooks. This essentially includes all of the laboratory investigations and also those activities that require students to engage with multifaceted complex data sets where the outcome of the investigation or the engagement cannot be easily deduced before hand – which includes performance tasks (to produce a product, ex. video). In the end I made a distinction between these kinds of activities and “mini-labs”, “thinking labs”, and demonstrations because most often the concept they are meant to illustrate could be easily determined before hand by students – thus I did not consider some of them an activity in the full sense as students did not have to engage with complex tasks (setting up apparatuses, research, analyzing compile of data) and therefore considered their status as being to close to “conceptual activities” such as the questions at the end of chapters (which would often suggest students “try” things but not necessarily do them). In the Mcgraw Hill textbooks I decided not to include “thinking lab activities” as part of the series of lab activities/investigations/performance tasks because they often were too short to constitute a real hands on activity where students were made to go through an activity with a research object, lab materials, or lengthy research study guidelines. In the Nelson textbooks some of these mini-lab activities included in-depth representational data that required fairly extensive engagement so I felt these could be counted in the series of lab activities/investigations/performance tasks. Any activities that were not extensive, structured activities were not used as these were considered as simply long questions with predictable ‘answers’, and do not represent any kind of action by the
students being taken. Admittedly the definition of activity versus non-activity has only been loosely defined. Ideally an activity would be consist of diverse practices that students and teachers thought embodied a kind of ‘doing’ of science. Here I have made a more open, personally defined category of ‘activity’ by trying to sort activities whereby teachers and students feel they ‘would have’ engaged in some kind of activity. Large research projects were included as these often involved students coordinating large amounts of texts, dialoguing and writing multiple documents that I count as engaging in science practice. The data displayed in appendix E and in the examples below is the result of this selection process from each of the four textbooks. I want to suggest here that these activities represent a set of practices that contribute to the subjectification of students in a number of ways that will be developed here to different degrees: 1) First, they can be thought of, loosely, as a set of practices set out to prepare learners for engagement with both the world of science work and literacy in a broad sense; 2) Secondly, as alluded to in the introduction to the chapter, they can be thought of as part of the process to constitute humans as capital through the various skills and attitudes needed to enter the world of (science) work; 3) Thirdly, they can be thought of as a series of practices whereby the subjectivity of students is constituted through a series of repeated activities. That is, a set of practices in regards to science learning that needs to be repeated for the aims of subjectification to be realized (and these are open to debate). In this section and the next I will speak primarily of the first and the third aspects by first describing how they encapsulate what science learning is for students and what it is not (first aspect).

What I was trying to determine in this series of lab activities/investigations/performance tasks is how repetition works to form a kind of subjectivity in science through activities. In the case of these textbooks, as we shall see, this series of practices does not challenge the norms of science, but rather orients students towards correct answers to questions through controlled experiments. In other words, though these activities have many merits, science educators must ask what the repeated message entails in a series of practices and how this series inherently makes a break in this repetition difficult. A question that arises, and will be discussed afterward is, what is then considered as a break in repetitive subjectifying practices? Following Judith Butler and Louis Althusser I would like to try and describe the stakes, effects, and importance of coming to view this set of practices as a key process of subjectification, and how it is here that critical science educators can proceed in a process of intentional disruption of subjectification.
8.7 Science Investigations: Constituting the Subject in Repetition

In taking the list of Lab Activities/Investigations/performance tasks several features seem to be quite noticeable – that is repeated. The purpose of this aspect of the analysis is not to quantify or pinpoint specifically what is being repeated and what is not. I think this would require a more in depth analysis to define the scope of laboratory activities, which would detail the methods and modes of inquiry involved as well as the material processes involved. Instead I would have the reader, if anything, consider this section of the chapter to be a methodological exercise/experiment in the possible role of repetition related to Althusser’s work on interpellation. I should iterate that the inclusion of performance tasks, which are often project tasks and not laboratory inquiries, does provide a kind of “natural interruption” to the lab activities/investigations because students in these activities can ostensibly engage social, ethical and political issues. However, I also would argue that these activities are few and far between as can be seen in Appendix E (and there is no guarantee that teachers will choose these over more standard lab activities in an already extensive curriculum).

8.7.1 Skills and Closed Ended Activities

The lab activities listed in Appendix C largely focus on particular technical skills such as estimation, categorization, observing, and identifying, measuring, and comparing. Furthermore skills of identifying procedural error, sources of error in data, and suggestions for procedure improvement were in most laboratory instruction. Although I have not produced a catalogue of these skills many can be found in each procedure of each lab investigation. Safety rules or skills can also regularly be found in each investigation.

Almost all lab activities were close ended in two basic ways. First, lab activities were very seldom tied to broad community or sociopolitical contexts, the exception being some of the performance task activities, however even among these the engagement with broader social and political contexts was often unclear or absent. Secondly, generally all laboratory and even most of the performance tasks were close ended in that the results of the activity or research are/were already known. Even when students are asked to design a procedure for an investigation they were always investigating a process or an effect where the outcome is highly controlled and known. Students never had opportunities to research new questions or challenge existing assumptions through research (though some research projects have students report or debate
already existing information). The questions that do exist in these lab investigations often have students apply the results of their activity to the concepts they are already learning. It therefore is quite understandable that the vague instruction of “draw reasonable conclusions, finds its way into several of the investigations. If we take it in its inverted form – we can read this as “do not think beyond the scope of the data”!

8.7.2 Constituted for Work?

I have labeled this subsection in the form of a naïve question. Of course lab activities/investigations/performance tasks certainly do constitute students for (science) work, but how do we formulate useful questions about this link? That is, how is the subjectivity produced here vital for work? As I near the end of my analysis I feel I can only answer this question in one particular way. That is students are being prepared to work in a world of science where open ended questions and connection with the community are less important while a focus on skills and the consolidation of concepts takes precedence. Subjectification through repetition occurs also according to what students are NOT doing. If science as Žižek claims is ideological (and also therefore less a site of “class” antagonism) what kinds of repeated activities should students be doing to raise social awareness? think it important to note that I did these labs too as a teacher – many of them – and I thought some of them were provoking students and allowed them to be innovative and creative. However, after considering these labs and activities in a series I am not overly convinced of this.

8.8 Disrupting a Series of Practices

To conclude this chapter I would like to outline a theoretical understanding of this series of lab activities/investigations/performance tasks, and the importance of disrupting any series of constituting practices. At this point, we can say that the link between human capital, the discourse on careers and the series of activities is essentially that considerations of subjectivity can link how these discourses and practices (given through discourse) re-enforce a certain kind of political-economic subject.
8.9 Judith Butler on (Mis)recognition, Interpellation, and the Possibilities for (Science) Education

... an ideology always exists in an apparatus, and its practice, or practices. (Althusser, 1998, p. 156)

Using Butler (1997) as a guide I will now elaborate slightly on how interpellation in the Althusserian sense can provide a vision of how we are to see a series of practices or lab investigations. Interpellation is not to be understood as an “event”, but involves all that goes into setting the context for the call or hailing. The “turning around” after being hailed, the act that confirms a subject's relation to the law (in the abstract) and her own subjecthood, requires both the ‘call of the law’ and the subject’s ‘receptiveness to being hailed’. Temporally, we can ask what happens before the turn, that is, before the subject turns to the law, before the moment when the subject emerges as a subject of the law. The reason why this question is important is that individuals, according to Althusser are always already subjects, thus there already exists a compulsion to turn towards the law before a command is given. I contend that the series of lab activities exists as a set of practices that constitute a particular type of subject (a depoliticized one), and therefore we must understand that students and teachers do not necessarily ask critical questions before they are being hailed in the ideological apparatuses involved in science education. As Butler (1997) states:

The one addressed is compelled to turn toward the law prior to any possibility of asking a series of critical questions: Who is speaking? Why should I turn around? Why should I accept the terms of which I am hailed?” (p. 108).

As I’ve stated before, this means students and teachers must ask after the constitution of subjectivity. However, in terms of pursuing change in science education it may often not be enough to ask critical questions after the fact!

In dealing with a series of practices that work to constitute subjectivity science educators must think about what they would like students to do before they come to being hailed in a series of practices. That is, by the time students are “hailed” to do a laboratory activity as ‘scientists’ something they themselves are expecting in formal schooling, it is always already too late. Butler makes the point that criticality towards the law is limited by an already present desire or complicity towards the law (before being hailed). Thus in terms of science we can see that students always already understand they must engage science and its lab activities -
representative of the law in the abstract. This is all to say that the struggle here seems to be is to interrupt and replace the series of activities (representative of the law in the abstract) with new practices! Critiquing this series of lab activities (and seeing them as representative of the “law”) then also means that if science educators are to undo this series then they must be prepared to be changed irrevocably, as adherence to the law confirms our constitution as subjects. **To change in fundamental ways, the series of lab investigations/activities/performance tasks must also change, the science student, educator and scientists – the subjects of science education - in irrevocable ways!**

Althusser (1998) relates the problem of “speaking properly” to the ideological formation of the subject in terms of labour power. Butler (1997) elaborations this point: The “‘diverse skills’” of labour power must be reproduced, and increasingly this reproduction happens “outside the firm” and in *school*, that is outside production and in educational institutions. The skills to be learned, above all, *are the skills of speech*” (p. 116). The fact that the series of lab investigations resemble an attempt to have students master particular skills for the purposes of labour in science also allows us to consider the linkage between subjection and mastery in that, **according to Althusser, subjection to the ruling ideology involves mastery of its practices.** As Butler states, “the more a practice is mastered, the more fully subjection takes place (p. 116). This paradoxical relationship outlines the stakes involved in lab investigation activities – once students approach mastery of the skills and concepts involved, which commonsensically would seem to afford student more opportunities and freedom (from subjection), this mastery also furthers their own subjection, in that these students may certainly be less free to (re)conceive and (re)investigate questions and practices of scientific inquiry (Foucault (1977) too, more or less, uses this formulation in Discipline and Punish where a subject is both that which is under submission but also finds her autonomy only under this subjectivation).

Though one might expect submission to consist in yielding to an externally imposed dominant order and to be marked by a loss of control and mastery, paradoxically, it is itself marked by mastery… In this view neither submission nor mastery is performed by a subject; the lived simultaneity of submission as mastery, and mastery as submission, is the condition of possibility for the emergence of the subject (p. 116).

While we are speaking of the mastery of skills in general and I think it important to keep *science skills* in mind. Butler (1997) elaborates here:
To say that the subject performs according to a set of skills is, as it were to take grammar at its word: there is a subject who encounters a set of skills to be learned, learns them or fails to learn them, and then and only then can it be said either to have mastered those skills or not. To master a set of skills is not simply to accept a set of skills, but to reproduce them in and as one’s own activity. This is not simply to act according to a set of rules, but to embody rules in the course of action and to reproduce those rules in embodied rituals of action (p. 119).

Here we are getting to a central tenet of Althusser’s theories of subjection in that it is “the repetition of performance a belief is spawned” (p. 199). This picks up from the point made by Žižek, concerning Althusser above, that the ideological subject is not necessarily constituted by a consciousness shift in terms of a dominant ideology, but rather through the repetitive performance of a set of skills where subjection is based on their mastery. Taking this quite literally this means that through the repetitive mastery of science skills through lab investigation the subject emerges. While some would see this explanation of subject constitution as incompatible with the constitution of subjectivity through discourse I see Foucault as advocating something similar through his focus on micropractices of power - that is from the ground up whereas Althusser’s Marxist orientation is still, though it is concerned with the subject of ideology, is more or less concerned with top-down power and the superstructure. These repetitive practices materialize within an apparatus – in this case the school. But there is a limit to these practices according to Foucault, and here I will paraphrase Butler (1997):

For Foucault, the subject who is produced through subjection is not produced at an instant of its totality. Instead, it is in the process of being produced, it is repeatedly produced (which is not the same as being produced anew again and again). It is precisely the possibility of a repetition which does not consolidate that dissociated unity, the subject, but which proliferates effects which undermine the force of normalization (p. 93).

That is, as Butler further elaborates, “it is in the possibility of a repetition that repeats against its origin that subjection might be understood to draw its inadvertent enabling power”. In the designation of new student lab activities we can find the power to enable new kinds of practices that will in fact establish their own regime of subjectification.

Ultimately this will involve forms of misrecognition where the subject (student) will eventually not recognize herself as being hailed by a particular lab activity/investigation. Indeed it already happens in science classes today that attempt to do investigations “outside the box”. I
have found from my own experiences as a science educator that students are the first to protest with phrases like: “This is not science”; “This is not what other classes are learning”; “When are we going to do real science”. When students say this, there is recognition of being a student but partial misrecognition of being a student of science (and reprimand of the teacher by the law in the abstract!). But my hope is that students and teachers will eventually not necessarily misrecognize a possible science investigation/activity (as the lab investigations in the books have many good aspects to them) but will rather “insist on not being addressed in that way” (Butler, 1997, 95). That is to say students and teachers will insist on not recognizing certain aspects of themselves as scientists being addressed by lab activities. In other words some part will say, “This, on its own, is not science or this kind of activity will not lead to a proper “scientist identity”. One way to begin is to give students and teachers license to their own imaginations, as a place where what is asked of us symbolically (in Lacanian terms), does not always respond as demanded. However it is not just in disruption of a repetitive practice that can lead to disruption of subjectification. It is also the removal of these practices; here Butler elaborates:

Indeed, I would add, a subject only remains a subject through a reiteration and rearticulation of itself as a subject, and this dependency of the subject on repetition for coherence may constitute the subject’s incoherence, it’s incomplete character (p. 99).

The site of repetition is the place both of disruption and for “re-embodying the subjectivating norm that can redirect its normativity” (p. 99). However, a criticism of the law cannot fall too far away from the terms by which one is constituted; but Butler asks if there is not a possibility of escaping the full force of the law without denying our complicity to it. In terms of the “subject of science”, as Patti Lather (2012) puts it, it will mean the disruption of this repetition and the openness to what is either beyond the reach of interpellation and subjectivation – by reworking the very passionate attachment to subjection itself!

Here I see Larry Bencze’s (Bencze and Carter, 2011) STEPWISE framework as having the capacity to combat the influence of neoliberal global capitalism in science education by centering the well being of communities and individuals at its primary focus. The framework maintains that science education can begin at any point, for example taking action or learning content, must always be contextualized and imbedded in sociopolitical action for the common good, and continually examine the nature of science in relation to the sociocultural environment
in which it finds itself. Interruption of the series of lab investigations which continually work to constitute a skills-oriented and de-politicized subjectivity, opens the way for science educators to develop a science education that resists a close-ended, community-detached science education. This is not to say that the framework remain static, for example the boundaries school science can easily transcend the network of actors and material objects that make science possible (Latour, 2005). Bencze’s framework avoids the “add-on” approach to sociopolitical engagement (one question at the end of an investigation for example), which, rather than promote change at a fundamental level, works to keep what Bencze & Carter (2011) call the status quo. For me, what is most salient here is not the ontological or epistemological assumptions of Bencze’s STEPWISE framework (based on Latour’s (1986) actor-network theory), but the radical space it opens for science educators to refuse what has typically been thought of as proper scientific investigation within the context of school science. STEPWISE’s lasting potential lies in its “achievement” of a radical moment when educators can disrupt power relations constitutive practices (what is done and how this formulates a subjectivity), and the purposes of science (which needs a fundamental ideological shift towards human welfare and not a depoliticized quest for knowledge). Science educators need to inquire whether what they do with students works toward, or side steps, social and political change.
Chapter 9: Science education as a site for biopolitical engagement and the reworking of subjectivities

“Maybe the target nowadays is not to discover what we are, but to refuse what we are”
(Foucault, 1982, p. 785).

As I stated at the beginning, this thesis is at least half a theoretical exploration, this chapter involves seeing science education as a site for biopolitical engagement and the reworking of subjectivities. This chapter is part of this thesis because it is a kind of culmination of my thinking concerning Foucauldian subjectivity and science education, and also represents a framework by which I want to examine science education policy as it relates to environmental and biotechnological issues. This chapter represents the culmination of the time I worked on this thesis study and is currently setting the context for future research.

Science’s literal inseparability from life can be seen in the context of the new radio telescope being built in Australasia and Africa; one of its primary purposes is to search the universe for life (Amos, 2012). In a very real way scientific research, even in the coldest and darkest of places (outer space), is in every sense invested in life and how we come to think of ourselves in the world. Science’s necessary concern with all aspects of life makes it a fertile site for biopolitical action, that is intervening in the way discourses of what is true about life govern and order bodies, and define acceptable practices, future actions and statements. At the same time science takes a “naturalized” position as arbiter over many aspects of human life it is also infused with many social and political agendas such as the instillation of self-regulatory behaviour and ‘responsibleization’ of globalized neoliberalism. These intertwining contexts provide fertile ground for science educators and students who wish to be both critical and active in terms of the way science is practiced, to view science education as an integral part of what Foucault calls biopower, and to therefore subsequently intervene by engaging biopolitically. I am relating the terms biopower and biopolitics in the way Hardt and Negri (2009) do. Simply put, biopower represents control and exploitation of life forces and human bodies, and biopolitics operates in opposition, on the same terrain of bodies and subjectivities, and represents the
promise of new, reworked subjectivities and ontologies. This final content chapter attempts to set a detailed theoretical context for viewing science education as a site of (biopolitical) struggle over what constitutes (human) life, and how the subjectivities students and teachers are constituted through science education. This involves giving attention to how practices, discourses, and material relations maintained and created through science and science education constitute particular kinds of subjectivities; and then reworking these subjectivities towards different possibilities for thought and action. Biopolitics has been, and will continue to be, used differently depending on the particular theoretical focus or analytical necessity.

This chapter draws from the Foucauldian notions of subjectivity discussed in the rest of the thesis, Rabinow and Rose’s (2006) elaboration of Biopower, and Hardt and Negri’s (2009) notions of the biopolitical in order to think about how science education can be seen as a site of biopolitics and biopolitical struggle over subjectivities. It is not intended to provide a complete theoretical framework for biopolitics in science education since a completed framework would be more or less antithetical to the goals of freedom inherent in biopolitical engagement. It is instead meant to be a step towards conceptualizing science education in terms of a struggle over the production of subjectivity, as well as the organization of bodies and conceptions of human life. This involves considering science education as a site where subjectivities are produced (in conjunction with other sites) and also reworked in dynamic social, cultural, political and economic contexts that neither the metaphor of “schooling as emancipatory project” nor as “disciplinary apparatus” can fully encompass. Rethinking science education along biopolitical lines can unite parallel, ongoing struggles within science education, for example against white supremacy, western hegemony, heteronormitity, neoliberal restructuring and indoctrination, class/social exclusion, and complicity with environmental destruction. Due to its many possible forms, biopolitics remains a necessarily ongoing and unpredictable field of possible political intervention and thought.

