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The nature of dissection: Exploring student conceptions

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**THE NATURE OF DISSECTION:
EXPLORING STUDENT CONCEPTIONS**

BY

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**B.S., University of New Hampshire, 1995.
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DISSERTATION

**Submitted to the University of New Hampshire
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In

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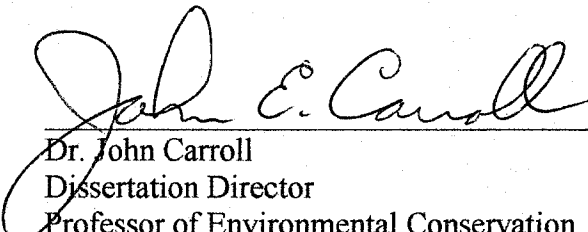
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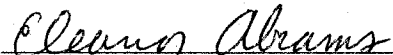
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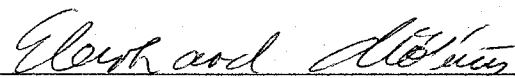
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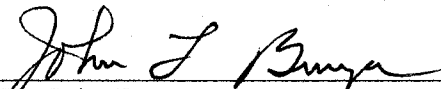
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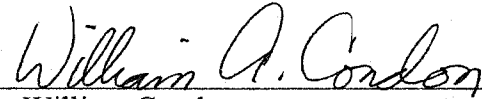
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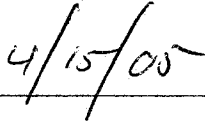

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DEDICATION

To my mother, who taught me to love animals.

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ABSTRACT

THE NATURE OF DISSECTION:
EXPLORING STUDENT CONCEPTIONS

by

Katharine York

University of New Hampshire, May, 2005

The model of conceptual change in science describes the process of learning as a complete restructuring of knowledge, when learners discover or are shown more plausible, intelligent alternatives to existing conceptions. Emotions have been acknowledged as part of a learner's conceptual ecology, but the effects of emotions on learning have yet to be described. This research was conducted to examine the role that emotions have on learning for thirteen high school students, as they dissected cats in a Human Anatomy and Physiology class. The project also investigated whether a student's emotional reactions may be used to develop a sense of connectedness with the nonhuman world, which is defined as ecological literacy.

This study utilized a grounded theory approach, in which student responses to interviews were the primary source of data. Interviews were transcribed, and responses were coded according to a constant comparative method of analysis. Responses were compared with the four conditions necessary for conceptual change to occur, and also to five principles of ecological literacy. Students who had negative reactions to dissection participated less in the activity, and demonstrated less conceptual change. Two female students showed the strongest emotional reactions to dissection, and also the lowest

amount of conceptual change. One male student also had strong negative reactions to death, and showed no conceptual change. The dissection experiences of the students in this study did not generally reflect ecological principles. The two students whose emotional reactions to dissection were the most negative demonstrated the highest degree of ecological literacy. These results provide empirical evidence of the effects that emotions have on learning, and also supports the opinions of educators who do not favor dissection, because it does not teach students to respect all forms of life.

INTRODUCTION

THE NATURE OF DISSECTION: EXPLORING STUDENT CONCEPTIONS

When I was in tenth grade, I refused to dissect a fetal pig. I walked out of the classroom, and stood in protest in the hallway. At the time, I could not articulate my reasons for refusing to dissect. It just felt wrong to me somehow. My biology teacher talked to me for several minutes in the hallway, and convinced me to return to the room. I did not touch the specimen, but I watched my lab partners perform the dissection. Later, I got an A on the exam, and eventually I received an A for the course.

As a sophomore in college, I enrolled in a Human Anatomy and Physiology course. In this class, we were required to dissect cats, and I refused. At this point in my life, I knew that I could not participate because it conflicted with my set of personal values. I was concerned about the treatment of animals as specimens in the biological supply companies where they are killed. I also felt that the activity violated my sense of respect for the cat as an individual, sentient creature. I watched my lab partners out of the corner of my eye, but mostly, I studied the diagrams in the textbook. At the end of the semester, I received an A for the class, and later I even became an undergraduate tutor for the course.

For five years of my Ph.D. program, I was a Teaching Assistant in the Biology 411 and 412 laboratory. In the spring semester, a large part of the curriculum was

devoted to dissection, of both invertebrates and vertebrate animals. I did not touch the specimens while I taught, which caused many students to raise their eyebrows, wondering how I could possibly teach dissection without performing it. I asked for student volunteers to demonstrate sagittal or frontal cuts, or other technical procedures when necessary. I always explained my views to my students, many of whom talked at length with me about their own experiences and opinions of dissection. These discussions were important to the development of this research project.

Many people believe in the value of dissection as a tool for learning. However, I always experienced a great tension surrounding dissection. How can a student like me care deeply about animals, and still participate in the activity of dissection? I was never able to reconcile my emotional feelings for animals with the task of cutting them apart for dissection. And given my success in biology and anatomy classes despite never touching the specimens, I ask the question, is dissection necessary to teach the internal anatomy and physiology of animals? I wondered whether there might be other students, like me, whose emotional reactions to dissection were so strong that they found themselves unable to participate in the activity. Would they be encouraged to pursue a career in science? What difference might these reactions make in the development of their attitudes toward science? I also wondered whether these emotional reactions might lead some students, like me, to question the root sources of dissection: where the animals came from, how they were killed, and whether or not this should be considered a justifiable use of animals as resources. How does dissection compare with the body of literature that emphasizes the importance of ecologically literate, responsible behavior toward the earth and its creatures? These questions developed into the current research, in which I explored

student conceptions of dissection. I investigated the importance of emotions in the learning process of dissection, and I also compared student experiences in dissection to ecological principles, to determine whether they can be considered ecologically literate.

In discussing the results of this study, I have found that there are two levels of understanding the issue of dissection. First, there is a pedagogical level, on which one can decide to agree or disagree with the use of dissection as a tool for learning anatomy and physiology of organisms. Secondly, there is a personal level of understanding, on which one can examine the values inherent in the activity of dissection, and agree or disagree with them. My personal set of values does not agree with dissection, because I believe it does not foster a sense of respect for the life of the organism. For me, dissection was not a helpful activity, nor do I prefer to use it to teach my own students about anatomy. I used book diagrams and models to effectively learn about internal structures, and I refused to violate my belief that animals are not things to be taken apart for the sake of learning. I learned more from the year I worked as a veterinary technician, when I assisted with surgeries and had many good opportunities to see and touch real, living tissues and organs. I thought this was much more valuable than dissection could ever be, and it was not a waste of life.

However, on a pedagogical level, I realize that many educators believe that there are learning situations, such as upper level anatomy and physiology classes, in which dissection is a useful and constructive tool. They contend that dissection is the best way for students to learn about the intricacies of physical structures, and they believe that the hands-on aspect of dissection is valuable because it provides students with a way to see, touch, and manipulate the tissues and organs of specimens. I know that some of my own

students enjoyed dissection, and also thought it was the best way to learn anatomy and physiology, preferring to see “the real thing” instead of look in a book. This complexity and tension is inherent in the issue of dissection, and will be evident throughout the discussion of the current research.

In this section, I present the purpose for the study and the research questions that guide the study, followed by a discussion of the major themes involved. First, I introduce the model of conceptual change learning in science. This model, developed in 1982, has been useful in describing how students learn science, and what the most effective methods for teaching science might be. The research in conceptual change has generated new theories about how students learn, and also has helped to define significant components of learning for all students. My research adds emotions as a factor to be considered as part of learning in dissection. Secondly, I define the term *ecological literacy* and compare it to scientific literacy as an educational goal. Scientific literacy provides the facts for students to base decisions about their lives. My research explores the importance of ecological literacy, which provides the knowledge necessary to make responsible choices in life that support the health and well-being of the planet and all of its creatures. Whether dissection can encourage the development of this type of literacy is the focus of the second part of my research. Finally, I discuss the significance of the study to science educators.

Purpose

The purpose of this study is to explore student conceptions of dissection. Student conceptions of dissection are comprised of objective facts learned about the structures and processes of a living body, and also the subjective aspects of emotions and values

associated with the activity (Doster, 1997; Orlans, 1988; Shapiro, 1992). To examine this complex process, I began with an examination of how students learn the objective facts in dissection, using the model of conceptual change in science learning. In the next section, I introduce this model, and I question its limitations when applied to an emotional activity like dissection.