This chapter contains three inter-related parts to provide a theoretical constellation for thinking about science education as a site of biopolitical struggle. First, the context for science education will be (re)addressed, followed by some background notes concerning biopolitics and Foucauldian notions of subjectivity. Afterwards a notion of biopolitics as a way to reconceptualize science education as a site of political struggle over subjectivity will be developed.
9.1 A Context For Science Education

Science education’s interstitial locus between the discourses of science (ex. biotechnology and human ecology), and the motives behind public and private educational initiatives make it an idea place to think and act biopolitically. While I have attempted elsewhere to articulate a case for the consideration of subjectivities in science education as they are constituted through discourse, disjuncts, and power relations (Bazzul, 2012), there is still very much a need to describe the broad political, sociocultural and historical contexts inquiry into the constitution of subjectivity may take. These contexts and various forms of struggle should seek alliances amongst those who declare the need for a more sociopolitical and culturally engaged science education (Carter, 2011b; Barton, 2003). Like Angela Calabrese-Barton and others (such as Bencze and Carter, 2011; Roth, 2009), I see the desperate need for a more politicized and theoretically divergent way of highlighting the cultural, political, and social contexts of science and science education. While I agree with Derek Hodson’s (2011) call for a less conservative, more socially just and active, science education there also simultaneously needs to be spaces opened for alternative ways of thinking and acting in science education. These spaces will necessarily not align with the status quo (what has already been articulated) within science education literature, its disciplinary walls, and its foci of citizenship and democratic (individual) decision making; all of which, while valuable, often do not significantly challenge fundamental assumptions about how we are to act and think politically regarding science and schooling.

Challenging assumptions requires the allowance to think alternatively, especially in a field that is insular and rather isolated from other disciplines (Carter, 2011a). What seems to be a troubling practice in science education scholarship is the easy reverence given to STS, STSE, ecological literacy, and other acronyms/catch words that offer little in the way of political, sociocultural, or philosophical transparency. One problem with this kind of discourse is that the political positions they embody (ex. those aligned with state power) are simultaneously obscured, hidden in science education initiatives and jargon created by senior researchers and government bureaucrats, yet also exercised “in the open” as can be seen in the way science educators “self-reference” (ad nauseum) a field already well known to be politically conservative (see J. Lemke, 2011). Seeing the use of science education jargon as neither conservative nor radical it is important that we fundamentally question the focus on initiatives such as citizen-power-as-usual, scientific literacy, as well as the apparent pressure of having to always encapsulate the vast field
of science education “correctly”. This compulsion to package science education, hide in field-jargon, and adopt elusive political positions, while useful for normalizing science education, makes calls for radical action, alternatives, and insubordination rather difficult (and if we take Jacques Rancière seriously then it is only when we are being insubordinate, working towards dissensus, that we are truly acting politically (Rancière and Corcoran, 2010)). I take encouragement from Sandra Harding’s (2006) call for openness regarding the increasingly apparent political, social, and cultural contexts of scientific knowledge (so often case in a negative light):

> What if the goal were not to eliminate all such values and interests, but instead (as indicated above), to evaluate whether there are patterns of productive relations between culture and knowledge, and between prodemocratic culture and knowledge that can advance democratic social relations as well as the growth of knowledge (p. 51).

Conceiving of science education as a site for biopolitics and biopolitical intervention can be a way to explore, rework, and intervene in productive relations between the discourses of science and how these work to constitute the subjectivities of students in various ways.

### 9.2 Biopolitics and Biopower

The word ‘biopolitics’ can refer to different processes and analytical fields depending on who is deploying the term. A particularly useful description of these differences can be found in the both in the work of Maarten Simons (2006) and Thomas Lemke (2011). The notion of biopolitics presented here will not be limited to environmentalist conceptions (where ecological concerns become a basis for politics) nor a kind of bioethicist version (where legal or moral questions directly related to biology become the sole basis for political action) (see T. Lemke, 2011, chapter 2). In addition, other theoretical conceptions of biopolitics have been excluded for brevity such as the work of Giorgio Agamben whose work does not seem to give enough attention to the specific historical circumstances of modernity when it comes to thinking about biopolitics. Though the meaning and use of biopolitics can necessarily change depending on the context of its use, this chapter will attempt to employ as much as possible Michel Foucault’s envisioning of the concept.
Foucault’s historical work (Foucault, 1977; Foucault, 1980; Foucault and Senellart, 2010) investigated the shift of sovereign power and its disciplinary practices on the body (public executions, physical brutality) to practices linked to the management of populations in the seventeenth century. That is, “a power bent on gathering forces, making them grow, and ordering them, rather than one dedicated to impeding them, making them submit, or destroying them” (Foucault, 1980, 136). As Rabinow and Rose (2006) elaborate, power had become “situated and exercised at the level of life” (p. 196). In other words, power exercised in the ‘taking’ of life becomes diminished, while the power to foster, and in some cases stunt, life begins to take shape in early modernity and these changes represent a shift towards the development of biopower.

As Foucault (1980) maintains, “biological existence was reflected in political existence” (p. 143). Therefore, in modernity we have two poles of governance, the discipline of the body and management of the population. The discipline of individuals and the regulation of populations are not two extremes but rather two sides of the same “global political technology that simultaneously aims at the control of the human as individual” (p. 38). Moving forward, biopolitics, the way it is used entails a focus on biopower and the ways in which human life is controlled at the population level through practices such as preventative health, statistical analysis and material infrastructure. A point of confusion may sometimes centre on whether technologies and discourses of biopower are not themselves forms of biopolitics; or is biopolitics specifically the intervention and struggle against forms of biopower? While the former seems quite reasonable, the latter seems to make more definitive sense, and is a general distinction, from Hardt and Negri (2009) used in this essay, it should be acknowledged that practices of biopower and biopolitical interventions into this form of power are, to a substantial degree, inseparable.

Paul Rabinow and Nikolas Rose’s (2006) treatment of biopolitics provides space for both further theorizing and ‘molecular’ analyses of how biopower operates. They describe biopolitics as a term used,

...to embrace all the specific strategies and contestations over problematizations of collective human vitality, morbidity and mortality; over the forms of knowledge, regimes of authority and practices of intervention that are desirable, legitimate, and efficacious (p. 197).
They describe a plane of actuality for biopower encompassing three interrelated elements. These elements are very relevant to science education for several reasons, some of which are also listed in table 1.

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<tr>
<th>Elements of Biopower</th>
<th>Relation to Science Education</th>
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<tr>
<td>1) One or more truth discourses about the ‘vital’ character of living beings, and an array of authorities considered competent to speak the truth</td>
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<tr>
<td>2) Strategies for intervention upon collective existence in the name of life and health, initially addressed to populations...sometimes specified in terms of race, ethnicity, gender or religion, as in the emerging forms of genetic or biological citizenship</td>
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<td>3) Modes of subjectification, through which individuals are brought to work on themselves, under certain forms of authority, in relation to truth discourses, by means of practices of self...or indeed in the name of life or health of the population as a whole</td>
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<tr>
<td>1) Once biology even implies the application of its knowledge(s) to human life there is a situation set up (for better or for worse) whereby an authority speaks</td>
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<tr>
<td>2) Science and science education are involved with regimes of health and population management; education materials are replete with exercises concerned with problems of collective existence</td>
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<tr>
<td>3) How does science education constitute subjects? “Who” can think and act in scientific ways or in the name of science? What relationship to self is required to think and take action in science?</td>
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Table 1. Elements of Rabinow and Rose’s (2006, p. 197) notion of biopower and their relation to science education

Rabinow and Rose sensibly differentiate between engaging the macro and micro poles of biopower through biopolitics. That is, thinking broadly about the governing and administering of bodies at the population level but also looking at individual strategies of biopower and subsequent biopolitical intervention. It is in micro or molecular practices of biopower that science educators can intervene biopolitically. This may involve looking at curriculum materials for modes of subjectification or the role of space in schooling and science education in upholding a particular agenda (see Ken Tobin’s (2011) article regarding how science education achieves neoliberal ends). Rose’s (2000) theoretical work on genomic research and biotechnology offer good starting points for science educators willing to take up difficult questions about the shifting nature of bodies, subjectivities, and their subsequent management and production.

Finally, Hardt and Negri (2009) offer those willing to engage biopolitically a broad political vision of what biopolitics could look like by interweaving the concept closely within both a politico-economic and philosophical framework. Hardt and Negri take the concept of
biopolitics and infuse it with a clear anti-capitalist political directive, emphasizing the production of subjectivities through the invasion of capital into all spaces of life where value is produced and then subsequently usurped by mechanisms of biopower. Undergirding Hardt and Negri’s version of biopolitics is their conception of empire, a new era of capitalism nobody remains untouched by global capitalism or immune to capitalist subjectifications in the (re)production of affects, bodies, and subjectivities (Hardt and Negri, 2000). Their notion of empire involves the exploitation of immaterial labour, individuals and collectives to extract surplus value. To put it in line with Rabinow and Rose (2006), empire is a global regime of biopower regulating social life by having self-responsible individuals continually reactivate this power in their own lives. It both produces subjects and is in turn reproduced by these subjects through immaterial labour - which is why subjectivity needs to be an important focal point for critical (science) educators! Biopolitics is concerned with the production of life in its social and economic forms, and as Hardt and Negri argue in Commonwealth the production of subjectivities. Biopolitics then is not a political position itself, but the inextricability of life and politics.

One of the base philosophical considerations for Hardt and Negri’s biopolitics involves a reckoning with two forces of modernity, one of the immanence of human powers (of reason) and one of transcendent power that aims to restore order. For these authors the discovery of immanent creative forces is one of the primary events of modernity, where human beings “discover” their power in the world by realizing the potential of reason that exists right before them in this world (and not in a transcendent other). Thus, at the beginning of modernity knowledge shifts from transcendent ways of knowing towards a practice of doing and transformation – “… the powers of creation that had previously been consigned to the heavens are now brought down to earth” (p. 73). It is through this force of modernity, that of immanence, were singular freedoms and new subjectivities can be attained, as there is no external (above) mediation. The second mode or force of modernity arises to “wage war against the new forces and establish an overarching power to dominate them” (p. 74). Consequently, modernity can be seen as a constant battle between immanent creative forces and forces of transcendence and control, aimed at restoring order and disciplining subjects. For Hardt and Negri it is important to recognize the danger of a transcendent control over human thought, action, and subjectivity as it is in direct conflict with the realization of immanent possibilities. The dangers of transcendental control are demonstrated in they way Hardt and Negri (2009) describe fundamentalisms, as these
always appeal to transcendental concepts that are meant to unify ontologies and ethics. They are notorious, the authors claim, for their double focus on the body (and thus are able to employ biopower), as they simultaneously are obsessed with the body (what it is, what it does) and at the same time make the body disappear (refute bodies). In biology, a fundamentalist view of the “nature” of human beings relies on an understanding of the body (as a particular kind of mammal or set of genomic instructions) yet precisely because there is an adherence to a transcendental concept (ex. natural selection conceived in dogmatic terms) alternate behaviours of the body are neglected (ex. homosexuality is labeled as a malfunction or anomaly – it disappears).

This explanation of modernity as two countervailing forces is best understood as part of an overall narrative for Hardt and Negri’s biopolitics. We can choose to foster the immanent forces of modernity over the forces that subordinate and bring singularities and difference under universal control. Likewise we can choose to resist the way structures, dispotifis, and discourses of modernity have constituted human life and subjectivities as well as disrupt and even shrewdly manipulate the forces of biopower through political action in order to intercede in the way modes of life and subjectivities have been produced. In science and science education this means asking after how it has come to be that we find particular, contingent ways of thinking about science and human beings natural.

In *Commonwealth* Hardt and Negri (2009) put some ideas and conditions forward for a broad vision of biopolitics that can provide guidelines for the remaking of (struggle over) subjectivities in science education. Though these aspects are general in nature, they do provide guidance for what it might mean to engage biopolitically as science students and educators.

*Free and accessible knowledge* - Knowledge must be made free and accessible. Educational efforts towards equity must focus on giving all students the competencies and tools to access this knowledge so that the reworking and production of subjectivities, organization of bodies continues.

*Tearing Down Hierarchies* - Seeing science education as a site for biopolitics means tearing down hierarchies and using science to achieve these political ends. Science education might do as Michael Hardt (2010) insists and tear down hierarchies as the educational process unfolds.
Trouble the “Expert” - De-privilege the voice of the expert (read education expert), which tells us we have no choice. Wealth comes from below, not through neoliberal efficiencies or extraction of value for the elite classes that could otherwise be put into research and development.

Inclusiveness - Science education must be an inclusive enterprise as those subjectivities at the “precarious edges” of politics and production have the greatest capacity to challenge how we’ve come to be constructed as subjects and speak against the mechanisms of biopower.

Preserve the natural commons - Biopolitical reason must put the “natural” world to work without consuming it completely. It must put its rationality to the service of life, ecology and social relations, between humans and nonhumans.

As a last word to this section, there is no reason why different articulations of biopolitics and biopower cannot be employed simultaneously by different scholars in different contexts. In the next section I will significantly shift focus towards the production and constitution of subjectivities, a key aspect of engaging biopolitically according to Hardt and Negri.

9.3 The “Making of Subjects”

A focus on subjectivity, such as was set out in this thesis, adds a vital layer of analysis to the already apparent sociocultural and (bio)political struggles in science and science education such as privatized biotechnology, and science’s complicity with ‘the north’s’ geopolitical domination of ‘the south’, and asks after the kind of subject that is both formed by discourses in science education, and also what kind of subject is needed to take up the specific political projects already present within science education. As was demonstrated in the five previous chapters, a focus on subjectivity can help find ways to think differently about what effects discourses of science have on who we think we are, what we find important in research, and how we’ve come to see inequitable social and material conditions as natural. That is, asking how it came to be that we view particular research choices and descriptions of science as “indispensable” or taken for granted. Although I have discussed subjectivity in a fairly lengthy
way already I think it useful here to reiterate some key aspects of a Foucauldian poststructural subject as well as some different aspects not previously mentioned.

Subjection in relation to *making-the-subject* needs to be understood not as simply a process by which some exterior power subordinates individuals, though this is certainly involved. Instead individuals are formed as subjects discursively in terms of the “identity” that proceeds from the process of becoming a subject. For example, while a student is regulated and shaped by the overt disciplinary structures of school (subject to powers running through educational institutions) they also become a constituted subject when they themselves, *always already*, embody particular (idiosyncratic) relations to objects, institutions, others, and themselves. As Butler (1997) maintains,

> [s]uch subjection is the kind of power that not only unilaterally acts on a given individual as a form of domination, but also activates and forms the subject….the subject produced and the subject regulated or subordinated are one, and that compulsory production is its own form of regulation (p. 84).

Again, the subject is produced through various restrictions, limits, and the ways the subject is meant to see herself in relation to objects, meaningful action, herself. Part of the process of subjectification will involve the *perception of freedom* in this “identity”, since, as Foucault (1982) says, power “is exercised only over free subjects, and only insofar as they are free” (p. 790). Complete domination is, to Foucault, not in-line with the fundamental relational aspect of power. Interestingly, this freedom has both illusory elements, as the subject has been constituted in a particular way and not another, yet real in the sense that, to be free, the subject must have a range of choices before her – thus change is quite possible. We can see schooling then not just as the *discipline* of bodies (which is often the most common Foucauldian notion that gets peddled in education) but rather, since schools are manifestations of power relations, as *co-extensive* with the subjects that are formed within its material and discursive manifestation(s). The kinds of questions we ask in science classrooms/labs/field studies will be contingent on these subjectivities. Butler points out that it is not “kicks or thrills” that has people question the very grounds of who they are, and argues that,

One does not drive to the limits for a thrill experience, or because limits are dangerous and sexy, or because it brings us into a titillating proximity with evil. One asks about the
limits of ways of knowing because one has already run up against a crisis within the epistemological field in which one lives (Butler, 2004, p. 310).

That is to say, the question of the (subjective) foundations is raised because certain subjectivities are *unlivable* or the subject herself is *unable* to reconcile how she has been constituted with (her) lived realities.

Central to Foucauldian conceptions of subjectivity is the idea of resistance and Butler (1997) describes two basic ways the normalizing effects of power and the subjectivities they produce may be subverted. In the first instance, subjectification, and the normative aims of a discourse, exceeds the goals for which it is first intended (ex. rigorous religious education can often lead to radical political movements and vice versa). The second entails the merging of discursive regimes that produces subjects that work against the goals of normalization of either one or many of the regimes involved. I think we can see this over calls for the freedom of information - at once in line with (neo)liberal market logic, yet converse to the logic of profit and commodification of knowledge. It is also important to understand that resistance is *always already* inherent within an agonistic power relation. Butler, following Louis Althusser, maintains that the making of subjects relies on *repeated* subjectification and the temporal gaps between these moments may allow for anomalies and contradictions to appear. Indeed we saw this with the repetitive lab activities of science and their apolitical contexts and monotonous procedures! On a more basic level, Althusser (1998) maintains that there is always the possibility that subjects, in the act of being interpellated or hailed, will refuse recognition or misrecognize themselves thereby confounding the production of subjectivity. This highlights an important feature for those (educators) who wish to intervene in processes of subjectification. Namely, that practices of resistance are quite reasonably within reach as resistance to subjectification is *already inherent* in relations of power, and resides the very dispositifs (apparatuses) and discourses that produce subjects also introduce the very conditions for its subversion. As Butler (1997) argues, prior to any critical review into what makes us subjects (the law in the abstract) we must also recognize our *vulnerability* to the law. Since subjects are constituted through discourse and the truth-power nexus (law), in an almost counter-intuitive way the subject must understand its *necessary attachment* to how it has (already) been constituted before critique can continue. In order to engage in critique that challenges the very grounds of the law (what can be said, thought, and acted upon) the subject must also be willing to be *undone* by the critique (as
mentioned in the previous chapter), since the law is what has “done-up” the subject in the first place.

Foucault makes a substantial effort to outline the “doubleness” of power and the agonistic forms that arise between the dual actions of subjection and resistance. And it is through the latter, *always already* in connection with the former, that alternative subjectivities are born. Here I would like to turn back to Hardt and Negri’s (2009) reading of Foucauldian notions of power, freedom and resistance where they claim that:

We should not think of power as primary and resistance as a reaction to it; instead, paradoxical as it may sound, resistance is prior to power. Here we can appreciate the full importance of Foucault’s claim that power is exercised only over free subjects. Their freedom is prior to the exercise of power, and their resistance is simply the effort to further, expand, and strengthen that freedom (p. 81-82).

New subjectivities can be produced through resistance to power and these must involve new ways of thinking about science and researching the world. The kinds of subjectivities we want (or politically speaking *should* want) involve collectives, respect the equality of singularities, and may even defined in terms of complex social relations.

### 9.4 Biopolitics and Subjectivities in Science Education

Critique in science education, according to Foucault (1982), needs to focus on forms of power rather than one particular institution or elite group (for example sufficing to blame pharmaceutical companies for the corruption of science).

This form of power applies itself to immediate everyday life which categorizes the individual, marks him by his own individuality, attaches him to his own identity, imposes a law of truth on him which he must recognize and others must recognize in him, it is form of power that makes individual subjects (p. 781).

There are at least two levels of subjectivity related to science and biopolitics. First, there are the biopolitical struggles of subjectivity that easily fall under the purview of science (ex. What does it for the integrity of a ‘self’ now that the human genome has been sequenced?) and then subjectivities that haven’t hither-to been addressed adequately within the sciences (ex. science’s production of a “colonizer/colonized” subject). This complexity is compounded if we take
seriously Deleuze’s (1992) claim that we have moved from societies of discipline to societies of social control where the modes of governing and the production of subjectivity can no longer be isolated to sites such as the factory or the school, but must include networks made available through communication technology and media. However, it is this very elusiveness of subjective constitution in global capitalist societies of control that make the project more necessary than ever.

The following subsections represent particular ways that subjectivities in science may be constituted within a context of biopolitical engagement as presented in this thesis. They relate to ethics, neoliberalism, biotechnology, and sex/gender and are not to be thought of as a representation of the range of “real” subjectivities produced in/through science education.

9.4.1 Racisms, Colonialisms and the Power to Make Die

As we saw in chapter 5, Science and Science Education are involved in the constitution of both “colonizer/colonized” subjects; as shown here, discourses of textbooks often tacitly portray “other” modes of human life as inferior. Subjectification, in and through science education, can also have variable (hybrid) results as Elizabeth McKinley (2008) noted in her study involving the ever-shifting subjectivities of Maori women. A biopolitical focus can inform the context of research that attempts to challenge the inherent (neo)colonial, eurocentrist, white supremacist orientations of science and science education. Approaching these realities with Hardt and Negri’s (2009) notion that colonialism is part-in-parcel with the controlling forces of modernity is helpful, but perhaps more so is Ann Stoler’s (1995) engagement with notions of race and sexuality within a colonial frame. Stoler’s thought is important for the development of a biopolitical approach to colonialism and racism as she shows that racisms and colonialisms are internal to the biopolitical state. Again, colonialism (and its supporting racisms) makes it possible to for states to solve the problem of maintaining both disciplinary and regulatory regimes of control when in the regulatory society the right to kill goes against the goal of fostering life. Racism becomes a discourse to decide and designate who must die. That is, the more particular (subaltern) people die, the more “we” (privileged subjects) live. Again, racism becomes a way for the biopolitical state to retain its disciplinary power, and is justified as a kind of incomplete cleansing of the social body (T. Lemke, 2011).
In this way, it may be useful to consider how certain indigenous and local knowledges, through discourses of science education, are viscerally attacked, subsumed, or even destroyed. Is the destruction of knowledges about the natural world a manifestation of the “right to kill”? It seems possible that scientific cultures, besides being a conveyer of racist colonial discourses, might also exercise epistemological and ontological forms of the “right to kill”, under the formulation of “what knowledges must die (read indigenous and local) for ours (scientific) to live? Who, through scientific discourses like biology and pharmaceutical research is dispensable and therefore “other”? How do racisms and colonialisms function despite the universalizing aspects of science and what sociopolitical functions do they serve? How is the health of one person (as manifested in/through/because of science) in direct relation to the poverty/ill-health or death of another?

9.4.2 Neoliberal Global Capitalist Subjectivity

Matthew Weinstein (2012) argues that neoliberal reforms of science and science education are inextricably linked to a global capitalist agenda that benefits elites and therefore the consideration of neoliberal agendas must be part of any social justice movement in science education. While successful critiques and radical choices for action in science education have already been put forward (see Bencze, 2010; Bencze and Carter, 2011) ranging structural analyses are needed to challenge neoliberal realities, looking at how neoliberal subjectivity is actually constituted in science education needs to be included for any comprehensive picture to emerge. (Science) educators may look to Foucault’s (2010) lectures concerning the birth of biopolitics where he traces the history of liberalism and its relation to the modern nation state. While it may not be intuitive to imagine an entrepreneurial self in science education, one may be surprised to private research entrepreneurs like Craig Ventnor and the ways students are meant to invest in their own futures as human capital.

Broad questions that have been asked in thesis related to science and neoliberal theories are: What is the relationship between the rational self-responsible subject and that of human life as capital (read “careers in science”)? In the sciences, how are these relationships forged through normalizing discourses involving health, biotechnology, and ecological knowledge? While more work needs to be done regarding neoliberal subjectification through (science) education, research
with curriculum materials seems to suggest that economic issues discussed in textbook exercises frame the limits of thought and action around private ownership, the shared values of business and science, and corporate influence on both public and private science research (Bazzul, 2012).

9.4.3 Sex/Gender and Sexuality

In the *History of Sexuality Vol 1*. Foucault (1980) describes his interest in the topic of sexuality precisely because it takes an overt position between the two modes of power/governance (disciplinary and population/regulatory as discussed above). Sex/sexuality and gender (as performance), and the power effects that help shape this performance, are both situated on the body literally and controlled at the level of population. The erection of norms through discourse regarding personal (responsible) behaviours as well as the concerns of population health and “proper” growth (both in the past and today) make the topic of sex/gender and sexuality ideal for engaging in an analytics of biopolitics in science education. In biology textbooks, my current research focus, there very detailed concerns both in terms of sexual practices related to aids/population growth as well as issues of individual sexual behavior such as those concerned with sexually transmitted infections (it is interesting to note that AIDS is another topic that manifests the effects of power both on the population and the individual).

The philosopher Luce Irigaray (1985) is perhaps the most delightfully brazen of those who have challenged science’s gendered voice (male) under its pretense of “neuterdom”. Here she aptly predicts:

One of the places most likely to provoke a questioning of the scientific landscape is that of the examination of the subject of science and its psychic and sexed implication in discourse, discoveries and their organization (p. 79).

In science education, researchers such as Snyder and Broadway (2004) have been successful in linking discourses of sex hormones to essentialized sex/gender identities, through a process of queering, in biology textbooks. Broadway (2011) pushes the limits of queering in science by envisioning space for transformation and the love of fellow human beings as strangers, reminding those who engage in queering (with hope, all of us) that this process must not stop. Catherine Milne (2011) astutely points out that a sharp dividing practice between what is social
and cultural and what counts as science in these materials often works to exempt science and science education from answering tough questions. In this regard, Irigaray (1985) asks a painful but politically pertinent question for those who love both difficult questions and science:

[D]oes the alternative become either do science or “be a militant”? Or again to continue to do science and to divide yourself up into different functions, several persons or characters? Should the truth of science and that of life remain separate, at least for the majority of researchers? *What science and what life is then under discussion?* Especially since life in our time is greatly dominated by science and its techniques (p. 78, Italics added by author).

The expanse of sex/sexuality and gender and the way science has and continues to constrain and define people, their social relations - their very subjectivities - makes this topic a raging battleground for biopolitical action.

### 9.4.4 The “Ethical Subject” in Science Education

Science education discourses may also constitute a specific kind of ethical subject, how one is meant to think and act along ethical lines. What does it mean to be and/or think of one’s self as an ethical subject in spaces of formalized science education? This will involve thinking about “the way a human being turns himself into a subject” (Foucault, 1982, p. 778) as well as these specific relations to self required for ethical actions (Foucault, 1986).

After conducting my own research into this topic of ethics, using several Ontario biology textbooks it seems apparent that the subject who is meant to think and act ethically must engage social issues primarily on a legal level; thus rendering ethical issues inevitably under the auspice of state governance; and an ethical actor as someone who, first and foremost, attempts to change, evaluate or creatively amend the law. It also seems clear that personal health and the health of the general population is a crucial underlying motive for ethical action. These aspects demonstrate that before an ethical action can be taken a student (subject) in science classrooms must reason in a particular way, have a relationship to who and what grants authority, and *come-to-recognize* herself as an actor Butler. (2004) insists that examining relations to self (and by extension the idea of self-making) is essential to the politics of desubjugation that Foucault advocated. It may be that the question of ethics in biology education can best be understood
using a detailed framework of biopolitics (this includes designed activist projects in science education). That is questions of ethics in biology operate along the poles of biopower (disciplinary and regulatory) and can be reformulated along the lines of biopolitical intervention. For example, regarding biotechnology, we might shift the lines of ethical thought in science education to include not just legal questions of individual rights, but also questions about how new forms of exploitation and exclusion take place along genetic lines and with populations that have been exposed to insecurity and poverty in global capitalist economies. Thinking again about subjectivity, it is important to ask, “who” science education and its curriculum materials “think you are” when thinking ethically and making decisions (Lather, 2012).

9.4.5 The Biosubject of Biotechnology

Maurizio Lazzarato (2002) credits Foucault as “already pointing out in the seventies what, nowadays, is well on its way to being obvious: ‘life’ and living being [le vivant] are at the heart of new political battles and new economic strategies” (p. 1). Lazzarato describes our current situation as a state where genomic research, artificial intelligence, and biotechnology trace a new “cartography” for biopower. Currently, a number of biopolitical focal points in science and science education having to do with the question of sovereignty, rights, and what “a body” entails are growing in terms of their urgency. In globalized agriculture, the contexts of the privatization of seeds and the domination of farmers in the global south by rich elites involves a whole series of complex histories of exploitation that are inextricably linked to practices of science. Vandana Shiva (1995) reminds us also that ideas of biotechnological progress are not gender or class neutral, and progress and efficiencies, especially when dictated by companies such as Monsanto, often mean different things depending on whether you are from the global north or south. Regarding an ever-shrinking wealth of biodiversity Shiva predicts that “not until diversity is made the logic of production can diversity be conserved” (p. 207). Biopolitically this will involve disrupting and reformulating the rule of property and the means it gives some bodies to ruthlessly control the material circumstances of others.

As Gerlach et al (2012) argue in Becoming Biosubjects, biotechnology is presenting us with new ways of thinking about governance, human beings, and the limits of the body, and thus
it is imperative to consider our constitution as biosubjects. These authors give a detailed description of this subject:

Consequently, a powerful new mode of subjectivity emerges in this altered field of social relations. This biosubjectivity troubles traditional modernist dualisms between natural and artificial, human and animal, private and public, and present and future. The subject is both alienated from and dependent upon a fragmented body. It is a subject outside of humanist ethics and firmly within capitalist relations…It is a subject that is always already in conversation with other late modern subjects – the entrepreneurial subject, the prudent subject, the subject under surveillance (p. 6-7).

Now the body comes under what Evelyn Fox Keller (1996) calls the “biological gaze”, but at the molecular level, which as Gerlach and colleagues, stress can be “informed, sold, killed, manipulated, reproduced, copied, and circulating along networks of exchange and knowledge production” (p. 9). Different forms of identity and biotechnical knowledge, as well as normative judgments rendered by wide ranging authorities such as scientists, pharmaceutical companies, counselors, and education systems, will (must) inevitably lead to different and unforeseeable forms of political activism surrounding science.

9.5 Biopolitics as a Path Forward

Viewing science education as a site for biopolitical engagement and reworking how subjectivities have been constituted through particular discourses and practices is vital if science educators are going to confront realities created by new scientific developments and the global capitalist/neoliberal agendas that infuse most contexts of scientific research. Since power is works not as something that merely dominates, but as a relation, biopolitical engagement consists not in overthrowing biopower, but working within various configurations of biopower towards alternative subjectivities and forms of life. According to Hardt and Negri (2009) biopolitics can be seen as the flight from power over life toward the power of life to rework how we have come to see ourselves and operate in the world. Biopolitics then proceeds as a necessarily queer endeavor as its goal is to smash norms, and put forward something different, only to be changed again. But, this requires that all students have access to science education (Siatras, 2012) and that teachers and students be given the spaces to disrupt the processes of subjectification in science education. Educators and students can intervene in the practices,
apparatuses, and discourses of biopower that control bodies and subjectivities, and rework these toward the goals of collective existence and social justice. The ultimate goal is to think about what subjectivities are possible, to allow freedom for singularities and difference. As Thomas Lemke (2011) maintains an analytics of biopolitics must include the scientific experts and disciplines that have authority to “tell the truth” about health, populations, and life, what forms of life are socially valuable, as well as forms of subjectification in various science education discourses and institutions where (responsible) subjects are brought to embrace certain forms of conduct. The hope and critical function of seeing science education as a site for biopolitical intervention and the reworking of subjectivities is “to reveal and make tangible the restrictions and contingencies” underneath universal political terms and evolutionary logic to see that they also the result of social practices and political decision-making – something which can be changed. Indignation, as suggested by Hardt and Negri (2009), can be a means by which to locate what needs changing.

Thinking biopolitically, we can find similarities amongst various struggles already ongoing in science education, from the colonialisms of science to struggles against the corporate control of science by multinational corporations. By examining the wide-ranging ways biopower orders how we come to think of ourselves, each other, and objects in the world we can come to see struggles over subjectivity as central to projects of freedom against what governs (or being governed in such and such a way). Furthermore whatever new forms of life emerge from biopolitical intervention into biopower and the reworking of subjectivities it is important to show, philosophically speaking, fidelity to these new “truths” or modes of life (Badiou, Clemens, and Feltham, 2005).

In this chapter I have outlined a fairly in-depth and particular theoretical context for seeing science education as a site for biopolitics and the reworking of subjectivities. However more theorization, along with research into the micro-practices related to subjectification processes in science education needs to be undertaken by critical (science) educators. For example Tyson Lewis (2007) stresses the need for notions of biopolitics to be reformulated in conjunction with educational philosophy, such as John Dewey’s imaginative construct of educational life and the life of the child. Turning back to the opening quotation from Foucault, biopolitical engagement means to, some extent, refuse common sense understandings about how modes of life have been defined, oriented and constituted up until now in science education.
Science educators and students are perhaps best situated to engage biopolitically as science education is encompasses multiple normalizing forces as well as oscillates between concern for the individual (student) and preoccupation with populations.

Chapter 10: Synthesis? Or Coming Back?

I would like to conclude this thesis with a chapter that does not necessarily tie up loose ends or synthesize the outcomes of what was attempted in the preceding chapters. I will now outline the positive and negative outcomes of the thesis. In a sense I am coming back to questions of subjectification that will continue to guide my work.

10.1 But, First, Who is the “Subject” of Science?

After looking into several aspects of subjectivity in these science textbooks from a variety of angles, I conclude, first, that there is no one subject of science education. Science students, teachers’ subjectivities are always already multiple and will subsequently transform in multiple ways. There are however, aspects of subjectivity that can be outlined. And the stakes are extremely high. First in that science is aligned with many oppressions (Harding, 2004), and a politicized science is necessary to deal with these oppressions. Secondly, in that transformative subjectivities in science have the power to direct science’s awesome powers of creation. From this research then we can say that subjectivities constituted through science education involve several aspects that I will list here:

10.2 Some Positives!

There are several positive outcomes of this thesis study that I would like to go through and punctuate. These are not all of the positive outcomes of the thesis, but they are some that excite me in the very fact that they have come out of the thesis. In some ways I feel like I am enjoying the excesses of the thesis – what both drives and cannot be contained by its ideological core – but as Žižek might say - “Enjoy your (the) symptom!”
10.2.1 Oppressive Discourses are Intersectional

In chapter five I show that race and sex/gender are linked in terms of representational images in these textbooks. This points to a possible ‘othering’ that operates like a clumping of all difference outside of white universal background. While binaric representations of sex/gender may be more ‘equal’ for racialized white people in science textbook images, there is a glaring lack of this equality for racialized people of colour. While the reasons for this are certainly multifaceted educators should not downplay the effects this could have on subjectivity. For whom is science a universal discourse? How do science education discourses reproduce oppressions through its tacit alliance with colonialisms and white supremacy? While these questions may seem extreme to some they are necessary and in direct relation to the empirical data of this thesis.

10.2.2 “People From the Global North?? Why They’re Objective, Conscientious, and Responsible!”

And what does this make people of the global south? - “Singular in vision, driven by industrial interests and incentives, perhaps not as objective as they should be!” I am paraphrasing here, but the constitution of the differentiated subjectivities, global north and global south – or rather the included and the excluded - needs to be properly traced to ascertain whether science education is (also) politically aligned with the global north (and I think it is). In a “deep” way the stakes are can again be described as very high. This research suggests that, actually, in order to engage in issues of social import “scientifically” students must see themselves from the perspective of global north – or one that diminishes alternative ways of knowing (traditional medicines).

Research in science education can specifically look at, how students are meant to work on themselves as part of the constitution of subjectivity. How does science education enact processes of subjectification so that students must attain very particular subject positions before they engage in science!

10.2.3 The Ethics of a Biopolitical State

Is the planet on a crash course for disaster? What are the new scientific-political-ethical frontiers of this century? The chapter on ethical situations in these texts outlines some contours of a very
specific kind of “ethical subject” that must engage in decisions concerning regulation and legal solutions, as well as personal lifestyle choices, in order to enact what should be done. I am optimistic about the possibilities for ethical engagement in science, but insist on the following questions. What is it about our political situation that has us see ethical situations in science in this frame? What will the coming environmental catastrophes and the ‘new exclusions’ caused by global capitalism and the frontiers offered by biotechnology demand in terms of ethical engagement? How will education take up this need?