Research Questions

The research questions for this study are as follows:

1. How do student conceptions of dissection change over the course of a school year?
2. How do emotions influence a student's ability to learn concepts through dissection?
3. Do student experiences in dissection reflect ecological principles?

I have chosen to explore student conceptions of dissection through in-depth interviews with thirteen high school students in a Human Anatomy and Physiology class. My decision to investigate the experiences of high school students was important. I could have easily utilized the population of college students in biology at my own university. However, college students have usually chosen a major in which they already anticipate dissection, and it is likely that many of them have already experienced dissection as part of their high school curriculum. Their opinions about the activity are more established than those of high school students. Middle school students sometimes participate in dissection in their science classrooms, but there are fewer experiences to explore. These factors led me to decide upon a high school population for the focus of my study.

Conceptual Change

The conceptual change model (CCM) of learning in science, as it was first developed, states that conceptual change occurs when learners discover or are shown more plausible, intelligible alternatives to existing conceptions (Posner, Strike, Gertzog, & Hewson, 1982). This model, which describes the process of reconstructing existing conceptions, assumes that the process of learning is linear and rational. However, as subjective factors in learning began to be investigated, the CCM was revised to include consideration of a student's conceptual ecology (Strike & Posner, 1992; Hewson, 1992). This is defined as the collection of beliefs, attitudes, and motivations that influence the learning process in science classrooms (Demastes, Good, & Peebles, 1995).

Emotions have been considered too subjective for study, and outside the bounds of empirical research (Sinatra, in press). They are not included as part of the definition of a learner's conceptual ecology (Demastes et al., 1995). However, the need to examine emotions as a factor in learning has been acknowledged (Cohen, 2001; Elias, 2003). Although studies have investigated such affective factors in learning as student beliefs and values, there is a lack of research that directly explores how emotions influence the learning process in science. This research was conducted in order to address that gap.

Ecological Literacy

In order to understand ecological literacy, it is helpful to begin with the definition of scientific literacy, which is a goal for all students (The American Association for the Advancement of Science (AAAS), 1989; The National Research Council (NRC) of the National Academy of Sciences, 1996). Scientific literacy means possessing and using scientific knowledge to make decisions which affect our lives. The ability to make

scientifically informed decisions about health care, energy use, and other issues is “viewed by many science educators as the educational solution to any economical, social, and environmental challenges we may face into the next century” (Moss, 1997, p. 1).

Ecological literacy means using ecological knowledge to make responsible decisions that affect our lives and the health of the planet (Orr, 1992; Hardin, 1993). Going a step beyond scientific literacy, ecological literacy refers to the ability to see one’s self as part of a greater whole, and to consider the consequences of action not just in a personal sense, but also an environmental sense (Orr, 1992; Hardin, 1993; Devall, 1985; Naess, 1972). Rather than detract from the importance of scientific literacy, ecological literacy enables students to make choices about resource use and consumption that are not only scientific, but also environmentally responsible. This should be a goal for all science educators, as we face new environmental challenges in the coming years. Scientific literacy can provide students with the facts about energy use, waste management, and other issues of resource use and consumption. But ecological literacy will provide them with reasons for the choices they make, and will hopefully encourage them to behave responsibly toward the earth and its creatures.

Significance of the Study

In this study, I explore the effect that emotional responses have on learning concepts of anatomy and physiology in dissection. I suggest that emotions should be considered part of the learning process, by adding them to the current model of conceptual change in science (Posner et al., 1982). In addition, I explore the question of whether dissection contributes to the development of ecological literacy in students. A better understanding of the role of emotions will enable educators to teach science more

effectively for all students, so that none will be left out of the learning process. This study may apply particularly to students like me, for whom relationships of care and concern are a priority. In the end, I hope to inspire environmental educators to include emotions in science classrooms, and to work toward the development of ecological literacy for all students.

CHAPTER I

A REVIEW OF THE LITERATURE

Introduction

Dissection is an activity that most students encounter during the course of their education. Many people are familiar with some of the arguments and tensions surrounding the activity. I present both sides of the issue, from different educational perspectives, in order to provide a background for the current research, which investigates student experiences and emotions as they participate in the year-long dissection of a cat.

For this study, dissection is defined as a concept, made up of three parts:

1. the physical act of cutting apart an organism for study,
2. the cognitive act of learning new conceptual information, and
3. the ethical dimension of coming to terms with the death of an animal for use in dissection.

In this chapter, I first discuss the availability of alternatives to traditional dissection. Next, I present a review of the literature on dissection, first from those who support its use in schools, and then from those who oppose the activity.

It is also important to understand how students learn concepts in science. In the second section of this chapter, I discuss conceptual change literature. I present the existing model of conceptual change in science learning, and critiques of the early research. I discuss the need for viewing conceptual change from different perspectives,

the definition of a conceptual ecology, and the growing recognition of the influence of subjective factors in the conceptual change process. The role of emotion in this process is not well understood. The current study was conducted in order to provide teachers with a better understanding of the emotional reactions students have to dissection, and how they may influence learning. This research contributes a new dimension to the original CCM: the consideration of emotions as part of the learning process in science. In this section, I present a discussion of the psychological definition of emotion, and I discuss the importance of social-emotional learning in schools.

Finally, I connect the exploration of emotions in learning science to the development of ecologically literate students. Do emotional reactions to dissection cause some students, like me, to disconnect themselves from the activity of dissection? Can those emotions be used to develop ecologically literate behavior in students? If so, should they be included and acknowledged as part of the learning process? Before answering these questions, it is necessary to define what I mean by the term ecological literacy, which I do in the third section of this chapter. I draw upon various sources to construct five ecological principles for use in this study. These principles are my definition of what it means to be ecologically literate.

Dissection

Alternatives to Dissection

Alternatives to dissection, such as computer programs, CD-ROM's and simulations, have become cheaper and more sophisticated, and studies have shown that students perform as well or better using these alternatives (Balcombe, 1997; Orlans, 1988; Strauss, 1994).

However, alternatives to dissection are not as prevalent or as accessible as one might think. Some biology teachers object to the use of alternatives, stating that there is no substitute for the real “hands-on” experience of dissection. In fact, this is the formal position statement of the National Association of Biology Teachers, which has 9,000 members (source: www.CNN.com). The National Science Teachers Association, which has 53,000 members, defends the use of dissection, but also advises teachers to be flexible when dealing with students who object (source: www.CNN.com). Currently, only nine states in the United States offer students the choice of using alternatives to dissection in their science programs: CA, FL, IL, LA, ME, NY, PA, RI, and VA, which recently passed its law in September, 2004. Legislation is pending in MI and NJ, while in the past seven years, DE, MA, NH, VT, and WA have attempted to adopt legislation offering choices for students but were unsuccessful (source: www.hsus.org). This means that in the majority of states in the U.S., dissection is mandatory for students in science classrooms. The Humane Society estimates that over six million animals, mostly frogs, fetal pigs, and cats, are dissected annually in American high schools (source: www.hsus.org).

In Favor of Dissection

Many educators favor dissection as a method for teaching anatomy and physiology of animals. In this section, I present articles that outline the position of those who advocate the use of dissection in science classrooms. The main arguments presented are that dissection teaches students respect for life, and that it is a vital exercise for those who will enter the scientific and medical professions. Finally, I present the recommendations of educators who have noted the importance of easing student

apprehension about dissection. These recommendations include explaining where specimens come from, establishing school policies and Animal Care and Use Committees, and providing open classroom environments where ethical concerns about dissection can be discussed.

Respect for Life. One assertion is that dissection can lead to an abiding respect for all forms of life, including the animal being dissected. Berman (1984) states that students can learn essential lessons about life through their emotional reactions to dissection, including an awareness and appreciation of variation and the continuity of life through the examination of species characteristics, and a greater insight into the relationship between an organism and its environment (p.44). He argues that students will only begin to respect organisms when they explore internal organization. Dissection, in his view, also provides students with a way to separate and analyze associated parts, and is a useful tool for assembling data into new ideas.

Offner (1993) strongly defends the use of dissection in the classroom. She states that dissection can teach students an enduring respect and reverence for life (Offner, 1993, p.148). She claims that no model can duplicate the fascination, wonder, and awe students feel when they find real structures in their specimens.

Similarly, Morrison (1992) states that dissection provides students with a unique opportunity to observe animal structure and function. In addition, he notes that students may come to “respect the marvels of their own bodies after dissection reveals the intricacies of animal anatomy” (Morrison, 1992, p. 22). While teachers should be sensitive to the squeamish, he says that it would be wrong to deny the majority of students the right to dissect.