10.2.4 Oppressive Ideologies and Practices of Science are Maintained by Repetition

In the final content chapter I presented the idea that we may think of the political positions, ideologies, oppressions, and material conditions that are produced in science as maintained by repetitive, subject constituting, practices such as lab activities. If students’ ‘actions’ in science class revolve around these activities then a disruption and re-establishment of this repetition is necessary for change. In the case of these textbooks, the close-ended, skills based labs need to be replaced by activities that socially, politically, ethically, and culturally engage students with the world outside. In this way, science education can constitute students with the outlook that science can be apart of social justice and political engagement. Students will then come to see science practices that do not engage this way as something misrecognizing – they can begin to say about past, close-ended activities ‘this isn’t science’!

10.2.5 (Neo)liberal Ideology: How close are the models of Science and the models of global capitalism and business?

At the beginning of my undergraduate degree, a good friend of mine (now a sports agent) used to argue that the business of governmental affairs and the nation were essentially a business: “A country is a business”, he used to say. While being far from the kind of country I want to imagine, he may have been correct in that this is how legitimacy in governing is now established. Can we say the same for science? This dissertation outlined evidence that suggests that the values of science, in terms of competition and the role of private property, are in line with a neoliberal, global capitalist mindset. Science does not need to be tied to this decimating
ideology, but can be re-appropriated towards projects of social justice – and done so in a way that does not depoliticize scientific claims, but rather celebrates the politics of science as reality.

10.3 Results in Negatives

In this thesis there were a few gaps or dead ends that I would like to speak about. My hope is that these can help form the grounds of future research.

10.3.1 A More Nuanced Theoretical Understanding of Subjectivity

There were at least four interdependent theoretical representations of the subjectivity employed in this thesis: Foucault’s (1982) constitution of the subject through discourse; Irigaray’s (1993) ‘Sexed Subject of Science’; Bhabha’s (1994) notion of hybridity; and Butler (1997)/Althusser’s (1998) notion of the subject through repetitive hailing. I feel this work compelled me to switch theoretical frames when necessary, and in doing so I feel that more thinking is required to form positive studies related to subjectivity and science. Furthermore, once a critical project related to subjectivity has a constellation of literature sources, studies, productive results, and theories, there will be a need to develop detailed descriptions and guidelines for the “subjective freedom or resistance”. This is where Foucault’s aesthetic treatment of ‘ethics of the self’ may be employed. In this thesis I have attempted to use Hardt and Negri’s (2009) conception of biopolitics as a politico-theoretical frame for thinking about subjectivity in future work. Along these lines science educators can think about the ways science and science education has come to produce and manipulate bodies and subjectivities. However, to do this a more robust multi-faceted understanding of subjectivities needs to be brought to bear on science (education) and subjectivities.

10.3.2 Failure to properly outline a colonizer/colonized subjectivity in Science Education

A way of reading that will better expose the colonizing discourses of science education needs to be designed and applied around Bhabha’s psycho-analytic notions of stereotype. Such an investigation will see racialized considerations of subjectivity alongside psycho-sexual connections which, among many things, tie bodies to sexual fantasy, and power-associated categories. The beginning of such analysis must begin and preoccupy itself with the unsettling of
science’s position of epistemic authority, an assumption that works constantly, to destroy any rivals to this authority - as I think we can see most clearly in cosmology and medicine.

Retrospectively it seems also that an interrogation of science texts may require new forms of analysis, such as the one begun in the display of images in chapter 5. Rather than search for a subject in an organized discursive analysis, which is arguably couched in the same terms as the discourse of which it critiques, we can look for what nuances (as Barthes sees it) exist as a part, and also ‘apart’, in representations and subjects of science education – perhaps put science education under a psycho-analytic lens. That is, we can see both the exceptions and the universalities that give rise to these exceptions (a beauty or hideousness that cannot be contained). However, to write like this consists in shifting the grounds of what it is to write. It also requires shifting the political ground of science education to consider such writing and what it brings to education, which is nothing short, of cultural analysis.
References


Kamberelis, G., & Wehunt, M. D. (2012). Hybrid discourse practice and science


Appendix A – Sex/race tables and Binaric Sex/Gender Examples

The follow tables were constructed by racializing images found in the four biology textbooks used in this study. These tables should be understood within the context of the entire study as they are problematic ethically, empirically, and do not represent my view on realities of “race”. My colleague Joanne Nazir asked me one day (October 2nd 2012), “How would you classify me”? As a racialized white person this line of research is very messy. I have decided to focus on the distinction between whiteness (focusing on it as a sign of privilege) and non-white. However the first tables demonstrate how implicated I am in seeing race as they contain in themselves, albeit somewhat unconsciously, a racial hierarchy. Not only does a basic quantitative analysis show that the texts are racist “through” gender, but my reading of this, from the very beginning is fraught with racialized (racist?) thinking. I have attempted to “flip” the organization of the tables, and I leave the reader with the question. Does it make a difference?

Sex/Race Images in Nelson Biology 12

Table A1. Total Racialized/Sexed Images in NB12

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>49</td>
<td>42</td>
<td>91</td>
</tr>
<tr>
<td>People of Colour</td>
<td>19</td>
<td>18</td>
<td>37</td>
</tr>
</tbody>
</table>

Table A2. Lay (student, citizen) Images in NB12

<table>
<thead>
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<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>18</td>
<td>20</td>
<td>38</td>
</tr>
<tr>
<td>People of Colour</td>
<td>14</td>
<td>16</td>
<td>30</td>
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</tbody>
</table>

Table A3. Professional Position Images in NB12

<table>
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<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>31</td>
<td>22</td>
<td>53</td>
</tr>
<tr>
<td>People of Colour</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

Race/Sex Images in Biology 11 College Preparation
Table A4. Totals Racialized/Sexed Images in NB11CP

<table>
<thead>
<tr>
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<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>15</td>
<td>17</td>
<td>32</td>
</tr>
<tr>
<td>People of Colour</td>
<td>7</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>
Table A5. Lay Images (Students, etc) in NB11CP

<table>
<thead>
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<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
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<td>21</td>
</tr>
<tr>
<td>People of Colour</td>
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<td>1</td>
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Table A6. Professional Images in NB11CP

<table>
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<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>White</td>
<td>5</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>People of Colour</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Race/Sex Images in McGraw Hill Biology 12**

Table A7. Totals in Racialized/Sexed Images of NB11CP

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>35</td>
<td>23</td>
<td>58</td>
</tr>
<tr>
<td>People of Colour</td>
<td>10</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

Table A8. Lay Images in NB11CP

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>17</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td>People of Colour</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
</tbody>
</table>

Table A9. Professional Images in NB11CP

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>18</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>People of Colour</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

McGraw Hill Biology 11

Table A10. Total Racialized/Sexed Images in MHB11

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>44</td>
<td>52</td>
<td>96</td>
</tr>
<tr>
<td>People of Colour</td>
<td>17</td>
<td>19</td>
<td>36</td>
</tr>
</tbody>
</table>
Table A11. Lay Images in MHB11

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>25</td>
<td>37</td>
<td>62</td>
</tr>
<tr>
<td>People of Colour</td>
<td>12</td>
<td>17</td>
<td>29</td>
</tr>
</tbody>
</table>

Table A12. Professional Images in MHB11

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>19</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td>People of Colour</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

Racialized/Sexed Totals

Table A13. Total Racialized/Sexed Images in All Texts

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Total</th>
<th>Percentage of Males to Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>143</td>
<td>134</td>
<td>277</td>
<td>52% Male 48% Female</td>
</tr>
<tr>
<td>People of Colour</td>
<td>53</td>
<td>43</td>
<td>96</td>
<td>55% Male 45% Female</td>
</tr>
</tbody>
</table>

- Over 74% of all the images in the text are racialized white people

Table A14. Total Lay Images in All Texts

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Totals</th>
<th>Percentage of Males to Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>70</td>
<td>83</td>
<td>153</td>
<td>46% Male 54% Female</td>
</tr>
<tr>
<td>People of Colour</td>
<td>40</td>
<td>39</td>
<td>79</td>
<td>51% Male 49% Female</td>
</tr>
</tbody>
</table>

- Racialized white people make up 66% of people in lay images in text

Table A15. Professional Images in All Texts

<table>
<thead>
<tr>
<th>Racialization</th>
<th>“Men”</th>
<th>“Women”</th>
<th>Totals</th>
<th>Percentage of Males to Females</th>
<th>Percentage increase of males in relation to females</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>73</td>
<td>51</td>
<td>124</td>
<td>59% Male 41% Female</td>
<td>42% more males than females</td>
</tr>
<tr>
<td>People of Colour</td>
<td>13</td>
<td>5</td>
<td>18</td>
<td>72% Male 28% Female</td>
<td>160% more males than females</td>
</tr>
</tbody>
</table>

- Women of Colour (non racialized white women) make up 3.5% of all professional
• There are 10 times as many white women as women of colour in professionalized positions and almost 15 times as many white men.
• 85% of all representations of professionalized workers in science were racialized white.

Table A16. Proportion of People of Colour in Lay Verses Professional Images

<table>
<thead>
<tr>
<th></th>
<th>“women”</th>
<th>“men”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lay</td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>professional</td>
<td>5</td>
<td>13</td>
</tr>
</tbody>
</table>

Table A17. Proportion of Racialized White People in Lay Verses Professional Images

<table>
<thead>
<tr>
<th></th>
<th>“women”</th>
<th>“men”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lay</td>
<td>83</td>
<td>70</td>
</tr>
<tr>
<td>professional</td>
<td>51</td>
<td>73</td>
</tr>
</tbody>
</table>

Table A18. Instances of Binaric sex/gender discourses

<table>
<thead>
<tr>
<th>Textbook and Page Number</th>
<th>Topic or Chapter</th>
<th>Discursive Fragments/Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson Biology 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p. 111,112 (NB12)</td>
<td>Cellular Respiration: Body Surface Area and Energy Expenditure</td>
<td>“Table 2 lists the average energy expenditures for different kinds of activities for men and women in kilojoules per minute.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“[Example Calculation] Calculate the body surface area of an adult male is 1.75 m tall and has a mass of 85 Kg.”</td>
</tr>
<tr>
<td>p. 116 (NB12)</td>
<td>Cellular Respiration: Energy Expenditure</td>
<td>“the male rufus hummingbird, like many diminutive animals must consume relatively large quantities of food to maintain body temperature and meet is body’s demands for energy.”</td>
</tr>
<tr>
<td>p. 131</td>
<td>Cellular Respiration: Estimating VO₂ Max</td>
<td>“If you are a female, enter the number 0 in column g, and if you are a male, record the number 1 in this column.”</td>
</tr>
<tr>
<td>p. 211</td>
<td>Homeostasis: Urinary System</td>
<td>Female Bladder Diagram</td>
</tr>
<tr>
<td>p. 376</td>
<td>Chemical Signals: Hormones</td>
<td>Luteinizing hormone (LH): in females, stimulates ovulation and formation of the corpus luteum; in males stimulates the production of the sex hormone testosterone</td>
</tr>
<tr>
<td>p. 390</td>
<td>Chemical Signals: Steroid Use</td>
<td>Image (see Fig 2.) Negative effects on male and females are quite essentialized</td>
</tr>
<tr>
<td>p. 398</td>
<td>Reproductive Systems</td>
<td>“Male characteristics result because the levels of androgens exceed the levels of estrogen. Males are ensured of maintaining low levels of female hormones by excreting them at an accelerated rate. This may explain why the urine of a stallion contains high levels of estrogen.”</td>
</tr>
<tr>
<td>p. 405</td>
<td>Hormone Levels: Menstrual Cycle</td>
<td>“Estrogen plays a crucial role in maintaining bone strength and density. This is why women over 50 and women who experience premature menopause are at risk for developing osteoporosis. What can be done to minimize this risk? Investigate hormone therapies and lifestyle factors.”</td>
</tr>
<tr>
<td>p. 409</td>
<td>Hormone Levels: Gonadotropic hormones</td>
<td>Design an experiment to show how ovarian hormones regulate female gonadotropic hormones.</td>
</tr>
</tbody>
</table>
### Evolution

During courtship some males intentionally sacrifice their body as food to the female.

### Evolution: Sexual Selection

The most common forms of sexual selection result from female mate choice and from male versus male competition. In some species females, choose mates based on physical traits, such as bright colouration, or behavioural traits, such as courtship displays and songs.

### Evolution: Cumulative Selection

Figure 6. A male wasp grasps the orchid’s flower which resembles a female wasp’s abdomen.

### Evolution: Speciation

Mules are bred from a female horse and a male donkey.

### Evolution:

Male elephant seals often compete violently the chance to fertilize females and their injuries can serious, sometimes fatal. Explain how such behavior evolves, even though it lowers the average life expectancy of the males and reduces their chance of survival?

### Population Ecology:

The females of some species have a high fecundity, having the potential to produce very large numbers of offspring in their lifetimes- many species of star fish for example can lay over 1 million eggs per year. In contrast a female hippopotamus may have the potential to give birth to just 20 young in an entire lifetime of 45 years. While longer lived species have the potential to complete more reproductive cycles an adaptation that increases their fecundity- many such species produce fewer offspring per reproductive cycle.

### Nelson Biology 11 College Prep (NB11CP)

<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>p. 41</td>
<td>Functional foods</td>
<td>strongly supports women’s cyclic nutritional needs”</td>
</tr>
<tr>
<td>p. 123</td>
<td>Microbiology: Passive Immunity</td>
<td>Antibodies pass from the woman to her unborn child during the last month of pregnancy and the initial stages of breast-feeding.</td>
</tr>
<tr>
<td>p. 124</td>
<td>Vaccine Research</td>
<td>There are other areas of research: a vaccine for pregnant women that would protect their babies against group B Streptococcus bacteria</td>
</tr>
</tbody>
</table>
| p. 163 | Energy Requirements for a Day | Teenage girl 9 500  
Teenage boy 12 000 |
| p. 174 | Human endocrine system | Diagram: Female ovaries male testis  
Table: in females, stimulates ovulation and formation of corpus luteum |
<p>| p. 193 | Diet and the Media | Most adolescent boys, however, do not have a muscular body. |
| p. 203 | Circulatory Disorders | In the early morning, John Smith, a 47-year-old male, enters the emergency ward of St. Michael’s Hospital in Toronto complaining of chest pains. |
| p. 210 | Excretory System | Male and Female Bladders |
| p. 218 | Respiratory System: VO2 max | A VO2max value over 35 ml/kg/min is considered good for females aged 13-19. A VO2 max value over 45 ml/kg/min is considered good for males aged 13-19. |
| p. 228 | Smoking and Lung Cancer | Lung Cancer is the leading cause of cancer death in Canada for both women and men |
| p. 230 | The Reproductive System | Males and Females play specific roles in the process of reproduction |
| p. 234 | Sexual Intercourse | Sexual intercourse begins with sexual stimulation that causes blood to flow into the spongy tissue of the male’s penis, causing it to become relatively rigid and erect. |
| p. 236 | Reproductive disorders | Prostate disorders (male), infertility (male), infertility (female), impotence (male), abnormal menstruation (female), tumours (female) |
| p. 253 | Review points: The Reproductive System | The human reproductive systems are those organ systems in males and females that perform the functions of sexual reproduction |
| p. 283 | Plant Physiology | The male gametophytes are the microscopic pollen grains, and are produced on the stamen, the male part of the flower. |
| p. 359 | Environmental Science | Figure 3. The Greek goddess Gaia |</p>
<table>
<thead>
<tr>
<th>Page</th>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>Diabetes</td>
<td>A person’s genes may influence his or her metabolism.</td>
</tr>
<tr>
<td>P 146</td>
<td>Infant Development</td>
<td>Use blue dots for boys and red dots for girls. Does there seem to be a gender difference with regard to the age at which infants learn to walk?</td>
</tr>
<tr>
<td>147</td>
<td>Heart Rate</td>
<td>Discuss the apparent differences, if any, in the way males and females experience the fight-or-flight reflex.</td>
</tr>
<tr>
<td>176</td>
<td>Pituitary gland: Oxytocin</td>
<td>In women, the hormone oxytocin plays an important role during and after childbirth.</td>
</tr>
<tr>
<td>179</td>
<td>Bone Mass</td>
<td>Biofact: Postmenopausal women are at greatest risk of osteoporosis because they have less bone mass than men and begin losing it earlier.</td>
</tr>
<tr>
<td>185</td>
<td>The Adrenal Cortex</td>
<td>The adrenal cortex also produces male sex hormones (androgens) and female sex hormones (estrogens).</td>
</tr>
<tr>
<td>195</td>
<td>Testosterone and Baboon Behaviour</td>
<td>The dominant males have better access to food, the best resting spots, and the female baboons.</td>
</tr>
<tr>
<td>196</td>
<td>Steroid Use</td>
<td>Would you still want to take steroids if you knew they can result in shrunken testes, reduced sperm count, breast enlargement and impotence in males, and menstrual irregularities, and reduction, masculine features, and sterility in females?</td>
</tr>
<tr>
<td>202</td>
<td>Hormones:</td>
<td>Describe the difference between hormones produced prior to the onset of puberty and after puberty in males and females.</td>
</tr>
<tr>
<td>205</td>
<td>Growth</td>
<td>Averages for Growth of humans (table).</td>
</tr>
<tr>
<td>224</td>
<td>Rosalind Franklin:</td>
<td>Her contribution was not readily accepted in part because of prevailing attitudes towards women in science in the 1950’s.</td>
</tr>
<tr>
<td>244</td>
<td>Chromosomal abnormalities in sperm</td>
<td>We know that women’s eggs deteriorate as women age, but what about men’s sperm?</td>
</tr>
<tr>
<td>328</td>
<td>Medical Scenario</td>
<td>55. You are a medical doctor with two young female patients who are hoping to be treated with a form of gene therapy that can build muscle mass.</td>
</tr>
<tr>
<td>384</td>
<td>Sexual Selection</td>
<td>While one male may be able to fertilize all of his species, virtually every other male is in the same position.</td>
</tr>
<tr>
<td>493</td>
<td>Population Age Effects</td>
<td>Of course, in populations in which females reproduce only once, individuals do not survive after reproducing therefore, there are no older non reproducing members.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Page</th>
<th>Topic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>Stem Cell Debate</td>
<td>They had a little boy, and their daughter received stem cells from his cord blood in the hope that she will now produce healthy bone marrow.</td>
</tr>
<tr>
<td>132</td>
<td>Genetics</td>
<td>“What traits can you see in your family?”</td>
</tr>
<tr>
<td>135</td>
<td>Genetics: Heredity</td>
<td>A couple has two children, one which is a boy. What is the probability that the other child is a girl?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A woman has a father who died of Huntington’s disease. What is the probability that she will develop the same symptoms of the disease?</td>
</tr>
<tr>
<td>141</td>
<td>Genetics: Phenotypes</td>
<td>Dino, another fruit fly, is homozygous recessive for body colour and homozygous dominant for antennae. He mates with Daisy’s sister Lulu, who is homozygous dominant for body colour and homozygous recessive for antennae.</td>
</tr>
<tr>
<td>146</td>
<td>Genetics: Blood Type and Transgendered?</td>
<td>Mrs. Doe and Mrs. Roe had babies at the same time. Mrs. Doe took home a girl and named her Nancy. Mrs. Roe received a boy and named him Richard. However, Mrs. Roe received a boy and named him Richard. However, Mrs. Roe was sure she had a girl and sued the</td>
</tr>
</tbody>
</table>
Blood tests showed that Mr. Roe was type 0 and Mrs. Roe was type AB. Mr. and Mrs. Doe were both type B. Nancy was type A and Richard was type O. Had an exchange occurred? Explain your answer. (yes there was a switch).