Medical Career Training. Offner (1993) contends that dissection is a vital part of training future scientists and doctors. She says that it is the responsibility of adults who know the practice is safe and productive to encourage students to “try it” so that they might become interested in careers in science or medicine (Offner, 1993, p.149). Similarly, Keiser and Hamm (1991) claim that dissection provides an important way for students to prepare to enter medical and scientific professions, and that when students are not given the chance to dissect, they will be less likely to be able to transfer their knowledge into real life situations, especially in the medical field. These researchers believe that dissection may be a way to desensitize students, enabling them to overcome negative emotions like fear and disgust, so that they will continue their training as doctors and nurses.

When students reach medical school, they are still confronted with significant ethical issues about dissection. Because of the fear that students will have negative experiences when confronted with cadaver dissection, first year medical students frequently take part in discussion sessions that focus on their emotional reactions. Gustavson (1988) conducted a study that found that students “sensed or feared that they were becoming ‘desensitized’ to the human body in the process of dissecting a cadaver” (p. 62). Over half of the 125 students interviewed regarded the cadaver as an image of “self,” and associated the dissected body as the “self” in a morbid condition. “The greater the dismemberment or disorganization of the cadaver, the greater the number of expressions of morbid personal images reported by the students” (Gustavson, 1988, p. 63).

In a similar study, Marks and Bertman (1979) found that early consideration of the student emotional reactions to death and dissection was beneficial because it demonstrates that recognition of personal emotions is important in patient care. Particularly, they note that “unresolved negative emotions can be the reason physicians fail to deal with the total patient” (Marks, 1979, p. 51). They contend that the more faculty members display compassion and understanding in the context of medical education, “the less likely are students to be discouraged from being humane” (Marks, 1979, p. 51). While these studies are directed at the experience of dissecting a human cadaver, the dissection of animals is also frequently a traumatic event for students. Educators favor similar approaches when confronting student emotional reactions to those found in medical school curriculums.

Overcoming Student Apprehension. Wheeler (1993) recommends that teachers explain to students where animals used in dissection come from and how they are killed. He notes that student apprehension can be overcome when they learn that “an animal anaesthetized and killed before recovery, or killed before dissection commences, will suffer no pain from the experience” (Wheeler, 1993, p.33). He says that although a student’s first exposure to mammalian dissection may be a traumatic experience, repeated exposures are “typically far less disconcerting” (Wheeler, 1993, p.34).

Snyder (1994) recommends that schools develop policies to handle student objections, and suggests that Animal Care and Use Committees in schools can help to assure that teacher directed activities are ethical and appropriate (p.40). He also notes that it is important for teachers to clarify student motives when they object, to discern

whether students are just squeamish or if they have real ethical concerns about the activity (Snyder, 1994).

Similarly, Allchin (1991) recommends that teachers utilize a process of “values clarification” when deciding if a student should be excused from dissection. He advocates decentralized class discussions, similar to those of first year medical students, in which the teacher openly deals with difficult ethical issues like dissection. He states that to disregard ethical issues in the classroom, or to discourage discussion of them is “to neglect our duty to teach *all* of science” (Allchin, 1991, p.47).

These educators recommend open discussion about ethical concerns, but because they favor the use of dissection, the primary goal is to convince students that their objections to dissection should be overcome. In the next section, I will present the ideas of educators who do not favor the use of dissection. Open discussion in their view would be used to explore student reactions to dissection, and to provide support when ethical opinions about dissection are not in agreement with the requirements of science curriculums.

Summary. Dissection is favored by some educators as a way for students to learn respect for all forms of life, and it is considered the best, hands-on way for students to learn about the anatomy and physiology of organisms. It is considered a vital exercise for those who will someday enter the scientific and medical professions. To prevent negative emotional reactions, some recommend that teachers inform students that organisms are not killed or harmed needlessly for dissection. However, teachers and schools should be prepared to discuss ethical concerns with students, and to clarify student motives and values.

Opposed to Dissection

There are also educators who do not favor the use of dissection in science classrooms. First, I present the argument that students perform as well or better using computer simulations, instead of traditional dissection. I present three arguments against the use of dissection: 1) it desensitizes students to animal suffering, 2) it can trigger thoughts of death, decay, and defilement, and 3) it may contribute to the disconnection of female students from science. Finally, confronting difficult ethical issues through open classroom discussion is again presented as a valuable educational technique.

Alternatives to Dissection and Student Performance. Strauss and Kinzie (1994) argue that alternative materials for high school through graduate level anatomy instruction should be used in place of traditional dissection. In a study involving two high school biology classrooms, one of which used traditional frog dissection and the other a computer simulation called Interactive Frog Dissection, the researchers compared student achievement as well as attitudes toward the instructional technique. Of the students who used the simulation, 100% believed they had developed a better understanding of frog anatomy, and 75% indicated that they had learned the locations of the major organs of the frog. Of the students using dissection, 89% believed they had a better understanding of frog anatomy, while only 44% indicated they had learned the location of the major organs (Strauss & Kinzie, 1994, p. 401). Attitudes toward the instructional methods did not differ significantly, although those who used the computer simulation became less positive over time about the value of animal dissection, while those who dissected a frog became more positive. These findings suggest that alternatives such as Interactive Frog Dissection are as effective as traditional dissection in

learning frog anatomy.

Desensitization to Animal Suffering. Orlans (1991) contends that dissection desensitizes students to animal suffering and that the use of millions of organisms every year (an estimated 3.2 million frogs alone) for teenagers' education fosters the impression that animal life is cheap (p.38). Mayer & Hinton (1990) argue that heavy exposure to dissection has been found to harden attitudes toward animal suffering and to foster a disrespect for living things. Shapiro (1992) contends that students learn to identify the teacher as an authority in the exercise of dissection, and then project that authority onto nonhuman animals. In this way, he claims that dissection teaches students that human interests take priority over nonhuman animals, and that the suffering of animals is beneath consideration (Shapiro, 1992).

Thoughts of Death, Decay, and Defilement. Orlans (1988) notes that students often perceive dissection as the desecration of a dead body, which may lead to natural feelings of horror (p. 39). Similarly, Shapiro (1992) notes that cutting up animals in dissection may trigger thoughts of death, defilement, and decay, which may lead to emotional conflict in students. Medical schools have already recognized the negative effects that cadaver dissection has on first year students (Marks & Bertman, 1979; Gustavson, 1988). Discussions about these emotional reactions, similar to those conducted during the first year of medical school, can help students understand these emotions and avoid a negative experience in dissection.

Disconnection of Female Students. Research has shown that male students in science tend to receive support for assertiveness, and that they receive more praise and critical feedback than female students (Jones & Wheatley, 1990; Tobin & Garnett, 1987;

Morse & Handley, 1985). Boys in the United States “do better than girls and are more interested than girls in mathematics and science” (Burstyn, 1993, p. 116). Female students overall seem to have less confidence in their scientific skills than male students (Eccles, 1987; Brophy, 1991; Sadker & Sadker, 1985). However, even when female students express confidence in their ability to undertake science courses, they are still less likely to pursue careers in scientific fields such as engineering and medicine (Osborne, 2003).

The reason for this may be that the epistemology of objectivism has been the dominant framework of science teaching (Keller, 1985; Harding, 1991). This framework is at odds with feminine values, such as the development of emotionally responsive, caring relationships (Noddings, 1990; Osborne, 2003). Although some studies have found that gender was not a significant factor in student experiences of dissection (Doster, 1997), other researchers have concluded that it remains an important consideration in the classroom (Dunlap, 1990; Osborne, 2003). Dunlap (1990) notes that in dissection, concern for the animal is discounted, while the emphasis is on objective facts and concepts. She believes that activities such as dissection may push students, especially girls, to abandon more intuitive, sensitive approaches to science (Dunlap, 1990).

Confronting Difficult Ethical Issues. Balcombe (1997) warns that students may feel pressure from the teacher or other students to dissect. The result is that students are unlikely to object, even when the teacher explains their right to choose. He recommends that teachers provide open classroom atmospheres in which to discuss ethical concerns about dissection. Unlike the views of those who are in favor of the use of dissection,

however, Balcombe recommends this type of discussion to provide support for students who object to the activity. In his opinion, a supportive atmosphere would encourage students to voice their objections more openly, rather than convince them to participate in the dissection despite their ethical concerns.

Summary. It has been shown that students perform as well on interactive computer simulations as they do in traditional dissections. Some educators believe that dissection desensitizes students to animal suffering, and may trigger thoughts of death, decay, and defilement. Dissection may also contribute to a disconnection of female students from science. Others contend that dissection skills do not apply to the majority of students, and should be reserved for those who truly wish to enter the sciences. Students may feel pressure from their peers or the teacher to dissect, and to counter this, some educators recommend open classroom atmospheres in which students are encouraged to discuss ethical concerns openly.

Much of the literature about dissection is based on opinion. There is a lack of recent studies in this area, probably because of the general awareness that people have about alternatives to dissection. It is easy to think that because alternatives to dissection are available, the problem has gone away. As I have shown, however, alternatives to dissection are not as prevalent as one might think. There is still a need to examine student reactions to the activity. Few studies have directly investigated the emotional reactions of students to dissection, and none have explored the effect that these reactions may have on learning science. The current research will add empirical data to the body of literature surrounding this issue.

In the next section, I will discuss conceptual change literature. This research attempts to describe how students best learn in science, and what the most effective methods for teaching might be.

Conceptual Change

Many educators use the model of conceptual change to understand the process of learning in science. Within this model, students are thought to possess a network of related conceptions through which he or she understands a topic. This network is called a “conceptual framework” (Demastes et al., 1995). Demastes et al. (1995) state that “learning is characterized as a series of cognitive restructurings in which a learner’s conceptual framework undergoes structural modifications or revisions based upon new experiences, information, or concepts the learner encounters” (p. 638). Conceptual change research is an attempt to model this process. According to the conceptual change model (CCM) proposed by Posner et al. (1982), four conditions determine how a student learns new concepts in science:

1. there must be dissatisfaction with existing conceptions,
2. the new conception must be intelligible,
3. the new conception must be plausible, and
4. the new concept should suggest the possibility for future research.

If these conditions are met, an old concept will be replaced with a new one, causing a change in the learner’s preexisting conceptual framework. This model assumes that the change experienced by a learner is holistic, involving the complete replacement of one competing conception with another, more useful conception (Demastes et al., 1995).

Types of conceptual change

The type of holistic change described by the CCM is also known as conceptual exchange or *accommodation* (Demastes, Good, & Peebles, 1996). Another pattern of conceptual change is known as conceptual capture or *assimilation* (Demastes et al., 1996), in which a new concept is added to concepts the learner already knows, but does not completely replace them. There are current attempts to further define the real mechanisms of conceptual change in learners, so that the process may be better understood by educators. Demastes et al. (1996) describe four additional patterns of conceptual change in learners, and they suggest that science educators be aware that students do not only experience complete, holistic restructuring of conceptions as described by the CCM. Two patterns of conceptual change documented by these researchers are cascade and wholesale, both of which are similar to holistic change in that they are instances of accommodation of major, organizing conceptions (Demastes et al., 1996). However, two other patterns have been documented, incremental and dual constructions, in which competing conceptions are constructed, but the use of preexisting conceptions is partially retained (Demastes et al., 1996).

In this study, I will refer to conceptual change as a holistic process, similar to the wholesale restructuring of knowledge described by the original CCM (Posner et al., 1982). I think it is possible that students in this study experience different types of change, such as those identified by Demastes et al. (1996). My focus in this study, however, is not so much on identifying patterns of change as it is to demonstrate the need to include emotions as a part of the CCM in science learning.

Conceptual ecologies

The conceptual change model described by Posner et al. (1982) has been strengthened by the recognition of the role of a student's *conceptual ecology* in learning. In their original description, Posner et al. (1982) state that a conceptual ecology includes the learner's "epistemological commitments, anomalies, metaphors, analogies, metaphysical beliefs, knowledge of competing conceptions, and knowledge from outside the field" (Demastes et al., 1995, p. 658). Analogous to Cobern's definition of worldview (1993), a conceptual ecology includes the fundamental concept that serves as the environment in which conceptual change occurs; thus, a learner's conceptual ecology both regulates and modifies the learning process (Demastes et al., 1995). Strike and Posner (1992) have broadened this definition and explain that "a learner's related prior knowledge, including both alternative and scientific conceptions, shape the process of conceptual change" (Demastes et al., 1995, p. 658). Conceptual ecologies are interactionist in nature, meaning that "conceptions are both acted on by the ecology and act to change this ecology" (Demastes et al., 1996).

Hewson (1992) states that "a conceptual ecology provides the context in which the conceptual change occurs, that influences the change, and gives it meaning" (Hewson, 1992, p. 8). He says that knowledge gained is only valid in relation to the student's conceptual ecology, and that because a learner's conceptual ecology "is a product of all the experiences and social interactions he or she has had, it will have many elements in common with those of other people" (Hewson, 1992, p. 9). In the constructivist view, humans construct knowledge using existing knowledge and social interactions to do so, which means that two individuals exposed to the same events may

interpret them in different ways, depending on their preexisting set of beliefs about these events (Hewson, 1992). This means that a curriculum should include not only theories and phenomena, but also the basis for their acceptance. Hewson notes that “the purpose of conceptual change teaching of science is not to force students to surrender their alternative concepts to the teacher’s or scientist’s conceptions but, rather, to help students both form the habit of challenging one idea with another, and develop appropriate strategies for having alternative conceptions compete with one another for acceptance” (Hewson, 1992, p. 9).

A multi-dimensional process of change

Tyson, Venville, Harrison, and Treagust (1997) note that most of the empirical research on conceptual change to date documents the changes in a student’s knowledge without directly considering those influences that contribute to the acquisition of knowledge. They suggest that there is a need to view conceptual change as a multi-dimensional process involving ontological, epistemological, and social/affective factors.

The ontological lens of the multidimensional framework of conceptual change examines the way a student perceives the nature of the thing being studied; that is, the student is looking “out” at the world. The epistemological lens examines how a student perceives his or her own knowledge about the thing being studied; that is, the student is looking “in” at their own knowledge. The social/affective lens examines the social/affective conditions necessary for conceptual change to occur. (Tyson et al., 1997, p. 398)

These researchers claim that viewing conceptual change as a multi-dimensional process would present a more holistic picture of science learning. While the social/affective lens may be compared to the definition of a learner’s conceptual ecology, the importance of this research is to build on that definition, and to emphasize the idea

that previously held conceptions are influenced by many different factors, including life experiences in the home as well as beliefs, values, and emotions.

The difficulty in studying affective components of learning

Lee and Anderson (1993) suggest that conceptual change research must begin to examine the influence of student motivations and affective orientations in science learning. Demastes et al. (1995) also state that conceptual change has significant affective components that require further study, and suggests that “goals, emotions, and motivations play a significant role in controlling conceptual change, and so have a place in the learner’s conceptual ecology” (p. 661). Similarly, Sinatra and Pintrich (2003) note that researchers have begun to address the need to explore epistemological beliefs, belief identification, and the willingness to question beliefs, although there is still a need to examine the role of emotions as a factor in learning. Generally, it is acknowledged that learning is not controlled solely by external factors such as the nature of content or instruction. Rather, “the learner plays a significant role in choosing whether to consider alternative points of view” (Sinatra, Southerland, McConaughy, & Demastes, 2003).

It is helpful to define exactly what is meant by knowledge and beliefs. Knowledge is used to refer to “a justified, ‘true’ belief” (Siegel, 1998). To qualify as knowledge, a concept must therefore have some basis in reality, and the learner must have appropriate justifications in place to accept the concept. Beliefs, which are important to distinguish from emotions, are defined as a subjective way of knowing, or “personal truths as opposed to truths about the world” (Smith, Siegel, & McInerney, 1995). Beliefs are “extra-rational,” and therefore are difficult to isolate, because of the difficulty in obtaining empirical evidence (Sinatra et al., 2003). For example, scientists

do not *believe* in evolution; they accept evolutionary theory as the best scientific evidence based on systematic evaluation of data (Demastes et al., 2003). Beliefs are of great importance in learning, however, because “if students are allowed the opportunity to juxtapose their beliefs against those ideas presented by the teacher, this can evoke relevant dispositions, such as the willingness to think deeply about a complex problem and question one’s own beliefs” (Sinatra et al., 2003). This is in concert with the opinions of educators who favor open discussion of ethical concerns related to dissection (Allchin, 1991; Balcombe, 1997). Ultimately, if conceptual change requires that students compare the usefulness of competing conceptions as described by the CCM (Posner et al. 1982), then “such comparisons require a relatively open-minded, nonabsolutist cognitive disposition when the construct is a controversial one” (Sinatra et al., 2003).