<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>148</td>
<td>Genetics: pedigrees</td>
<td>Symbols are used to denote males and females with shading to show those who are affected with the trait under study. Assume that each descendent of a couple marries an individual who is not a tongue roller.</td>
</tr>
<tr>
<td>160</td>
<td>Cell Reproduction</td>
<td>Other than identical twins, every individual in the world is unique. Diversity exists between sisters, brothers, and even between you and your parents.</td>
</tr>
<tr>
<td>167</td>
<td>Cell Reproduction: Origin of Sex Chromosomes</td>
<td>The sex of a person is determined by their chromosomes. Other characteristics, such as personality and intelligence, may be influenced by the environment.</td>
</tr>
<tr>
<td>p. 175</td>
<td>Sex Linked Traits</td>
<td>How do you think people discovered that the inheritance of certain traits was governed by the sex of an individual?</td>
</tr>
<tr>
<td>p. 180</td>
<td></td>
<td>What is your sex-linked inheritance? What is the probability of a couple having a child that is colourblind if the man is colourblind and the woman is heterozygous for normal colour vision?</td>
</tr>
<tr>
<td>p. 223</td>
<td>Colour Blindness</td>
<td>About 8% of men and 0.04% of women cannot identify the number as a result of colour blindness. Why is there such a large difference between the sexes?</td>
</tr>
<tr>
<td>p. 230</td>
<td>Genetic counseling: disability</td>
<td>Couples who have a family history of a genetic disorder or have a child with a heritable disorder may want to consult a genetic counselor before the conception of their next child (what’s a couple?)</td>
</tr>
<tr>
<td>p. 234</td>
<td>Gene therapy</td>
<td>In 1992, a 30 year old Quebec woman made genetic history. “the woman’s liver” … “the woman’s large hepatic portal vein”</td>
</tr>
<tr>
<td>p. 235</td>
<td>bioethics</td>
<td>When a 38 year old father of three sons (gender has no bearing on the case)</td>
</tr>
<tr>
<td>p. 477</td>
<td>Reproduction in Gymnosperms</td>
<td>Female cones develop ovules…Male cones produce microspores</td>
</tr>
<tr>
<td>p. 481</td>
<td></td>
<td>Most pollen grains do not fall on an appropriate female cone…</td>
</tr>
<tr>
<td>p. 622</td>
<td>Pictures</td>
<td>Royal family</td>
</tr>
<tr>
<td>p. 623</td>
<td>Biofact</td>
<td>Sir Arthur Conan Doyle</td>
</tr>
</tbody>
</table>
Appendix B – Specific Ethical Situations in Four Biology Textbooks

The following discursive fragments represent situations where students are called to think and act in overtly ethical ways. I have provided some notes in some cases in order to give the reader a sense of what I saw as pertinent regarding these fragments. The primary purpose of this appendix is for the reader to have a look at the examples as they appeared in the text as the chapter on the ethical subject doesn’t afford the space to display them. Although these examples have been selected as examples that provide a direct ethical situation for students some examples are included which are (still) only indirectly ethical. This are marked clearly in with the label (INDIRECTLY ETHICAL) and while these examples may support some of my discussion points that have not been considered in the body of the thesis.

Table B1. Ethical McGraw Hill Biology 11

<table>
<thead>
<tr>
<th>pg #</th>
<th>Topic</th>
<th>Ethical Situation as found in Textbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>Stem Cells</td>
<td>[Following a description of Stem Cell Research and the indication that moral, ethical and legal questions arise] Debate with classmates the pro or con aspects of stem cell research. You may want to use the following real-life situation to help focus your discussion: In the U.S. parents of a six year old girl with a rare inherited blood disease asked doctors for help in conceiving a baby that could provide donor stem cells for their daughter. They selected the most suitable embryo from among 15 created through in-vitro fertilization. They had a little boy, and their daughter received stem cells from his cord blood in the hope that she will now produce healthy bone marrow.</td>
</tr>
<tr>
<td>298</td>
<td>Artificial blood</td>
<td>[Title of “Biology Magazine” Section: Fake Blood: A Real Alternative?] Other than in surgeries, emergency transfusions, and medical treatments such as chemotherapy, what uses might a blood substitute have? Conduct research to determine what risks may be associated with the use of a blood substitute. Given the potential benefits and risks, prepare a brief report arguing whether or not the use of artificial blood should eventually replace natural blood in all cases</td>
</tr>
<tr>
<td>594</td>
<td>Loosestrife</td>
<td>INDIRECTLY ETHICAL TITLE: CAN GARDENERS PLAY A ROLE IN THE CONTROL OF LOOSESTRIFE? Loosestrife is still considered an ornamental species by some gardeners. Nurseries sell sterile cultivars of this plant, but the seeds that are produced may be viable if they are grown in close proximity to the wild species. This is because the bees carrying the pollen may inadvertently pollinate the garden plant, thereby allowing the formation of seeds that can germinate. Gardeners must take some responsibility for the plants they choose to grow. If a plant is considered invasive in your area caution must be exercised. Growth and seed development must be monitored. Gardeners must be diligent in reading plant labels and staying informed about the possibility of new plants becoming invasive.</td>
</tr>
</tbody>
</table>
| 574  | Issues on GMO Plants       | [Title of “Biology Magazine” Section: Issues on Genetically Modified Plants]: Directly ethical questions from this section: 1. Should farmers plant seeds that are genetically manipulated? 2. Are consumers entitled to specific labeling on products that contain genetically modified organisms? 3. In your opinion what are the risks and benefits of genetically modified crops 4. What responsibilities do developed countries have to develop technology that will benefit Third World countries. 5. (Imperative) By examining the risks and benefits you will be able to decide for yourself.
| 485 | Conservation versus Food | **Title of “Biology Magazine” Section: Adjusting the Balance**: Which do you think is more important: developing a better food source for hungry people, or conserving the monarch butterfly? |
| 362 | Prenatal Nutrition | **Title of “Biology Magazine” Section: Nutrition for the unborn**: Suppose fortified with folic acid was found to cause problems for the elderly, but to benefit the general population. In small groups, discuss the controls these foods should be subject to, including how they should be marketed, advertised, and displayed. |
| 406 | Foods of Tomorrow | **INDIRECTLY ETHICAL**
**Title of “Biology Magazine” Section: Foods of Tomorrow**: What exotic or unusual foods from the tropics can you find in your local store that were not widely available a few years ago? List the advantages and disadvantages of eating locally produced foods rather than imported foods. |
| 196 | Genetic Testing | **Title of “Biology Magazine” Section: Is Genetic Testing a Threat?**: Should law enforcement agencies promote genetic screening? What role should the provincial and/or federal governments take to regulate genetic testing? Debate this issue in class. |
| 77 | Research Priority | **Making Connections Questions**: 28. Although many diseases can cause tissue damage or kill people there are limits to the financial support and teams of trained researchers available to find treatments. Who sets the priorities for research? Identify four criteria that should help people prioritize research funding. |
| 148 | Genetic Screening | **Making Connections**: 18. People who are heterozygous for a recessive condition do not express the trait, but may pass it on to their children. Do we have a responsibility to inform our children of certain recessive traits they may have inherited? Present your thoughts in a one page essay. |
| 204 | Controversial Research | **Section Review**: 8. Should scientists be allowed to pursue certain types of research even if some people consider the research to be controversial? Explain your answer. |
| 236 | Genetic Research | Section Review 10. If you were part of a government task force that set policy relating to the findings of the human genome project, what are some guidelines you would propose? |
| 240 | Group Action Plan on Genetic Technologies | Students put together a regulating plan on the use of biotechnology: |
| 328 | Employee | **INDIRECTLY ETHICAL**
**Making connections**: 25. A florist is showing a new employee how to care for the potted plants on display. “These ones grow best when their foliage is misted with water every day,” says the florist. The new employee thinks “I can save time, and get the same result, by watering the plants more.” Is the employee right? Explain. |
| 352 | Lifestyle | **Section Review**: |
### Choice

13. Cirrhosis of the liver is a serious disease. What environments and lifestyle choices can put someone at risk for this condition? How would it affect the person’s health?

17. An older friend of the family has just had her gall bladder removed. Describe the kind of diet you think she would be wise to follow.

### Lifestyle Choices

361 **Weblink:** Use the weblink below to learn more about fitness, nutrition and lifestyle choices.

### Diet

366 **Section Review:**

8. One of your friends talks constantly about losing weight, while another has decided she is going to become a vegan. What advice would you give each of them?

10. It has been said that the following foods should be included in everyone’s diet: oranges, cantaloupe, broccoli, multi-grain bread, sweet potatoes, beans, salmon or sardines, spinach, skim or 1% milk. Make a case for their inclusion. (INDIRECTLY ETHICAL)

### Sports Drug Use

366 **Section Review:**

6. Many professional athletes are known to use drugs of one kind or another. In small groups discuss whether the use of certain drugs or all drugs should be prohibited in professional sports. How would you enforce your ruling?

### Small Pox Virus

411 **Making Connections:**

27. Medical Scientists claim that the small pox virus has been eradicated in the human population. However, one sample of this virus still exists in the Center for Disease Control in Atlanta, Georgia. Write a short essay outlining your feelings about this. Why might this be a positive or a negative situation?

### Antibiotic Use

428 **Design your own investigation section: Observing variations in bacterial response to antibiotics**

6. Why might the excessive or improper use of antibiotics eventually lead to an increase in the number of infections? How can this risk be reduced?

### Research Priorities

460 **Making Connections:**

31. ... Science and Technology should produce new medicines, and discovering these drugs should be a priority to the medical community. Others feel that prevention is the solution. Society must eliminate conditions that support passing the bacteria, and ensure that infected people finish prescribed medications. Write an essay about your ideas concerning this problem. What do you feel the priorities should be?

28. There are many products on the market such as soaps, hand lotions, and bathroom cleansers, that claim to be anti-bacterial. Do you believe it is a good idea to rely on these products to keep our homes and bodies free of harmful bacteria?

### Plant Regulators

565 **Section Review:**

7. Plant growth regulators are involved in the cultivation, processing, and storage of many commercially grown fruits or vegetables. Yet, few shoppers are aware of this. Should supermarkets post signs identifying produce treated with plant growth regulators? Give reasons for your answer.

### Gene Transfer Technology

580 **Making Connections:**

28. Gene transfer technology is a promising technology. Possible benefits include creating and improving resistance to disease-causing viruses, to insect predators, or to herbicides so the herbicides can be used to control weeds without killing crop plants. However, like all technologies, gene transfer technology could be used unethically or inappropriately. Give examples of how gene transfer technology can be used for potential benefits and how it may be used inappropriately.
Defending the Biosphere
Take Action. Decide what issue is most important to you and pursue it. Write to politicians and corporations expressing your opinions.

Farming Tradeoffs
Making Connections:
27. What trade-offs in the development of food technologies do you find most alarming? State your reasons. How did the decision to make this trade-off get made? by whom? Must we keep on making this trade-off? Could the original decision be reversed or modified?

| Table B2. Ethical Situations in McGraw Hill Biology 12 |
|---|---|---|
| **Pg#** | **Topic** | **Ethical Situation as found in Textbook** |
| 372 | Biotechnology | INDIRECTLY ETHICAL |
| | | “Are organisms more than just their genes?” |
| 494 | Alien invaders | INDIRECTLY ETHICAL |
| | | “What can be done to reduce or eliminate [alien species] problems?” |
| 196 | Steroid Use | Biology Magazine: |
| | | 2. One survey of professional athletes reported that about half would be willing to take a drug that ensured their success, even if it shortened their lives. In groups, discuss the arguments for and against the use of synthetic anabolic steroids by athletes in competition. |
| 118 | Kidney transplants | Biology Magazine: |
| | | 1. Debate with classmates whether Canada should adopt an “opting out” policy to increase the number of cadaveric donors. What problems might this create? |
| | | 2. Should a destitute person be allowed to sell one of his or her kidneys to avoid starvation? Is this different from a family member donating a kidney? |
| 78 | Nutrition and cellular energy | INDIRECTLY ETHICAL |
| | | 2. c) Make recommendations on how you would improve or expand each set of [dietary guidelines]. |
| 19 | Thalidomide Use | Biology Magazine: |
| | | 1. Debate in class the arguments for and against prescribing a therapeutic drug that has been proven to pose serious health risks. Who should decide on its use? |
| 45 | Raw Food Diet | Thinking Lab: |
| | | 2. Is a diet of raw food healthy for people? For dogs and cats? Why or Why not? |
| 135 | Daily Health Habits | Making Connections: |
| | | 41. What are some daily habits you could adopt to help reduce your chances of contracting a contagious disease (such as cold or flu) from people you come into contact with on a regular basis? |
| 162 | Loud Music/Hearing Damage | Section Review |
| | | 19. What can you do to prevent damage to your hearing from extremely loud or persistent noises in your environment? Is the school presently doing enough to protect student hearing? |
What types of policies could be adopted to help protect students from hearing loss while attending noisy school functions, such as school dances?

<table>
<thead>
<tr>
<th>Page</th>
<th>Topic</th>
<th>Text</th>
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</thead>
<tbody>
<tr>
<td>208</td>
<td>Cure for Diabetes?</td>
<td>Ethical Text?</td>
</tr>
</tbody>
</table>
| p. 165 | Caffeine as Controlled Substance | Making Connections:  
22. Both alcohol and caffeine affect the neurological system. Although alcohol is a controlled substance, caffeine is not. Develop an argument to make caffeine (coffee and other caffeinated beverages) a controlled substance.  
23. Identify points to support more research into acupuncture and acupressure therapy. Identify cautions to further research in each therapy. (supported by question #36 on p. 206 with the use of the word “apparent” to describe its pain relieving effects)  
25. Your class has raised $200 to donate to charity and has narrowed the choice down to supporting Alzheimer research, Multiple Sclerosis research, or research into alcoholism. You and two classmates will debate the merits of donating the money to each group. After the debate the class will select which charity to support. |
| 183, 191 | Minimize Exposure | INDIRECTLY ETHICAL  
Section Review:  
11. List strategies to minimize exposure to these substances? What long-term changes are needed to radically reduce the degradation of the environment. Strategies to minimize exposure |
| 207 | Food Labeling | Making Connections  
47. Do you think that the labels on food products should include information on the use of supplements such as hormones?  
48. In your opinion, should animals be used for [endocrine disease] research studies? Are there effective alternative research protocols that could replace research procedures involving laboratory animals?  
49. Some of the major issues concerning prescription drug use and safety involve providing timely information about new medications to Canadian doctors and the reporting of adverse reactions to new medications. What changes would you make to current legislation to address these issues?  
51. While testing a new asthma medication, a test subject claims that she is using the new drug. She is pleased with the product and agrees to be interviewed on television to promote it. Has this person compromised the study?  
53. Should anabolic steroids be banned? |
| 209  | Cure for Diabetes | Project: (As you gather information think about how you will incorporate the following points)  
5) Some new forms of treatment raise ethical questions. What criteria could be used to determine if some forms of scientific research should be curtailed or regulated for ethical reasons? |
<p>| 231  | Sharing Information | Section Review: |</p>
<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Question/Comment</th>
</tr>
</thead>
</table>
| 292  | Mutagens in Products | Section Review:  
5. b) In a small group, brainstorm some of the social and ethical issues that are associated with the deliberate use of mutagens. Write a short report that explains the circumstances under which you believe the risks of exposure to mutagens can be outweighed by the benefits of using these substances. |
| 311  | GMO | Section Review:  
8. Some companies that produce transgenic crop plants forbid farmers from saving the seeds from their crops in order to replant the transgenic organisms. Instead, the farmers must purchase new seeds each year. Write a brief report explaining some the advantages and disadvantages of this policy. If you were a researcher working for one of these companies what policy would you recommend? |
| 318  | DNA Library | Section Review:  
9. In addition to its role in the sequencing of the human genome, what are some of the potential uses of a human DNA library? What risks are associated with maintaining such a library? |
| 321  | Human Cloning | Making Connections:  
32. In 1997, the United Nations declared that “Practices which are contrary to human dignity, such as reproductive cloning of human beings, shall not be permitted.” In a short report discuss why the United Nations considers human cloning to be a practice contrary to human dignity. In your summary add your own reasons for why you agree or disagree with the United Nations’ position. |
| 329  | Eugenics | Making Connections  
54. What effects might the creation of such “designer babies” have on society? Explain what laws, if any you think the government should enact to regulate this area of genetic research.  
55. You are a medical doctor with two young female patients who are hoping to be treated with a form of gene therapy that can build muscle mass. One has a genetic disorder that causes a breakdown in muscle tissue. The disorder is not life-threatening, although the treatment may help her live an active life and take part in sports with her friends. The other has the skill to be an exceptional hockey player, but is disadvantaged by having a very slight build. The treatment might help her develop the musculature needed to compete in professional hockey. The parents of each girl argue that the treatment is necessary if their child is to be able to live a fulfilling life and achieve her full potential. How would you respond to each family’s request for treatment?  
57. Some groups argue that all food products containing genetically modified ingredients should be clearly labeled. Others argue that this labeling will harm producers, and that genetically modified foods have been demonstrated to be safe. What labeling policy would you propose? Explain your reasons.  
58. You are a senior official in a government health department. You must decide how to allocate $100 million in genetics research funding among the following three areas: development of transgenic crops; somatic cell gene therapy; therapeutic cloning of human cells. How much funding will you allocate to each area? You eugenics questions and the law...#55 is interesting ... whether a procedure should be needed or not and what constitutes an active life...#57 Genetically modified foods#58 is interesting and political.. |
| 425  | Extinction (p. 510 # 26, 29 too) | Indirectly Ethical  
48. … Develop a brief presentation that explains to funding officials why this population is still...
in peril even though it now numbers over 200. Outline the steps you would take to help save the population.