Southerland and Sinatra (in press) state that controversial topics are difficult to teach because of “the high emotional investment that students bring to these topics—emotions that make engagement with the material very difficult for the teacher to orchestrate” (p. 2). Rather than investigate these emotions, however, they focus on understanding the difficulty students have in learning the material from an empirical point of view: “We argue that it would be inappropriate to target a learner’s personal beliefs in a science classroom, as beliefs are by definition outside empirical bounds, and thus outside the bounds of scientific discussion” (Southerland & Sinatra, in press, p. 4).

Few studies have directly investigated student beliefs about dissection, and none have examined the role of emotions in learning concepts related to dissection. The current study provides evidence that emotions are a part of learning in controversial subjects like dissection. In the next section, I present one study that explores student

beliefs and values about dissection, that is also helpful in defining values inherent in the activity.

Student beliefs and values about dissection

Doster (1997) compares student beliefs and values about dissection to values inherent in secondary science curriculums, using six values relevant to scientific inquiry defined by Simpson, Koballa, Oliver, and Crawley (1994). These six values are:

1. longing to know and understand;
2. questioning of all things;
3. search for data and their meaning;
4. demand for verification;
5. respect for logic; and
6. consideration of the consequences.

Doster found that the student values reflected in the study move beyond the boundaries of these issues, a limitation which may be due to the fact that “although scientific inquiry is a value-laden human endeavor, value constructs such as kindness, respect for authority, love, excitement, aggression, and suffering are absent from its description” (Doster, 1997, p. 156). She concludes that students whose values conflicted with the values embedded in the activity of dissection were less likely to have a positive experience with the activity. Although her study does not define emotions as part of the research criteria, her findings are helpful in describing some of the values inherent in the activity of dissection. These values are:

1. The killing of animals for the purpose of learning is a justifiable and acceptable behavior;

2. Touching the dead body of an animal is a socially and culturally acceptable behavior;
3. The greater the similarity between the body of the animal and the human body, the greater the gains in understanding human anatomy;
4. Cutting apart, probing, and pinning is acceptable treatment of a dead animal's body;
5. Interaction between students and the dissection specimens will result in their gaining understanding of the structure and function of the animal's internal anatomical structures;
6. Touching, seeing, or smelling the dead body of an animal is not offensive enough to negatively impact students' learning; and
7. Dissection as an activity is independent of the experiences students are familiar with, and how they interpret those experiences. (Doster, 1997, p. 156-7)

Understanding student beliefs and values is helpful in teaching controversial subjects like dissection, but these are not the only affective components of a student's experience of the activity. Emotions also need to be defined and included as part of the total learning experience for students. In the next section, I present a psychological definition of emotion, and perspectives on teaching emotional literacy in schools.

Emotions in learning

What are emotions? A psychological definition of emotion would be that "an emotion represents an organized, highly structured reaction to an event that is relevant to the needs, goals, or survival of the organism" (Watson & Clark, 1994, p. 89). But even among psychologists, it is difficult to agree upon a single, unified definition of emotion. Griffiths notes that "although the concept of emotion is part of our everyday self-understanding, it is utterly vague in the same way as concepts like 'spirituality'"

(Griffiths, 1997, p. 17). However, despite the difficulty in defining emotions, the effects of emotion in learning can be examined.

Clore (1994) says that emotion influences cognitive processing, perhaps in very fundamental ways. Positive emotions appear to encourage unconstrained, creative processing, while negative emotions seem to foster a focus on more controlled, systematic approaches to learning (Clore, 1994). In other words, “sad subjects reject more potential answers and therefore appear more analytical and discriminating” (Clore, 1994, p. 110). In education, the effect of emotions on student learning is important, so that successful learning environments may be created. In the next section, I present the idea of emotional intelligence, and the importance of understanding the effect of emotions in learning is discussed.

Emotional intelligence. Elaine Batcher (1981) comments on the paradox of class life and emotion. She says that “human emotion is inseparable from human intellect,” and “human emotion is always a component of human experience” (Batcher, 1981, p. 164). However, she says that while emotion may be central to experience, schooling as it is must exclude emotion. She says that “in class life, as far as the teacher is concerned, emotions have little positive use. They are costly in time and energy, they are beside the point, which is to work, and they are a distraction” (Batcher, 1981, p. 165). She states that “to exist is to feel yet to be schooled is to deny feeling” (Batcher, 1981, p. 165). There seems to be no way out of the paradox, in her opinion. This may have been a prevailing point of view at one time, but current trends in education are challenging this paradox, as the emotional development of students is considered more important.

Daniel Goleman (1995) says that “our schools and our culture fixate on academic abilities, ignoring emotional intelligence, a set of traits—some might call it character—that also matters immensely for our personal destiny” (Goleman, 1995, p. 36). He notes that behaviorists such as B. F. Skinner felt that only behavior that could be seen objectively, from the outside, could be studied with scientific accuracy. They ruled all inner life, including emotions, as “out-of-bounds for science” (Goleman, 1995, p. 40). This view is consistent with much of the current conceptual change research (Sinatra & Pintrich, 2002; Southerland & Sinatra, in press). However, the “lopsided scientific vision of an emotionally flat mental life—which has guided the last eighty years of research on intelligence—is gradually changing as psychology has begun to recognize the essential role of feeling in thinking” (Goleman, 1995, p. 41). He claims that the higher values of the human heart—faith, hope, devotion, love—are “missing entirely from the coldly cognitive view. Emotions enrich; a model of mind that leaves them out is impoverished” (Goleman, 1995, p. 41). This is the same argument presented by Doster (1997), and by the current study, which includes emotions as a part of the conceptual learning process in science.

In addition to IQ, Goleman suggests that emotional intelligence should be recognized in teaching, as it adds “far more of the qualities that make us more fully human” (Goleman, 1995, p. 45). As an emerging educational trend, he notes that the “strategy in emotional education is not to create a new class, but to blend lessons on feelings and relationships with other topics already taught” (Goleman, 1995, p. 271). Emotional lessons, he says, can merge naturally into reading and writing, health, science, social studies, and other standard courses (Goleman, 1995). Finally, he argues that

students today are not very good at handling anger or resolving conflicts, a defect which he says is due to the fact that:

Education has not bothered to teach empathy, impulse control, or any of the other fundamentals of emotional competence. By leaving the emotional lessons children learn to chance, we risk largely wasting the window of opportunity presented by the slow maturation of the brain to help children cultivate a healthy emotional repertoire (Goleman, 1995, p. 286).

Dissection may be an activity that can teach empathy, kindness, and responsibility in science classrooms. Is this an example of a method that may be used to blend emotional lessons into science curriculums, so that the window of opportunity for emotional development will not be wasted?

Social-emotional learning. How can educators best facilitate the development of emotional literacy in students? Jonathan Cohen (2001) says that “cognitive growth is dependent on the development of social and emotional understanding” (Cohen, 2001, p. xi). He claims that social-emotional learning is as important as linguistic and mathematical learning, because it provides the foundation for all learning (Cohen, 2001). Cohen says that “the foundation for any mode of literacy—be it linguistic, mathematic, musical, or social and emotional—is *decoding*: being able to recognize and understand the data that defines a given domain” (Cohen, 2001, p. xiv). The current study also adds ecological literacy to this list. I discuss the meaning of this form of literacy in the final section of this chapter.

Cohen points out that “when we have powerful emotional experiences, this can complicate or interfere with our ability to think. Some of these ideas are simple and we tend to take them for granted: People feel. Yet, there are many instances when this basic truth is minimized or negated” (Cohen, 2001, p. 15). Social and emotional literacy

provides the skills that students need to be reflective about the process of learning, which is a continuous process of discovery about concepts and about themselves (Cohen, 2001, p. 15). “Reflective capacities also shape how we interpret literary and historical texts and relate to the development of scientific reasoning and critical thinking” (Cohen, 2001, p. 17). He notes that “students learn about being related or not, being sensitive or not, being responsive or not, being open to discovery or not, being joyful in this process or not, from us” (Cohen, 2001, p. 17). This is how the process of teaching controversial subjects like dissection can be important to the emotional development of students. Dissection can teach students to feel connected to all other living creatures by fostering a sense of respect, or it can teach students to become desensitized if emotional reactions are not supported and discussed (Berman, 1984; Offner, 1993; Morrison, 1992; Orlans, 1991; Mayer & Hinton, 1990; Shapiro, 1992).

Taking the emotional needs of students into consideration has been the focus of some current trends in education (Cohen, 2001). To this end, social and emotional learning (SEL) programs have been constructed to help teach emotional literacy in schools, and are widely available to educators today.

An example of a SEL program. The Child Development Project (CDP) is a school reform program designed to “promote children’s fullest social, emotional, intellectual, and ethical development” (Dasho, Lewis, & Watson, 2001, p. 87), by focusing on four key principles:

1. Building supportive relationships,
2. Teaching humane values,
3. Fostering children’s intrinsic motivation, and

4. Teaching for understanding.

This reform is brought about by systematic collaboration with schools to affect not only school culture but also attitudes and learning philosophies in schools (Dasho, et al., 2001). The program seeks to create caring classroom environments in which students feel invested as members of a community of learning, which has direct effects on learning skills and on the development of emotional literacy. When students feel connected to the classroom community in supportive learning environments, it is believed that they will “be disposed to care about its values, such as kindness, helpfulness, responsibility, and so forth” (Dasho, et al., 2001, p. 90). Further, the CDP emphasizes that children should be motivated by “the *intrinsic* reasons to be kind, fair, and responsible—such as the good feeling it gives you or the need to make the world a better place—rather than relying on *external* rewards, recognition, praise, and so forth” (Lewis, Watson, & Schaps, 1999).

Maurice J. Elias (2003) states that social-emotional learning is necessary because

It represents a part of education that links academic knowledge with a specific set of skills important to success in schools, families, communities, workplaces, and life in general. As recent world events have taught, there is a danger to each of us—locally and globally—when children grow up with knowledge but without social-emotional skills and a strong moral compass (Elias, 2003, p. 9).

The local and global dangers that Elias is talking about may be political or personal, but we should also recognize the potential dangers to the environment. In these times of environmental crisis, scientific knowledge must be linked to a specific set of skills that are also important to “life in general” (Elias, 2003). I call this set of skills *ecological literacy*, which is the ability to use ecological awareness and knowledge to make informed decisions that affect the health and well-being of the environment. This

is related to the “need to make the world a better place” (Lewis, et al., 1999). I discuss the definition and use of this term fully in the next section of this chapter.

Summary. While subjective factors like beliefs and values have been recognized as parts of a learner’s conceptual ecology, the effect of students’ emotional reactions in science learning has not been studied. However, educational programs such as those in social emotional learning (SEL) are widely available, and the need for teaching emotional literacy has been acknowledged by educators. The current research addresses this need, and also investigates whether student emotions can be directed toward the development of a sense of connectedness and relationship with not just the classroom community, but also the natural world. This is the sense of connection that I call ecological literacy.

Ecological Literacy

In this section, I discuss what it means to be ecologically literate, and the need to include the development of ecological literacy in science education. I draw upon several theorists and scholars to develop five ecological principles for use in this study. No one scholar has defined principles like these; they are my own definition of what it means to be ecologically literate.

Being Ecologically Literate

Literacy is the ability to read, numeracy is the ability to count, and “ecolacy,” according to Garrett Hardin (1993), is the ability to ask “What then?” It means going beyond the facts and truly considering the consequences, for humans, non-humans, and the earth as a whole. David Orr (1992) says that “if literacy is driven by the search for knowledge, ecological literacy is driven by the sense of wonder, the sheer delight in

being alive in a beautiful, mysterious, bountiful world” (p. 86). This sense of wonder is rooted in the emotions, or what E. O. Wilson (1984) called “biophilia,” which is simply “the affinity for the living world” (Orr, 1992, p. 86). Orr writes:

In contrast to the directions of modern society, [ecological literacy] emphasizes democratic participation, the extension of ethical obligations to the land community, careful ecological design, simplicity, widespread competence with natural systems, the sense of place, holism, decentralization of whatever can best be decentralized, and human-scaled technologies and communities. (p. 94)

He adds that “ecological literacy leads in other, and more durable, directions toward prudence, stewardship, and the celebration of the Creation” (p. 95).

Emotional literacy has been a focus of current educational trends (Cohen 2001; Goleman, 1995; Elias, 2003). The current study links the development of emotional competency with the understanding of the connectedness of all creatures on earth. It goes a step beyond scientific literacy, which means utilizing scientific knowledge to make informed decisions about our lives. Ecological literacy means using ecological awareness and knowledge to make decisions that are beneficial to the environment as a whole.

The Need for Ecological Literacy in Education

Orr (1992) states that education has failed to provide students with a sense of the relatedness of ecological systems and of the limits of the earth. This failure to include ecological principles has led students in the modern world to believe that “ecology is unimportant for history, politics, economics, society, and so forth” (Orr, 1992, p. 85). He argues that an ecologically literate education would instill a “sense that one’s self is inseparable and inexplicable from that of a larger community which is part of an understandable cosmos” (Orr, 1992, p. 182).

There is a need to recognize that “all education is environmental education,” because “by what is included or excluded, emphasized or ignored, students learn that they are a part of or apart from the natural world” (Orr, 1992, p. 90). Dissection, for example, may be one activity that discourages the development of connections to the environment.

Gregory Smith writes, “Rather than encouraging a sense of participation with and wonder about the natural environment, most school instruction treats the world as something that is abstract and other” (Smith, 1992, p. 62). He claims that the focus of education is on “the accumulation of data that often is neither personal nor meaningful, only required” (Smith, 1992, p. 62). However, he warns that “as environmental conditions force us to adjust to new necessities—such as recycling, the use of sunscreens, the avoidance of polluted beaches—recognizing the interrelationship between our own behaviors and the broader ecological systems in which we live will become inescapable” (Smith, 1992, p. 144).

Smith recommends that educators develop schools “that enable children to understand their place in broader systems and help them to acquire the economic, social, and political skills required to protect themselves from the activities of those who are insensitive to the damage they perpetrate on us, future generations, and the planet” (Smith, 1992, p. 144). Together, these skills define what it means to be ecologically literate: using ecological knowledge and skills to make decisions that affect our lives.

Five Ecological Principles

In the next section, I present the five ecological principles that I designed for use in this study:

1. A student should understand that he or she is connected to the nonhuman world;

2. A student should show respect for all creatures, both human and nonhuman;
3. A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings;
4. A student should appreciate the beauty and diversity of the nonhuman world, and should kill or use animals only with good reason;
5. A student should be able to recognize the danger in excessive human interference with the nonhuman world.

In the following sections, I discuss the development of each principle, drawing on the works of several ecological theorists and scholars. These principles represent my understanding of what it means to be ecologically literate, based on my readings of the works of environmental philosophers and scholars. Together they are used as my model for ecological literacy, which provides the framework to answer the third research question guiding this inquiry: "Do student experiences in dissection reflect ecological principles?"

1. A student should understand that he or she is connected to the nonhuman world.

I developed this principle by borrowing from the works of David Orr (1992), Stephen Clark (1997), Nel Noddings (1992), and Arne Naess (1989). In the following section, I present a review of the literature supporting this principle.

Orr (1992) says that "the ecologically literate person has the knowledge necessary to comprehend interrelatedness, and an attitude of care or stewardship" (p. 92). Such a person would have "the practical competence required to act on the basis of knowledge and feeling" (Orr, 1992, p. 92). If a student understands that he or she is connected or

related to the nonhuman world, then that is one step toward a sense of ecological literacy. This sense of connectedness is the essence of the first principle used in this study.

One way that people can come to understand this connection is through relationships with pet or companion animals. This is important to define for the current study, because many of the students I interviewed related their experiences with the cat used in dissection to their pet cats at home.

Clark (1997) says that identification with pets is a natural extension of our association with animals. He says that “only a doctrinaire humanism can ignore the obvious fact that among those domestic ties are ties of friendship and family loyalty to animals not of our species” (Clark, 1997, p. 106). Pets are part of the family for many people, and children learn at an early age to treat pets kindly and to be responsible for their welfare. Clark claims that “our main problem is, as it has been for most human communities, that we thereby establish habits of care and concern for animals that we then make it our business to extirpate or neutralise in other areas” (Clark, 1997, p. 107).

Of course it is possible to *understand* a connection to the nonhuman world and not *care* about it. But according to these scholars, teaching children to recognize their connection to the nonhuman world will help them develop a sense of caring about it and responsibility toward it, in the same way that we care for that which is part of ourselves.

Care theory, according to Noddings (1992), is an understanding that “there are no sharp divisions between caring for self and caring for others” (p. 127). While the central focus of her theory is on human relationships to other humans, she also notes that children learn about compassion and empathy through their emotional connections to pets. She says that “sensitivity to the responses of animals is basic to the development of

compassion for them,” and “a creature’s capacity for response in part defines our obligation to it” (Noddings, 1992, p. 127-8). This issue is an important part of the first principle of ecological literacy because student relationships to their pet animals were a part of their views of the cat used in dissection.