<table>
<thead>
<tr>
<th>450</th>
<th>Vegetarianism and food production</th>
</tr>
</thead>
</table>

Section Review:
9. We have seen that there are fewer carnivores than herbivores in ecosystems because of the inefficiency of energy transfer between trophic levels, and that the world could support more people if we are only plant material. Some of the people feel this means that humans should switch to a vegetarian diet; others disagree. There are, in fact, a variety of issues to consider in addition to the relatively simple one of energy transfer. Take a stand. Prepare your arguments carefully and be prepared to debate the issue in class. You might want to prepare a pamphlet you could use to educate the public about your point of view.

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### Table B3. Ethical Situations in Nelson Biology 11 College Preparation

<table>
<thead>
<tr>
<th>pg #</th>
<th>Topic</th>
<th>Ethical Situation as found in Textbook</th>
</tr>
</thead>
</table>
| 42   | Nutriceuticals | *Take a Stand:*  
Debate Statement: Nutriceuticals should be regulated as a drug under the Canada food and Drug Act. |
| 55   | Animal Welfare | *Take a Stand:*  
Making Connections:  
6. d) The ante mortem (before death) method of tenderizing meat involves the physical injection of a solution of papain or bromelain into the living animal. The enzyme tenderizes muscle tissue while the animal is alive. Discuss this method with fellow classmates and write a brief position paper on the ethics of this procedure. |
| 115  | Food (Milk) Technology | *INDIRECTLY ETHICAL*  
Making Connections:  
Taking a global view (societal, economic, etc.), list the advantages and disadvantages of UHT technology. |
| 127  | Food Production Antibiotics | *Take a Stand:*  
Debate Statement: Non-therapeutic use of antibiotics in farm animals should be banned |
| 140  | Personal Lifestyle Fungi | *INDIRECTLY ETHICAL*  
Making Connections:  
12. What steps could people who are allergic to fungal spores take to ensure that their living environment is relatively spore free? |
| 144  | Pesticides | Making Connections  
5. Your town Council is debating whether or not to pass a resolution banning pesticide use in local parks. Compile a list of pros and cons that could be used in reaching a decision. Be sure to include the effect of pesticides on micro-organisms. |
| 148  | Biotechnology | Reflecting:  
14. “With recombinant DNA technology, the gene pool has become a gene ocean.” Explain the meaning of this statement. What are your personal opinions on recombinant DNA technology? What are some ethical problems with gene manipulation? |
<table>
<thead>
<tr>
<th>Page</th>
<th>Topic</th>
<th>Ethical Situation as found in Textbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>182</td>
<td>Banning Substances</td>
<td>Making Connections:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marijuana, an illegal drug in most countries, has been getting a lot of attention lately. Several</td>
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<td>countries around the world are considering changes in their laws that would decriminalize possession</td>
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<td></td>
<td></td>
<td>and use of marijuana. Write a brief position paper containing your recommendations to a legislature</td>
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<tr>
<td></td>
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<td>on this issue.</td>
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<tr>
<td>194</td>
<td>Body Images</td>
<td>Take a Stand: What is Healthy?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debate Statement: The media should show bodies of different shapes, not just the stereotypical</td>
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<td></td>
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<td>“ideal” figures.</td>
</tr>
<tr>
<td>214</td>
<td>Drug Test</td>
<td>Making Connections:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. Do you think people’s urine should ever be tested for drugs? Do you think it could be more</td>
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<td>justified in some cases than in others? Use a PMI chart to examine the advantages and disadvantages</td>
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<td></td>
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<td>of urine testing in terms of ethical, health, and technology issues, and make recommendations on its</td>
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<td></td>
<td></td>
<td>use.</td>
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<tr>
<td>250</td>
<td>Bike Helmet Regulation</td>
<td>Making Connections:</td>
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<td>13. Research both sides of the Bike Helmet issue and prepare a position paper indicating your</td>
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<td>recommendations to the Ontario Ministry of Transportation.</td>
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<td>264</td>
<td>Kidney Transplant</td>
<td>Making Connections:</td>
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<tr>
<td></td>
<td>Healthy Environment</td>
<td>kidney transplants, health precautions for breathing, ant-acid?</td>
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<td>48. In some countries, kidneys are sold for transplant. Do you believe that this practice is</td>
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<td>acceptable? Explain your answer.</td>
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<td>51. What precautions should you take to ensure a safe and healthy breathing environment?</td>
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<tr>
<td>274</td>
<td>Naturalness Monoculture</td>
<td>Making connections:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debate Statement: Monoculture should not be used in agriculture or forestry operations because it</td>
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<td></td>
<td></td>
<td>is unnatural. Debate your position with a classmate who holds the opposite view.</td>
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<tr>
<td>332</td>
<td>Genetically Modified Foods</td>
<td>Making Connections:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research the issue of labeling GMO foods What are the advantages and disadvantages of labeling</td>
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<td>genetically modified foods? When your research is complete write a letter to the editor of your local</td>
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<td></td>
<td></td>
<td>newspaper outlining your position on this issue.</td>
</tr>
<tr>
<td>334</td>
<td>Pesticides</td>
<td>Take a Stand:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debate Statement: The cosmetic use of pesticides in urban settings should be banned.</td>
</tr>
<tr>
<td>400</td>
<td>Public Research Funding</td>
<td>Tech Connect Questions:</td>
</tr>
<tr>
<td></td>
<td>Decisions (Telemetry)</td>
<td>6. In a small group discuss the costs and benefits of conducting [satellite telemetry for Leatherback</td>
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<td>Turtles] ... Who benefits? ... Should taxpayers pay for such research, or should it be funded by the</td>
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<td>private sector? Do the benefits justify the costs? On a priority scale of 1 to 10 (10 is highest),</td>
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<td></td>
<td></td>
<td>where does this type of research rank?</td>
</tr>
</tbody>
</table>

Table B4. Ethical Situations in Nelson Biology 12
| 515 | Public Research Funding | Explore an Issue: The Economics of Fossil Study  
Debate Statement: Fossils should be donated to research institutions because their investigations benefit everyone |
| 51 | Nutriceuticals | Explore an Issue: Functional Foods and Nutriceuticals  
Statement: Nutriceuticals should be regulated as drugs under the Canada Food and Drug Act |
| 120 | Fetal Alcohol | Explore and Issue: Fetal Alcohol Syndrome  
Debate Statement: Women should not drink even a small amount of alcoholic beverages while pregnant |
| 472 | Stem Cells | Explore and Issue: The Future of Stem Cell Research  
Debate Statement: Governments should redirect some funding from organ transplant research to autologous (i.e. originating from the same individual) stem cell research |
| 562 | Drug Resistance | Explore and Issue: Treatment of Drug-Resistant Tuberculosis  
Debate Statement: Individuals being treated for multi-drug resistant TB should be placed under medical house arrest to ensure they complete their entire treatment under medical supervision. |
| 295 | Genetic Engineering | Explore and Issue: Genetic Engineering Guidelines and Regulations  
Debate Statement: International guidelines and parameters overseeing public and private recombinant DNA technology need to be established and reviewed annually. |
| 360 | Xenotransplants | Explore and Issue: Xenotransplants  
Debate Statement: The government should allow xenotransplants in Canada. |
| 391 | Banned Substances (Steroids) | Explore and Issue: Protecting Athletes  
Debate Statement: Not enough is being done to prevent the use of banned substances in sport |
| 180 | Tropical Rainforest | Explore and Issue: Tropical Rainforest Depletion: Is there Cause for Concern?  
Debate Statement: The governments of developing countries have the right to make room for agriculture and industrialization by clearing tropical rainforests. |
| 77 | Animal Welfare | Making Connections:  
10. e) The ante mordem method of tenderizing meat involves the physical injection of solution of papain or bromelain into the living animal. The enzyme tenderizes muscle tissue while the animal is alive. Discuss this method with fellow classmates and write a brief position of the ethics of this procedure. |
| 135 | Banning Substances | Extension:  
31. e) Write a short position statement on the proposition that human consumption of alcoholic beverages should be prohibited completely. |
| 203 | Biotechnology Eugenics Genetic Engineering | A group of ethical statements appear in the “Are you Ready Section” that prepares students for Unit 2 (Molecular Genetics). Students are asked to somewhat or fully agree or disagree with the following statements:  
Making Connections:  
6. a) Institutions that discover specific DNA sequences should be allowed to patent those sequences.  
b) Information gained from the Human Genome Project should only be used for medical |
<table>
<thead>
<tr>
<th><strong>231</strong></th>
<th>Scientific Research Recognition Inclusion</th>
<th>Making Connections:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Explain why Chargaff was not included in this group of scientists, despite his important contribution. Should Wilkins have been included? Franklin? Justify your answer. How does Watson and Crick’s work meet the parameters set by the Nobel Prize Committee?</td>
<td></td>
</tr>
<tr>
<td><strong>248</strong></td>
<td>HIV Screening (Health)</td>
<td>Making Connections:</td>
</tr>
<tr>
<td></td>
<td>Should health-care workers such as doctors, dentists, and nurses, be screened for HIV? Justify your answer. What pre-cautions do medical professionals take to protect themselves from the AIDS virus?</td>
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</tr>
<tr>
<td><strong>263</strong></td>
<td>Personal Lifestyle</td>
<td>Making Connections:</td>
</tr>
<tr>
<td></td>
<td>9. List three changes that can be made to your personal lifestyle that would reduce the odds of a mutation taking place.</td>
<td></td>
</tr>
<tr>
<td><strong>322</strong></td>
<td>Regulation Policy</td>
<td>Performance Task: Bovine Somatotropin: Canadian Approval or disapproval</td>
</tr>
<tr>
<td></td>
<td>In this Unit task you will explore and research the use of bovine somatotropin in boosting milk production in cows. In some parts of the United States, the hormone has been approved for use on dairy farms, but it has been banned in Canada. Your challenge will be to gather, synthesize, and analyse information about the use of bovine somatotropin. Based on your research you will decide whether the hormone should be used in Canada.</td>
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</table>
Appendix C – Discourse on Functional Foods/Nutriceuticals

The following is an excerpt from Nelson Biology 11 College Prep (DiGiuseppe, 2004, p. 40-41). The debate that follows is captured above in figure 6.2.
Table 1 Common Functional Foods

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product name</th>
<th>Nutraceutical ingredient(s)</th>
<th>Claimed health benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple &amp; Eve “Tribal Tonics”</td>
<td>Energy Elixir</td>
<td>guarana-seed extract, ginseng</td>
<td>enhances energy, stamina, and endurance</td>
</tr>
<tr>
<td>Arizona “Rx Eluxa”</td>
<td>Rx Stress</td>
<td>kava kava</td>
<td>relieves stress</td>
</tr>
<tr>
<td>Fresh Samantha “Body Zoomers”</td>
<td>Super Juice (beverage)</td>
<td>echinacea</td>
<td>keeps colds at bay</td>
</tr>
<tr>
<td>Golden Temple Cereals</td>
<td>Mango Passion Crisp</td>
<td>St. John’s wort, kava kava</td>
<td>supports emotional and mental balance</td>
</tr>
<tr>
<td>Hansen’s Beverage Co. “Healthy Start”</td>
<td>Immune-ox Juice</td>
<td>echinacea</td>
<td>stimulates the body’s production of interferon, a cell-protecting protein</td>
</tr>
<tr>
<td>Odwalla</td>
<td>Femme Vitale</td>
<td>vitex, nettles, dong quai</td>
<td>strongly supports women’s cyclic nutritional needs</td>
</tr>
<tr>
<td>Snapple</td>
<td>Earth</td>
<td>grape-seed extract, ginseng</td>
<td>helps provide your body with the balance it needs</td>
</tr>
</tbody>
</table>

Universal Remedy or Modern Snake Oil?
Producers of functional foods are targeting a number of common conditions for functional food research. These include heart disease, osteoporosis, high blood pressure, diabetes, digestive disorders, menopausal symptoms, and lactose intolerance. In many cases, the health claims made on the packages of functional foods may be exaggerated and confusing to the consumer. For example, there is strong scientific evidence for the claim that soy protein can lower blood-cholesterol levels, but there is little to no evidence for the claim that green tea reduces the risk of cancer. While there is no legal definition for the term functional food, or nutraceutical, laws are in place to protect consumers. Manufacturers of foods are permitted to make claims about how their products affect the structure and function of the body, but they must obtain government approval before making claims about a food’s ability to treat or cure disease. For example, a label may say that a product helps maintain healthy vision, but it can’t claim to offer protection against cataracts unless it has gone through Ministry of Health testing and approval.

If functional foods live up to their claims, there is a growing concern that consumers could get too much of a good thing. For instance, makers of the “151 Bar” claim that it contains 151 vitamins and minerals, but it also contains an enormous 11 g of fat and 19 g of sugar. Australia has removed products containing cholesterol-lowering plant sterols from supermarket shelves after obtaining evidence showing that extra-high doses of plant sterols could reduce the absorption of carotene, a nutrient necessary for human health.

Nutraceutical producers would like to adorn their labels with health claims, but dieticians worry that consumption of these products might actually aggravate certain health problems. For example, Ginkgo biloba contains ingredients that may act as blood-thinning agents. People who are presently taking blood-thinning drugs, such as aspirin, to control a heart condition could experience additional heart problems if their blood becomes too thin after taking Ginkgo. Taking aspirin and Ginkgo at the same time could lead to increased bleeding—there have been reports of bleeding behind the eye or bleeding in the brain in...
Appendix D – Lab Activities/Investigations/Performance Tasks

Lists of lab activities/performance tasks and investigations from the four biology textbooks under study.

Table D1. Lab Activities/Investigations/Performance Tasks in Nelson Biology 11 College Preparation (NB11CP)

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<tr>
<th>Page</th>
<th>Activity/Investigation</th>
<th>Purpose/Inquiry Question</th>
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<td>16</td>
<td>Observing Cells</td>
<td>Students mount and observe the structures of two different kinds of cells</td>
</tr>
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<td>36</td>
<td>Biological 3D Compounds</td>
<td>Students build models of preset molecules that are important in biology</td>
</tr>
<tr>
<td>38</td>
<td>Identifying Nutrients</td>
<td>Students identify nutrients in a sample to describe sugars, starches, lipids and proteins</td>
</tr>
<tr>
<td>44</td>
<td>Counting Red Blood Cells and Yeast cells</td>
<td>Students follow a counting and multiplying procedure to determine blood cell count and concentrations.</td>
</tr>
<tr>
<td>56</td>
<td>Enzyme Activity</td>
<td>Students look at rate limiting factors (PH, Temperature) of enzyme activity</td>
</tr>
<tr>
<td>80</td>
<td>Food Technologist for the Day</td>
<td>Students take on a company research role and must determine if “k19” is a better yeast and make a report to the company (a report to the journal mycelium is also mentioned).</td>
</tr>
<tr>
<td>113</td>
<td>Culturing Bacteria</td>
<td>With the use of an incubator students describe the process of how bacteria is cultured.</td>
</tr>
<tr>
<td>125</td>
<td>Observing effects of antiseptics</td>
<td>Students engage in product testing for antiseptics as they relate to bacterial growth.</td>
</tr>
<tr>
<td>134</td>
<td>Examining Protists</td>
<td>Students Examine morphological and behavioural aspects of Protista</td>
</tr>
<tr>
<td>141</td>
<td>Monitoring bread mold growth</td>
<td>Students investigate what environmental conditions promote the growth of mold, and determine how they could prevent mold from growing on food.</td>
</tr>
<tr>
<td>191</td>
<td>Fish dissection</td>
<td>Students dissect a fish asking the following question: How is the structure of the fish suited to its function?</td>
</tr>
<tr>
<td>208</td>
<td>The Body’s response to exercise</td>
<td>Students investigate the question: How is blood pressure and pulse rate affected by exercise? Students are to engage the investigation as a personal trainer and compare student results.</td>
</tr>
<tr>
<td>217</td>
<td>Urinalysis</td>
<td>Students use urine analysis to diagnose problems (Infection, deficiency, disease, malnutrition)</td>
</tr>
<tr>
<td>225</td>
<td>Determining Lung Values</td>
<td>Students determine their normal breathing volume and maximum capacity.</td>
</tr>
<tr>
<td>251</td>
<td>Designing and Constructing a model hand</td>
<td>Students design and build a model hand from every day materials</td>
</tr>
<tr>
<td>256</td>
<td>Examining the Systems of a Fetal Pig</td>
<td>Students engage in an extensive anatomy identification task (in terms of structure and function) while dissecting a fetal pig.</td>
</tr>
<tr>
<td>285</td>
<td>Collecting and classifying plants</td>
<td>Students collect and classify plants from their local area to gain familiarity and a sense of local biodiversity.</td>
</tr>
<tr>
<td>293</td>
<td>Oxygen Consumption by Pea Seeds</td>
<td>Students determine the different rate of oxygen consumption of germinating and non-germinating seeds.</td>
</tr>
<tr>
<td>305</td>
<td>Separating compounds in plant leaves</td>
<td>Students use chromatography to separate different pigments found in a leaves.</td>
</tr>
<tr>
<td>310</td>
<td>Monocots and Dicots</td>
<td>Students compare monocots and dicots in terms of structure, metabolic activity and chemical composition.</td>
</tr>
<tr>
<td>312</td>
<td>How do growing plants respond to their environment?</td>
<td>Students test the effects of light, gravity, and touch on the growth of plants.</td>
</tr>
<tr>
<td>328</td>
<td>Planning a vegetable garden</td>
<td>Students must choose suitable seed varieties to grow for their particular purposes in</td>
</tr>
</tbody>
</table>

16 The repeated use of the word student is to signal the repetitive aspect of lab investigations and activities
their area

348 Playing the role of an employee at a garden centre

Students play the role of an (plant expert) employee at a garden centre, answering customer questions related to plant type, parts, appropriateness and pest control.

369 Research Biomes

Students research various geographical aspects of a particular biome or ecozone.