2. A student should show respect for all creatures, both human and nonhuman.

For my second principle, I have drawn from the works of Gregory Cajete (2000), and Bill Devall (1985). I have chosen these two because respect is a central aspect of Native American traditions, as Cajete (2000) describes; and deep ecological thought as described by Devall (1985) similarly places great importance in respect for all creatures. In the current study, respect for the cat used in dissection was a factor in student views and behaviors during the activity.

Gregory Cajete, in his book Native Science, states that “becoming open to the natural world with all of one’s senses, body, mind, and spirit, is the goal of the practice of Native Science” (Cajete, 2000, p. 21). Teaching students to feel this relationship with all of Nature is another step in the development of ecological literacy. Cajete says, “Humans’ relationship to animals and our participation in their world bring forward our innermost instinctual selves, the highest in the order of our biological senses and being and the core element of our consciousness” (Cajete, 2000, p. 152). Traditional peoples around the world have incorporated this sense into their relationships with animals, “as they see all animal species as having equal rights to life and a place on Earth” (Cajete, 2000, p. 152).

Cajete notes that “Native science is about mutual reciprocity, which simply means a give-and-take relationship with the natural world, and which presupposes a responsibility to care for, sustain, and respect the rights of other living things, plants, animals, and the place in which one lives” (Cajete, 2000, p. 79). He says that “the whole concept of animal rights is not new: among Native peoples animals have always been considered to have rights, and were equal to human beings in terms of rights to their lives and to their perpetuation as species. One could describe these beliefs as a type of natural democracy” (Cajete, 2000, p. 168).

Similarly, deep ecologist Bill Devall writes, “insofar as we perceive things as individual organisms or entities, the insight draws us to respect all human and non-human individuals in their own right as parts of the whole without feeling the need to set up hierarchies of species with humans at the top” (Devall, 1985, p. 68). In this study, I am interested in student expressions of respect as they dissect the cat. My hypothesis is that dissection may be an activity that encourages emotional disconnection in students. They may not feel respect for the cat if it is seen as simply an object, instead of an individual organism or entity with an equal right to live. In my opinion, this would not be an ecologically literate point of view.

3. A student should understand that the value of an animal’s life is not measured in terms of usefulness to human beings.

For my third principle of ecological literacy, I have synthesized the works of Gary Francione (2000), Bill Devall (1985), and Arne Naess (1989). In this study, I was

interested in whether students perceived the life of the cat as more valuable because it was used as a tool for human learning in dissection.

Francione (2000) says that “in virtually all modern political and economic systems, animals are explicitly regarded as economic commodities that possess no value apart from that which is accorded to them by their owners—whether individuals, corporations, or governments” (p. 50). He states that if we really believe that animals have morally significant interests, then “we must abolish and not merely regulate our institutionalized exploitation of animals” (Francione, 2000, p. 165). Including animals within the notion of rights would mean a radical change in society, in his opinion:

We would have to confront our moral schizophrenia about animals, which leads us to love some animals, treat them as members of our own family, and never once doubt their sentience, emotional capacity, self-awareness, or personhood, while at the same time we stick dinner forks into other animals who are indistinguishable in any relevant sense from our animal companions (Francione, 2000, p. 166).

He adds that “if we are going to apply the principle of equal consideration to animals and treat animal interests in not suffering as morally significant, then we must extend to animals the basic right not to be treated as our resources” (p. 101). This is a step toward ecological literacy, because it extends the connection to the non-human world, and describes the responsible, ecologically literate treatment of animals.

In addition, this principle is built upon the deep ecological premise that diversity and complexity in the natural world are values. Devall says that “so-called simple, lower, or primitive species of plants and animals contribute essentially to the richness and diversity of life. They have value in themselves and are not merely steps toward the so-called higher or rational life forms” (Devall, 1985, p. 71). One of the principles of deep ecology as defined by Arne Naess (1989) states that “The well being and flourishing of

human and nonhuman Life on Earth have value in themselves. These values are independent of the usefulness of the nonhuman world for human purposes” (Devall, 1985, p. 70). My wording in this third principle reflects this deep ecological principle.

My third principle of ecological literacy was developed to examine whether students thought that the cats were useful only as tools for learning. If cats are seen as resources in this case, and as valuable only when they are used for human purposes, I would not consider the experience reflective of my third ecological principle.

Ecologically literate behavior would entail not treating the cats as resources, and acknowledging the value of their lives as part of the greater complexity and diversity of the natural world.

4. A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

My fourth principle of ecological literacy is derived from deep ecological thought (Naess, 1989), as well as Native American traditions as defined by Cajete (2000). I have also utilized some of the works of animal rights scholars (Francione, 2000; Rollin, 1992; Regan & Singer, 1989; Clark, 1997). In this study, students are aware that the cats are killed and supplied as specimens for dissection in schools. They are told by their teacher that the cats are used in dissection to further the pursuit of human learning. I explore whether students feel that this is a sufficient justification for the death of the cats. In the following section, I will explain how their justifications about dissection are related to my fourth principle of ecological literacy, which states that an ecologically literate student should appreciate the beauty and diversity of the nonhuman world.

A principle of deep ecology states that every living creature has the right to blossom and flourish (Naess, 1989). If the creatures of earth are allowed to flourish in their own space and time, then great diversity, richness, and beauty are a direct result (Naess, 1989). The health of the planet is vitally linked to this diversity (Merchant, 1992; Zimmerman, 1993; Devall, 1985). Human beings have the capacity to appreciate natural beauty and diversity. This appreciation leads to a sense of connectedness and relationship with the nonhuman world, because we tend to protect and care for that which we know (Devall, 1985; Naess, 1989; Clark, 1997). Therefore, Naess says that human beings should not seek to reduce the richness and diversity of the natural world except to satisfy vital needs (Devall, 1985).

The definition of these vital needs is left intentionally vague, to account for differences in culture and societies (Devall, 1985; Naess, 1989). For example, the needs of an Eskimo might be vastly different from the needs of a citizen of modern-day Los Angeles. Naess notes that the "equal right to unfold potentials as a principle is not a practical norm about equal conduct to all life forms. It suggests a guideline limiting killing, and more generally limiting obstruction of the unfolding of potentialities in others" (Naess, 1989, p. 167). Therefore, a true appreciation of the beauty and diversity of the nonhuman world would, in Naess's opinion, preclude killing for anything except the satisfaction of vital needs.

According to Native American traditions, killing for vital needs like hunger can be done in a respectful manner, as he describes:

The rituals performed before hunting were thought to attract animals and to cultivate a proper attitude and respect. The process of hunting and all it entailed allowed hunters to understand the nature of self-effacement and humility, and to honor the greater family of animals of which they were a part. The animals they

hunted personified their sense of themselves as a particular group within the greater community of nature (Cajete, 2000, p. 162).

In Native cultures, not only was hunger a sufficient vital need to justify killing, but the whole animal, including structures like horns, hooves, and hide, were used to satisfy other vital needs like the construction of shelter, tools, and clothing (Cajete, 2000). There was no waste of life, and it was taken with an attitude of respect (Cajete, 2000). While our modern society satisfies all of our vital needs by providing food in grocery stores and clothing in malls, so that our hands are no longer necessary parts of killing, we tacitly support methods of killing and use of animals through our purchases as consumers (Francione, 2000). An example of this would be industrial agriculture, which treats animals as objects or resources that exist only to be used to satisfy human needs (Francione, 2000; Rollin, 1992; Regan & Singer, 1989; Clark, 1997).

In this study, I link a student's appreciation for the nonhuman world to their justifications about the use of cats in dissection. If a student appreciates the nonhuman world, in an ecologically literate sense, they should kill and use animals only for good reason. In comparing student responses to my fourth ecological principle, I specifically examine whether students feel that use in dissection is a good enough reason to kill cats.

5. A student should be able to recognize the danger in excessive human interference with the nonhuman world.

For the fifth ecological principle, I return to the work of David Orr (1992), and I also borrow from the principles of deep ecology as defined by Naess (1989). First I

present Orr's description of the condition and cause of the environmental crisis, to define what is meant by excessive human interference with the nonhuman world.