384 What happens to species when they compete?

Students use pre-given data to determine what happens to a species when it is made to compete for resources in the same ecological niche.

406 Estimating Population Size

Students (learn to) estimate the size of a population using a peanut simulation.

407 Plant and Animal Survey

Students are given or choose an area for potential development and determine what plant or animal species might be in the area and what this might mean for potential development.

Table D2. Lab Activities/Investigations/Performance Tasks in Nelson Biology 12 (NB12)

<table>
<thead>
<tr>
<th>pg</th>
<th>Activity/Investigation</th>
<th>Purpose/Inquiry Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>Buffers in Living Systems</td>
<td>Students look at the difference between different buffers and buffer molar strengths</td>
</tr>
<tr>
<td>80</td>
<td>Building 3-d Macromolecules</td>
<td>Students build 3-D models of important biological molecules</td>
</tr>
<tr>
<td>82</td>
<td>Factors affecting the rate of enzyme activity</td>
<td>Students look at various factors that affect the rate of enzyme activity (ex. PH, Temp).</td>
</tr>
<tr>
<td>126</td>
<td>Oxygen consumption in germinating and non-germinating seeds</td>
<td>Students look at the difference in oxygen consumption between germinating and non-germinating seeds</td>
</tr>
<tr>
<td>128</td>
<td>Energy consumption during exercise</td>
<td>Students look at the differences in the amount of glucose required (respired in) anaerobic and aerobic exercise</td>
</tr>
<tr>
<td>131</td>
<td>Estimating VO$_2$ max.</td>
<td>Students take a walking test to measure their own VO$_2$ (lung capacity)</td>
</tr>
<tr>
<td>182</td>
<td>Light and photosynthesis</td>
<td>Students investigate whether plants require light to produce starch</td>
</tr>
<tr>
<td>186</td>
<td>The Hill Reaction</td>
<td>Students investigate whether light and chloroplasts are necessary for the production of DCPiP</td>
</tr>
<tr>
<td>188</td>
<td>Factors Affecting the Rate of Photosynthesis</td>
<td>Students investigate how light intensity, temperature, and CO$_2$ concentration affect the rate of photosynthesis</td>
</tr>
<tr>
<td>194</td>
<td>Student Acquirist</td>
<td>Students investigate how various factors affect the health of an aquatic ecosystem model (light, Ph, dissolved chemicals such as ammonia and oxygen)</td>
</tr>
<tr>
<td>224</td>
<td>Isolation and Quantification of DNA</td>
<td>Students extract DNA from plant cells and test the quantity and purity</td>
</tr>
<tr>
<td>226</td>
<td>Evidence of Heredity Material</td>
<td>Students are presented with a (historical lab) situation and must answer heredity questions based on the results of bacterial injections/mortality in 3 groups of mice</td>
</tr>
<tr>
<td>268</td>
<td>Protein Synthesis and Inactivation of Antibiotics</td>
<td>Students explore the question: What effect does the presence of an ampicillin-resistance gene in a bacterium have on its growth on ampicillin-rich media?</td>
</tr>
<tr>
<td>269</td>
<td>Synthesis of Insulin: A Simulation of Protein Synthesis</td>
<td>Students are given the chance to decode the protein for insulin given nucleotide sequences on a DNA strand.</td>
</tr>
<tr>
<td>270</td>
<td>Protein Synthesis: A Very Close Look</td>
<td>Students identify organelles and enzymes involved in the synthesis of insulin</td>
</tr>
<tr>
<td>271</td>
<td>Comparison of Eukaryotic and Prokaryotic Genomes</td>
<td>Students compare various aspects of prokaryote and eukaryote cell DNA fragments.</td>
</tr>
<tr>
<td>310</td>
<td>Restriction Enzyme Digestion of Bacteriophage DNA</td>
<td>Students investigate the question: How do the patterns of DNA fragments compare when a piece of DNA is digested using different restriction endonucleases?</td>
</tr>
<tr>
<td>314</td>
<td>Calcium Chloride Transformation of E. coli with Ampicillin-Resistant Plasmid</td>
<td>Students evaluate how efficient the calcium chloride transformation protocol is</td>
</tr>
<tr>
<td>316</td>
<td>Constructing a Plasmid Map</td>
<td>In this activity students construct plasmid maps using information gathered from restriction enzyme digestions of plasmids.</td>
</tr>
<tr>
<td>317</td>
<td>Restriction Fragment Length Polymorphism Analysis</td>
<td>Students use this type of analysis to match DNA samples.</td>
</tr>
<tr>
<td>322</td>
<td>Bovine Somatotropin: Canadian Approval or disapproval</td>
<td>Students look at the use of this chemical in boosting milk production – in terms of many factors</td>
</tr>
</tbody>
</table>

224
<table>
<thead>
<tr>
<th>Page</th>
<th>Activity Description</th>
<th>Detailed Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>363</td>
<td>Comparing Solutes in the Plasma, Nephron, and Urine</td>
<td>Students answer questions related to data concerning solute quantities extracted from various organs.</td>
</tr>
<tr>
<td>363</td>
<td>Do Sport Drinks Really Work?</td>
<td>Students investigate the question: How do sports drinks affect reaction time?</td>
</tr>
<tr>
<td>365</td>
<td>Diagnosis of Kidney disorders</td>
<td>Students detect kidney disease in an array of urine samples (simulated).</td>
</tr>
<tr>
<td>400</td>
<td>The Identification of Hypoglycemia</td>
<td>Students investigate how urinalysis is used to diagnose hyperglycemia?</td>
</tr>
<tr>
<td>401</td>
<td>Effects of hormones on blood sugar</td>
<td>Students use graphical data to examine the effects of hormones on blood sugar.</td>
</tr>
<tr>
<td>402</td>
<td>Hormonal Control of Metamorphosis</td>
<td>Students use pre-given data to present an hypotheses on the effects of hormones on metamorphosis.</td>
</tr>
<tr>
<td>404</td>
<td>Hormone Levels During the Female Menstrual Cycle</td>
<td>Students explore how hormone levels regulate the female menstrual cycle.</td>
</tr>
<tr>
<td>450</td>
<td>Teaching a Planarian</td>
<td>Students investigate the question: Do all planaria learn at the same rate?</td>
</tr>
<tr>
<td>452</td>
<td>Reflex Arcs</td>
<td>Students engage in an activity to answer the question: What is the advantage of being able to test different reflexes?</td>
</tr>
<tr>
<td>453</td>
<td>Human vision</td>
<td>Students test their visual acuity and other aspects of their vision.</td>
</tr>
<tr>
<td>454</td>
<td>Hearing and Equilibrium</td>
<td>Students investigate the effect of environmental factors on hearing and equilibrium.</td>
</tr>
<tr>
<td>492</td>
<td>Diagnosing Disease by Examining Blood Cells</td>
<td>Students examine prepared slides to identify different types of white blood cells and determine how changes in blood cell counts are used to diagnose disease.</td>
</tr>
<tr>
<td>493</td>
<td>Virtual Immunology Laboratory</td>
<td>Students formulate questions using the Enzyme-Linked Immunology Assay (ELISA).</td>
</tr>
<tr>
<td>498</td>
<td>Determining the Effects of Caffeine on Homeostasis</td>
<td>Students formulate two questions that will inform an investigation into the effects of caffeine on different physiological systems.</td>
</tr>
<tr>
<td>534</td>
<td>Applying Fossil Evidence</td>
<td>Students make and test hypothesis about the order of events in Earth’s history.</td>
</tr>
<tr>
<td>535</td>
<td>Looking for Homologies</td>
<td>Students compare a group of organisms in order to identify particular homologies.</td>
</tr>
<tr>
<td>536</td>
<td>Industrial Melanism and the Peppered Moth</td>
<td>Students explore the questions: How might the appearance of individuals influence their likelihood of being seen and eaten by predators? What influence might natural selection have on survival from predators?</td>
</tr>
<tr>
<td>577</td>
<td>Agents of Change</td>
<td>Students explore how genetic drift and natural selection influence the allele frequency within a population.</td>
</tr>
<tr>
<td>578</td>
<td>Evolution in Motion</td>
<td>Students investigate how random mutation and nonrandom natural selection work at the same time to cause evolutionary change in a species.</td>
</tr>
<tr>
<td>629</td>
<td>Observing Liposome Formation</td>
<td>Students model the formation of cell like structures that may have existed on primordial earth.</td>
</tr>
<tr>
<td>629</td>
<td>Looking for “SINES” of Evolution</td>
<td>Students construct and apply cladograms depending on the existence of SINEs and LINEs in the simulated data given.</td>
</tr>
<tr>
<td>631</td>
<td>Comparing Hominid Chromosomes</td>
<td>Students compare the chromosomes of different hominid species (including Homo sapiens)</td>
</tr>
<tr>
<td>638</td>
<td>The Evolution of Lactose Intolerance</td>
<td>Students trace the evolution of lactose intolerance and speculate what this means for particular medicinal practices.</td>
</tr>
<tr>
<td>689</td>
<td>Estimating Population Size</td>
<td>Students apply quadrat analysis techniques and mark-recapture methods to determine population size.</td>
</tr>
<tr>
<td>691</td>
<td>Investigating Predator-Prey Cycling</td>
<td>What effect does the introduction of a natural predator have on the white tailed deer population?</td>
</tr>
<tr>
<td>746</td>
<td>The Impacts of Resource Consumption</td>
<td>Using pre-given data and outside research students answer the following questions: What resources are in the greatest demand by human populations? In what ways are the rates of consumption correlated to quality of life, population size, and environmental degradation?</td>
</tr>
<tr>
<td>748</td>
<td>Calculating Ecological Footprints</td>
<td>Using pre-given data and collected data and research students investigate the questions: How large do you think the ecological footprint of your household and your school might be? What do you predict is the number of hectares per person your household and school occupy?</td>
</tr>
<tr>
<td>754</td>
<td>Population Dynamics of Species Risk</td>
<td>Students Explore the population dynamics of a species at risk with other organisms in its community and make an informed and creative presentation</td>
</tr>
<tr>
<td>Page</td>
<td>Activity/Investigation</td>
<td>Purpose/Inquiry Question</td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>What’s Here? Testing for Macromolecules</td>
<td>Students engage the question: How can you determine the presence of glucose, starch, lipid and protein in various samples?</td>
</tr>
<tr>
<td>28</td>
<td>Osmosis in a model cell</td>
<td>Students design and conduct an experiment to determine how the composition of extracellular fluid affects osmosis</td>
</tr>
<tr>
<td>60</td>
<td>Exploring Organelle Function</td>
<td>Students investigate the question: How can you demonstrate the effect of pH on the catalase enzyme found in potato peroxisomes?</td>
</tr>
<tr>
<td>64</td>
<td>Modeling a Specialized Cell</td>
<td>Students create a scale model of a Eukaryote cell</td>
</tr>
<tr>
<td>86</td>
<td>Light Colour and Photosynthesis</td>
<td>Students use cellophane to investigate which colours of light an aquatic plant can use to “achieve” the highest rate of photosynthesis.</td>
</tr>
<tr>
<td>94</td>
<td>Seeds and Respiration</td>
<td>Students investigate the factors that affect the rate of cellular respiration in germinating seeds</td>
</tr>
<tr>
<td>96</td>
<td>Fermentation, A Form of Sugar Metabolism</td>
<td>Students go through a procedure that demonstrates that yeast cells break down sugar</td>
</tr>
<tr>
<td>110</td>
<td>Cellular Processes and Lactose Intolerance</td>
<td>Students determine the efficiency of a synthetic lactase product or the conditions under which the lactase works best</td>
</tr>
<tr>
<td>132</td>
<td>What Traits can you see in your family?</td>
<td>Students determine whether particular traits are homozygous or heterozygous in their families</td>
</tr>
<tr>
<td>138</td>
<td>Determining Plant Genotypes</td>
<td>Students determine the genotype of a tobacco seed based on the phenotype of the seedling</td>
</tr>
<tr>
<td>168</td>
<td>Meiosis in Easter Lillies</td>
<td>Students investigate where meiosis occurs in flowering plants?</td>
</tr>
<tr>
<td>178</td>
<td>Measuring Variation in a Trait</td>
<td>Students engage the question: How can you infer the inheritance pattern of a trait?</td>
</tr>
<tr>
<td>192</td>
<td>DNA Extraction</td>
<td>Students practice methods of extracting DNA from animal tissue</td>
</tr>
<tr>
<td>216</td>
<td>Genes and Population</td>
<td>Students decide which coot (bird) genotype is likely to survive in an environment</td>
</tr>
<tr>
<td>222</td>
<td>How is Eye Colour Inherited</td>
<td>Students use population genetics to develop a model for eye colour inheritance.</td>
</tr>
<tr>
<td>240</td>
<td>Group Action Plan on Genetic Technologies</td>
<td>Students put together a regulating plan on the uses of biotechnology</td>
</tr>
<tr>
<td>262</td>
<td>Measuring Respiratory Volumes</td>
<td>Students use respiratory equipment to measure lung volumes.</td>
</tr>
<tr>
<td>270</td>
<td>Controlling the Rate of Respiration</td>
<td>Students look at ways to alter the carbon dioxide levels in the body.</td>
</tr>
<tr>
<td>308</td>
<td>The Heart Rate of Daphnia</td>
<td>Students engage the question: How can you compare the effects of different substances on the heart rate of one animal?</td>
</tr>
<tr>
<td>316</td>
<td>The Effects of Stress on Blood Pressure</td>
<td>Students find ways to distinguish stress from other stimuli in relation to blood pressure (using themselves as research subjects)</td>
</tr>
<tr>
<td>344</td>
<td>Factors that Affect the Rate of which Enzymes Act</td>
<td>How do different factors (ex. pH and Temperature) affect the rate of enzyme activity?</td>
</tr>
<tr>
<td>348</td>
<td>Digestion of a Protein</td>
<td>Students demonstrate that pepsin and trypsin will digest protein</td>
</tr>
<tr>
<td>370</td>
<td>Making Medical History</td>
<td>Students write a report on the history of a single disease (focused on medical practices and the change in biological knowledge involved).</td>
</tr>
<tr>
<td>392</td>
<td>Creating a dichotomous key</td>
<td>Students construct dichotomous keys to classify insects.</td>
</tr>
<tr>
<td>398</td>
<td>Variation and Selection in the Paper Bird</td>
<td>Students use paper bird figurines to model the changes needed to undergo natural selection</td>
</tr>
<tr>
<td>422</td>
<td>The Bacteria around you</td>
<td>Students collect bacteria from different areas of the school.</td>
</tr>
<tr>
<td>428</td>
<td>Observing Variations in Bacteria Responses to Antibiotics</td>
<td>Students engage the question: Which antibiotic is most effective in killing bacteria?</td>
</tr>
<tr>
<td>434</td>
<td>Sampling Pond Organisms</td>
<td>Students collect and classify pond plankton to try and accurately reflect the diversity of the organisms in the pond</td>
</tr>
<tr>
<td>442</td>
<td>Observing Algae</td>
<td>Students observe and identify characteristics of algae as well as classify samples</td>
</tr>
</tbody>
</table>
Identifying Common Fungi | Students Observe and Classify Fungi
---|---
How Do Mosses Differ From Algae | Students observe the differences between algae and mosses in order to differentiate the kingdoms (Plantae and Animalia)
Alternation of Generation in Mosses | Students identify the different stages and characteristics of alternating generations (life cycles) in mosses
Identifying Conifers | Students identify different species of conifers found in their area
Observing Planarian Behaviour | Students engage the question: How is the shape of planarians related to their methods of locomotion and feeding?
Classifying Arthropods | Students determine what characteristics are most useful for identifying members of different arthropod classes
Comparing Monocots and Dicots | Students examine the external characteristics of angiosperms to determine if a plant is a monocot or a dicot.
Observing Stomatal Action | What environmental effects determine stomatal opening size and guard cell action?
Factors Affecting Plant Growth | Students investigate the effect of an external factor on the growth of plants?
How Gibberellic Acid Affects Plant Growth and Plant Development? | Students investigate the question: How does gibberlic acid affect the growth of bean plants?
Course Challenge: Using Forensic Science | Students design and present a mystery that can be solved with forensic science

Table D4. Lab Activities/Investigations/Performance Tasks in McGraw Hill Biology 12 (MHB12)

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<tr>
<th>Page</th>
<th>Activity/Investigation</th>
<th>Purpose/Inquiry Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Acids, Bases, and Cellular PH</td>
<td>Students explore how do acids and bases affect living cells?</td>
</tr>
<tr>
<td>24</td>
<td>Finding the Products of Hydrolysis</td>
<td>Students investigate the question: How can the products of hydrolysis of carbohydrates be identified?</td>
</tr>
<tr>
<td>38</td>
<td>Endothermic and Exothermic Changes</td>
<td>Students explore the question: What energy changes can you observe during different chemical reactions?</td>
</tr>
<tr>
<td>46</td>
<td>Affecting Enzyme Activity</td>
<td>Students determine test factors that affect enzyme activity</td>
</tr>
<tr>
<td>72</td>
<td>Enzyme Activity in the Krebs Cycle</td>
<td>Students determine the location of succinic dehydrogenase activity in cells.</td>
</tr>
<tr>
<td>98</td>
<td>Enzymes and Reaction Rate</td>
<td>Students determine the effect of one factor on enzyme activity and reaction rates</td>
</tr>
<tr>
<td>118</td>
<td>The Physiological Effects of Coffee</td>
<td>Students determine the physiological effect of consuming coffee.</td>
</tr>
<tr>
<td>130</td>
<td>Food Allergy Survey</td>
<td>Students collect data on allergies and food products through surveys and questionnaires to create a “demography” of allergies</td>
</tr>
<tr>
<td>154</td>
<td>The effect of light on Pupil size?</td>
<td>Students examine whether the colour of light influences pupil dilation</td>
</tr>
<tr>
<td>158</td>
<td>How do we Hear?</td>
<td>Students explore the question: How does distance affect hearing?</td>
</tr>
<tr>
<td>160</td>
<td>Invertebrate response to External Stimuli</td>
<td>Students investigate invertebrate responses to specific stimuli</td>
</tr>
<tr>
<td>188</td>
<td>Crowding Stress on a Guppy Population</td>
<td>Students investigate how guppy populations respond to crowded conditions</td>
</tr>
<tr>
<td>208</td>
<td>Is there a cure for Diabetes?</td>
<td>Students design a report on the future of diabetes treatment</td>
</tr>
<tr>
<td>238</td>
<td>DNA structure and replication</td>
<td>Students use models to simulate molecular interactions</td>
</tr>
<tr>
<td>266</td>
<td>Simulating Protein Synthesis</td>
<td>Students use household materials to simulate transcription and translation (DNA)</td>
</tr>
<tr>
<td>300</td>
<td>Gel Electrophoresis</td>
<td>Students use gel electrophoresis to compare two samples of DNA</td>
</tr>
<tr>
<td>336</td>
<td>Diversity Within a Species</td>
<td>Students engage the question: How can variability among (human) individuals be measured?</td>
</tr>
<tr>
<td>374</td>
<td>Population Genetics and the Hardy Weinberg Principle</td>
<td>Students calculate the genetic variety in their class by using the Hardy-Weinberg Equation</td>
</tr>
<tr>
<td>408</td>
<td>Skull Differences in Primates</td>
<td>Students examine the skulls of primates to look for evidence of evolution</td>
</tr>
<tr>
<td>420</td>
<td>Searching for a Common Ancestor</td>
<td>Students research and report on an area of common ancestry in living organisms related to early life, DNA change over time or symbiotic evolution</td>
</tr>
<tr>
<td>437</td>
<td>Foraging Strategies a Simulation Experiment</td>
<td>Students identify behavioral differences between the foraging strategies used by specialists and generalists and predict their success</td>
</tr>
<tr>
<td>458</td>
<td>Ecosystem Productivity</td>
<td>Students devise a model ecosystem and use them to study the impact of specific environmental factors on various trophic levels of a food web and how energy flows through these levels (this is not an environmentalist project!)</td>
</tr>
<tr>
<td>486</td>
<td>Paramecium Populations</td>
<td>Students determine the effect of various density-dependent and density-independent factors on the growth rate of paramecium populations</td>
</tr>
<tr>
<td>508</td>
<td>Cemetery Studies of Human Demography</td>
<td>Does survivorship change over time in human populations?</td>
</tr>
<tr>
<td>530</td>
<td>How Can the Tragedy of the Commons be Avoided?</td>
<td>Students engage in an activity whereby they strategize how to share a resource (red pebbles).</td>
</tr>
<tr>
<td>538</td>
<td>Sustainable development: Population and the Environment</td>
<td>Students make a presentation to the UN commission on sustainable development describing the perspective of a single country – talking about their countries' most pressing concerns and proposing solutions to specified problems.</td>
</tr>
<tr>
<td>544</td>
<td>Organize a Biology Symposium</td>
<td>Students organize a symposium where students get to choose a topic of any choice from disease to scientific discoveries. The project should highlight STSE issues.</td>
</tr>
</tbody>
</table>
Appendix E – Discourse on Careers

The following are discursive fragments concerning careers for students. Although the entire text orients students towards a career I thought it would be especially useful to isolate the discourse where this is done specifically and purposefully so as to discern how the text frames choices for future work. In NB12 and NB11CP this discourse was found primarily in rather small (2-4 sentence) sections found throughout the text called “career connections” (sometimes denoted by a tri-arrow symbol) as well as periodic pages called “Careers in Biology” where four careers are each profiled in a comprehensive paragraph. In MHB11 and MHB12 specific discourse concerning careers were found in “biology at work”, where the career of one individual is storied and detailed, and “Canadians in Biology”, which details the contribution of a Canadian to the field of biology.

Table E1. NB11CP: “Career Connections”

<table>
<thead>
<tr>
<th>Page</th>
<th>List of “Career Connection” Text(s) and Other Specific Career Discourse Instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Career Connection: Cytologist</td>
</tr>
<tr>
<td>39</td>
<td>Career Connection: Food Technologist</td>
</tr>
<tr>
<td>47</td>
<td>Career Connection: Hermatology</td>
</tr>
<tr>
<td>59</td>
<td>Career Connection: Venipuncturist</td>
</tr>
<tr>
<td>101</td>
<td>Career Connection: Art Drawing in Biology</td>
</tr>
<tr>
<td>103</td>
<td>Career Connection: Water Quality Technician</td>
</tr>
<tr>
<td>111</td>
<td>Career Connection: Microbiology</td>
</tr>
<tr>
<td>114</td>
<td>Career Connection: Biotechnology technician</td>
</tr>
<tr>
<td>125</td>
<td>Career Connection: Health and Safety technicians</td>
</tr>
<tr>
<td>135</td>
<td>Career Connection: Biological technicians</td>
</tr>
<tr>
<td>142</td>
<td>Career Connection: Cheese makers</td>
</tr>
<tr>
<td>165</td>
<td>Career Connection: Medical Sonographers</td>
</tr>
<tr>
<td>181</td>
<td>Career Connection: Pharmacy technician</td>
</tr>
<tr>
<td>187</td>
<td>Career Connection: Dietary technician</td>
</tr>
<tr>
<td>192</td>
<td>Career Connection: Fish Farming</td>
</tr>
<tr>
<td>203</td>
<td>Career Connection: Nurses, Medical specialists</td>
</tr>
<tr>
<td>216</td>
<td>Career Connection: Technologist</td>
</tr>
<tr>
<td>227</td>
<td>Career Connection: Certified heating inspectors</td>
</tr>
<tr>
<td>248</td>
<td>Career Connection: Paramedic</td>
</tr>
<tr>
<td>251</td>
<td>Career Connection: Prosthetist</td>
</tr>
<tr>
<td>278</td>
<td>Career Connection: Soil Testers, farmers, landscapers</td>
</tr>
<tr>
<td>281</td>
<td>Career Connection: Cone harvester (seasonal work)</td>
</tr>
<tr>
<td>297</td>
<td>Career Connection: Forestry Industry (general)</td>
</tr>
<tr>
<td>300</td>
<td>Career Connection: Wood processing machine operators</td>
</tr>
<tr>
<td>323</td>
<td>Career Connection: Landscapers and garden centre workers</td>
</tr>
<tr>
<td>336</td>
<td>Career Connection: Pest management</td>
</tr>
<tr>
<td>338</td>
<td>Career Connection: Working with plants special section</td>
</tr>
<tr>
<td>369</td>
<td>Career Connections: Ecosystem management technician</td>
</tr>
<tr>
<td>388</td>
<td>Career Connection: Wildlife technicians</td>
</tr>
<tr>
<td>424</td>
<td>Career Connection: Green job market: Sustainable forestry management; parks and recreation; air-and-water-quality control; waste management recycling; land-use planning; ecological restoration; and soil,</td>
</tr>
</tbody>
</table>
Table E2. NB12 “Careers in Biology”

<table>
<thead>
<tr>
<th>Page</th>
<th>Careers outlined in “Careers in Biology”</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>Kinesiologist; molecular biologist; biochemist</td>
</tr>
<tr>
<td>304</td>
<td>Gene Patent Lawyer; Genetic Engineer; Bioinformatician; Bioethicist; Genetic Counselor</td>
</tr>
<tr>
<td>491</td>
<td>Sports Nutritionist; Endocrinologist; Immunologist; Dialysis Technologist</td>
</tr>
<tr>
<td>627</td>
<td>Plant Breeder; Conservation Biologist; Natural Product Research Chemist</td>
</tr>
<tr>
<td>745</td>
<td>Ecologist; Demographer; Wildlife Biologist</td>
</tr>
</tbody>
</table>

Table E3. MHB11: “Biology at Work” and “Canadians in Biology”

<table>
<thead>
<tr>
<th>Page</th>
<th>Careers Outlined in “Biology at Work” and “Canadians in Biology”</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td><strong>Biology at Work:</strong> Civil Engineer</td>
</tr>
<tr>
<td>36</td>
<td><strong>Canadians in Biology:</strong> Mystery of the Frozen Frogs</td>
</tr>
<tr>
<td>70</td>
<td><strong>Canadians in Biology:</strong> Banting and Best Discover Insulin</td>
</tr>
<tr>
<td>104</td>
<td><strong>Canadians in Biology:</strong> Fighting Foodborne Illness</td>
</tr>
<tr>
<td>172</td>
<td><strong>Biology at Work:</strong> Bio Informatics</td>
</tr>
<tr>
<td>202</td>
<td><strong>Canadians in Biology:</strong> Programming Genetic Change</td>
</tr>
<tr>
<td>228</td>
<td><strong>Canadians in Biology:</strong> Pioneer Cytogeneticist</td>
</tr>
<tr>
<td>266</td>
<td><strong>Biology at Work:</strong> Perfusionist</td>
</tr>
<tr>
<td>310</td>
<td><strong>Biology at Work:</strong> Pathology Investigating Medical Questions</td>
</tr>
<tr>
<td>314</td>
<td><strong>Canadians in Biology:</strong> Fish that Fight</td>
</tr>
<tr>
<td>416</td>
<td><strong>Canadians in Biology:</strong> Oasis Under the Sea</td>
</tr>
<tr>
<td>438</td>
<td><strong>Biology at Work:</strong> Medical Laboratory Technologist</td>
</tr>
<tr>
<td>507</td>
<td><strong>Biology at Work:</strong> Marine Biologist</td>
</tr>
<tr>
<td>529</td>
<td><strong>Canadians in Biology:</strong> Naturalist and Artist</td>
</tr>
<tr>
<td>568</td>
<td><strong>Biology at Work:</strong> Museum Technician</td>
</tr>
<tr>
<td>577</td>
<td><strong>Canadians in Biology:</strong> Creating Edible Vaccines</td>
</tr>
</tbody>
</table>

Table E4. MHB12: “Biology at Work” and “Canadians in Biology”

<table>
<thead>
<tr>
<th>Page</th>
<th>Careers Outlined in “Biology at Work” and “Canadians in Biology”</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td><strong>Biology at Work:</strong> Cheese Plant Manager</td>
</tr>
<tr>
<td>53</td>
<td><strong>Canadians in Biology:</strong> “Marvelous” Mutants: The Enzymatic Synthesis of Oligosaccharides</td>
</tr>
<tr>
<td>113</td>
<td><strong>Canadians in Biology:</strong> Cellophane and Imagination - Dr. Gordon Murray</td>
</tr>
<tr>
<td>244</td>
<td><strong>Canadians in Biology:</strong> Chromosomal Abnormalities in Sperm</td>
</tr>
<tr>
<td>270</td>
<td><strong>Biology at Work:</strong> Molecular Biologist</td>
</tr>
<tr>
<td>356</td>
<td><strong>Biology at Work:</strong> Paleontologist</td>
</tr>
<tr>
<td>402</td>
<td><strong>Canadians in Biology:</strong> Sticklebacks and Speciation</td>
</tr>
<tr>
<td>457</td>
<td><strong>Biology at Work:</strong> Ecological Policy Maker</td>
</tr>
<tr>
<td>521</td>
<td><strong>Canadians in Biology:</strong> Landscape Ecologist</td>
</tr>
</tbody>
</table>
Appendix F – Sustainability Summit Activity

A major outcome of the Earth Summit was the development of Agenda 21, a plan for achieving sustainable development in the twenty-first century. Various international agreements were negotiated, including the Framework Convention on Climate Change or the Convention on Biological Diversity. To monitor the implementation of these agreements, the UN Commission on Sustainable Development (CSD) was established in December 1992. The CSD’s annual meeting provides a forum for exchanging information and building partnerships among nations, businesses, industries, and other concerned groups.

In this activity, you will have the chance to make a presentation to the CSD as part of a group representing a specific country. You will describe your country’s most pressing environmental issue and the state of its population. You will then propose solutions to some of the identified challenges.

Plan and Present

1. Working in groups of three or four, select a country. Half of the groups within your class will represent less industrialized nations (for example, Bangladesh, Botswana, Venezuela, Vietnam, or Iraq), while the other half will represent more industrialized nations (such as Japan, the United States, Germany, Australia, or the Netherlands).

Your group will analyze and write a report on the status of your country’s population and environment. You will then summarize this report in the form of a presentation to the CSD. Your analysis and presentation should address the following four general questions:

- What is the most pressing environmental issue affecting your country? Consider whether the following factors have an impact: thinning of the ozone layer, global warming, deforestation, desertification, air pollution, depletion of fresh-water resources, ocean pollution, loss of biodiversity, soil erosion, accumulation of hazardous wastes.

- What are the main causes of this problem? Are they generated from within your own borders by your own citizens, or are they the result of activities going on in other countries? Is the problem due to overpopulation (too many people attempting to live on insufficient resources, overconsumption of certain resources), or both?

- What is the state of your country’s population in terms of its growth rate and quality of life for its citizens? Consider such factors as food availability, average income, income distribution (is wealth concentrated in the hands of a few individuals or evenly distributed), average life span, infant mortality rate, and access to health care. Is the future population of your country projected to grow, stabilize, or decline?

- What measures might solve the problem or problems identified? Specifically, examine existing or potential partnerships with other countries. If you are representing a less industrialized nation, what sort of foreign aid might be useful? Does your country participate in projects in your country, perhaps with funding from the Canadian International Development Agency (CIDA), the International Development Research Centre (IDRC), or other bodies? If so, are these projects successful in improving your country’s quality of life? If you are representing a more industrialized nation, does your nation invest in foreign aid? Does your country participate jointly with Canada in any projects? If so, analyze the success of these projects.

2. When doing research on the major environmental issue facing your country, address the following points:

- What is the scientific understanding of the environmental issue? Provide data on the issue’s causes and effects.

- Does population density contribute to the issue? If so, in what ways?

- Does this particular environmental problem reduce the carrying capacity of your country for humans? If so, how?

- Consider the resources available to you. For example, the Internet is an excellent source of current information, and many Canadian organizations such as Pollution Probe have information available on certain topics. Reports on CIDA and IDRC projects are often available from libraries or obtained from these organizations directly.

In a group, write a detailed report that will serve as a background document for your presentation. Each group member should focus on one of the four questions listed in step 1, do the research, and write about that topic. The entire group should focus on each topic before writing begins and provide feedback during the writing process.

Prepare a presentation to summarize your detailed report. The format of the presentation can be in the form of a speech, video, or drama.

Make your presentation. Be prepared to field questions from your classmates posing as representatives from other countries at the CSD meeting.

Evaluating the Results

1. Compare the content of your presentation with that presented by others. Do the environmental issues described as being important by other countries contribute to the difficulties in your country? Do opinions differ as to the cause of, or effective solution for, certain issues? If so, explain the reasons for these differences.

2. Consider the issue of bias in your work, as well as in the work of other groups. How many sources of information were used? Did any of them seem biased?

3. Did any of the presentations make you think about revising your own report or presentation? Describe the changes you might make and why you would make them.

4. Did your work in this analysis help you understand the information you learned in this unit? Might you integrate your learning into your lifestyle? Explain your answers.

Figure F1. Sustainability Summit in Rio, 1992
Appendix G – Discourse Analysis Techniques

<table>
<thead>
<tr>
<th>Technique/Strategy</th>
<th>How Technique Works</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unspoken/Naïve Assumptions</strong></td>
<td>Naïve assumptions try to get at what the text is saying without actually saying it and can take the form of ontological, existential, propositional assumptions (what’s going to happen), and value laden assumptions. Assumptions (and other aspects of the text) are also tied up with the way they are legitimized – either through an appeal to authority, rationalization, or an appeal to values. Other considerations Are arguments for some things assumed and for others, not assumed?</td>
</tr>
<tr>
<td><strong>‘Making Strange’</strong></td>
<td>Similar to Foucault’s methodological point of dropping the pretence of the author, here we pretend (as much as possible) that we are foreign to a set of statements. In this way, assumptions and what is taken for granted is likely to emerge.</td>
</tr>
<tr>
<td><strong>Nominalization</strong></td>
<td>Instead of representing particular phenomena as historically situated processes open to change, they are spoken about like nouns leaving out actors.</td>
</tr>
<tr>
<td><strong>Intersecting Genres</strong></td>
<td>For example identifying genres that have the purpose of ‘selling’ to organizations or individuals. Genres of ‘promotion’ (advertising) are one such genre.</td>
</tr>
<tr>
<td><strong>Genre Mixing and Interdiscursivity</strong></td>
<td>Mediation involves tracing how the meaning is moved from one text (or social practice) to another. Analyzing the chains of texts involved in getting a piece of text into, for example, biology textbook.</td>
</tr>
<tr>
<td><strong>Intertextuality</strong></td>
<td>Looking at the presence of other texts within the biology texts along with the assumptions, that are made around the inclusion of these texts; the assumptions that connect one text to another.</td>
</tr>
<tr>
<td><strong>Universals and Particulars</strong></td>
<td>Essentially, how universals are constructed in terms of representations. What is seen is inevitable, and universal thereby constituting the political space.</td>
</tr>
<tr>
<td><strong>Constative and performative</strong></td>
<td>Does the utterance describe something in the world, or is it performative, attempting to do something in the world successfully or unsuccessfully.</td>
</tr>
<tr>
<td><strong>“Dialogicality”</strong></td>
<td>Involves paying attention to the various voices contained within a text. Does the text allow for many voices? Does it allow for disagreement? How does the text portray difference? Is the language absolute? (Eco, 1989; Holquist 1981)</td>
</tr>
<tr>
<td><strong>Internal Relations within the Text</strong></td>
<td>Involves the semantic relation between clauses, words, sentences, grammatical relations (subordination of one thing to another), and the lexical relations between terms (the occurrence of one word with another, ex. Achievement and money)</td>
</tr>
<tr>
<td><strong>Deictics</strong></td>
<td>How is the statement or utterance tied to a specific context through the definite articles; what specifics meanings must be filled for the statement to makes sense.</td>
</tr>
<tr>
<td><strong>‘Why This way?’</strong></td>
<td>How would a statement's meaning, connotation change if the statement were re-written grammatically; how does the way it is written now contribute to a particular effect/meaning.</td>
</tr>
<tr>
<td><strong>Activities/Relations Building</strong></td>
<td>For a Communication ask what practices are being enacted or re-enforced. What kinds of relations in terms of other institutions, groups, are these activities associated?</td>
</tr>
<tr>
<td><strong>Material Distribution</strong></td>
<td>How do statements describe and justify specific distributions of goods (social and material)</td>
</tr>
<tr>
<td><strong>Systems of Knowledge</strong></td>
<td>How do the statements privilege one system of signs and knowledge over another? What kinds of knowing/speaking are privileged?</td>
</tr>
</tbody>
</table>

Table 3. Discourse Analysis techniques стрategies and how they may be employed (Fairclough, 2003; Gee, 2011).