Orr (1992) says that "the ecologically literate person will appreciate something of how social structures, religion, science, politics, technology, patriarchy, culture, agriculture, and human cussedness combine as causes of our predicament." (p. 93)

Another stage in the development of ecological literacy would be "to know something of the speed of the crisis that is upon us, and to understand the human enterprise for what it is: a sudden eruption in the enormity of evolutionary time" (Orr, 1992, p. 93).

Orr (1992) also states that the global environmental crisis is "the sum total of violence wrought by people who do not know who they are because they do not know where they are" (p. 102). The only defense against this crisis, in his opinion, lies in education: "Those of us in environmental education need to renew our commitment to a sustainable human future. The foundation of sustainability, however defined, will be the clear awareness that our well-being is inseparable from that of nature" (Orr, 1992, p. 148).

In Orr's definition, "the ecological crisis represents, in large measure, a failure of education... this failure is reflected in that portion of our sciences, humanities, and social sciences that deal with (or ignore) the relation between humanity and the earth" (Orr, 1992, p. x, xiii). He claims that "modern science has fundamentally misconceived the world by fragmenting reality, separating observer from observed, portraying the world as a mechanism, and dismissing nonobjective factors, all in the service of the domination of nature" (Orr, 1992, p. 12). Dissection may be one activity that teaches this kind of disconnection, and encourages the separation of observer from observed. The current

study investigates emotions as a nonobjective factor in science learning that can be used to develop ecological literacy in students.

The wording of my fifth principle of ecological literacy directly reflects a deep ecological principle as defined by Arne Naess: "Present human interference with the nonhuman world is excessive, and the situation is rapidly worsening" (Devall, 1985, p. 70). As an ecologist, I can see connections between the careless or thoughtless use of resources (if the cats are considered resources in this case), and environmental degradation. Just as consumers can choose to support industrial agriculture through their choice of meat products, I also see a connection between the choice to support killing cats as specimens for dissection and a lack of respect and appreciation for cats as individual entities with an equal right to live and flourish. As we shall see, I am able to include only a few comments from students for discussion about this principle, but the lack of evidence here is not without significance. Instead, the examination of my fifth ecological principle suggests the need for teachers to instruct their students about these connections in science classrooms.

Summary

These five ecological principles represent my personal definition of what it means to be ecologically literate. David Orr's definition of ecological literacy involves many aspects, some of which I have discussed in the preceding sections. He does not list specific principles in the way that I have for this study. However, my five principles, developed from my readings of Orr, Noddings, Cajete, and other scholars, is the most succinct and coherent list that I could devise for use in comparing student experiences in dissection. I needed a list that I could use to measure, and rather than rely on opinion, I

decided to develop my own principles, using this body of literature as my source and inspiration.

In this study, I looked for responses and comments from students that indicated the possibility that a student may understand the essence of these principles, using the literature of ecological ethics, animal rights, Native American science, and deep ecology as a connected framework. I use them to raise discussion and to demonstrate the potential that may exist for teaching students about connections they have to the nonhuman world. These connections may then be used to develop ecological literacy in all students. J. Baird Callicott (1982) says that “ecology changes our values by changing our concepts of the world and of ourselves in relation to the world. It reveals new relations among objects which, once revealed, stir our ancient centers of moral feeling” (p. 174). It is this kind of moral feeling, connectedness, and relationship with the nonhuman world that I define and examine through my principles of ecological literacy.

This research project not only explores the influence of emotion in science learning, but also attempts to describe a connection between dissection and ecological literacy. This connection may be understood through an examination of student emotional reactions to dissection, which are subjective and require interpretation and reflection to be categorized. In the following chapter, I present the qualitative research methods used in this study.

CHAPTER II

RESEARCH PROCEDURES

Rationale

In order to better understand the subjective factor of emotions in the learning of concepts related to dissection, I chose to undertake a qualitative study of student conceptions about dissection, utilizing a grounded theory approach. There are few studies that directly investigate student conceptions of dissection, and none that examine student emotional reactions to the activity. Qualitative methods are best suited to this kind of investigation, in which the meaning of an experience for students is explored. This chapter will describe the research procedures used in this study, the setting and participants, and techniques used to collect and analyze the data. The research questions for this study are:

- 1) How do student conceptions of dissection change over the course of a school year?
- 2) How do emotions influence a student's ability to learn concepts through dissection?
- 3) Do student experiences in dissection reflect ecological principles?

Grounded Theory

Strauss and Corbin (1998) characterize qualitative research as “a non-mathematical process of interpretation carried out for the purpose of discovering concepts and relationships in raw data and then organizing these into a theoretical explanatory scheme” (p. 11). Similarly, Creswell (1998) proposes a definition of qualitative research:

“Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting” (p. 15).

The purpose of a grounded theory approach is to “generate or discover a theory, an abstract analytical schema of a phenomenon, that relates to a particular situation” (Creswell, 1998, p. 56). Strauss and Corbin (1998) note that a primary consideration of a grounded theory study is that the researcher does not begin with a preconceived theory, but instead must insure that the theory emerges from the data itself. They note that in this way, “grounded theories, because they are drawn from data, are likely to offer insight, enhance understanding, and provide a meaningful guide to action” (Strauss & Corbin, 1998, p. 12). Maxwell (1996) writes:

Grounded theory does not refer to any particular level of theory but to theory that is inductively developed during a study (or series of studies) and in constant interaction with the data from that study. This theory is grounded in the actual data collected, in contrast to a theory that is developed conceptually and then simply tested against empirical data. (p. 33)

I utilized this approach because of the difficulty I anticipated in describing the subjective nature of emotions and the complexity of student experiences in dissection. There are also no other studies of student conceptions and emotional reactions to dissection that I am aware of, so I had little previous work on which to base my research. I anticipated that the descriptions provided by the students would be unique, and that theoretical explanations would emerge from the data itself. However, I was aware that my biases were present throughout the study. Charmaz (2000) notes that the researcher, however incompletely, enters into and is affected by the participants’ worlds in

qualitative research. And yet, as Creswell notes, “the investigator needs to set aside, as much as possible, theoretical idea or notions so that the analytical, substantive theory can emerge” (p. 58). This was a challenge that I faced in the field, especially during the interview process. In the next section, I describe what I did to address this challenge.

Interviewing

Seidman (1998) writes that “at the root of in-depth interviewing is an interest in understanding the experience of other people and the meaning they make of that experience” (p. 3). He describes interviewing as a process in which the participants are asked to reconstruct their experience and explore its meaning (Seidman, 1998). Rubin and Rubin (1995) characterize qualitative interviewing as a way to describe how people understand and interact in the worlds in which they live and work. They note that the ultimate goal for the researcher is to maintain focus on the description of the experience, rather than insert your own world into the setting (Rubin & Rubin, 1995). I conducted a series of five in-depth personal interviews with the thirteen students who participated in the study. These sessions took place over the course of the school year September 2002 - April 2003. I also interviewed the teacher, Mr. Gibson, three times during the school year. During the interviews, I asked a set of questions that I developed prior to the session. I asked each participant the same questions, and I allowed time for follow-up to questions when needed. In this way, I allowed each student and the teacher to explore the meaning of their own experiences. I tried to listen without offering too much explanation or clarification. Some of the students were very talkative and needed little prompting from me; others required some encouragement in the form of restating questions, or

remaining silent long enough for them to comfortably speak. In the next section, I discuss the basis for the questions that I asked students during the interviews.

Questions

As soon as I had recorded all of the interviews in a particular session, I transcribed them and began to read them, looking for emergent categories. I developed the following matrix, presented in Table 1, to define categories as they emerged.

Interview questions were developed through my examination of the categories. Each sub-question is related to one or more of the research questions, which I have indicated with a numeral in parentheses following the question.

Research Questions

1. How do student conceptions of dissection change over the course of a school year?
2. How do emotions influence a student's ability to learn concepts through dissection?
3. Do student experiences in dissection reflect ecological principles?

TABLE 1:

Sub-Questions and Interview Questions:

What concepts are students learning? (1)	Are any ecological principles being taught? (3)	Are emotions evident? How do students express them? (2)	How do students feel about animals? (1,3)	How do they feel about dissection? (1, 2)
Why did you sign up for this class?	Do you see any connections between dissection and how we think about the environment?	What do you think about the process of desensitization that Mr. G talked about?	How do you feel about the cat you are dissecting?	If you were a teacher, would you use dissection in your classroom? Why or why not?
What is your favorite part of a science class?	If you were a teacher, how would you teach dissection to your students?	Are there parts of dissection you like best, or that you don't like?	Could you tell me a little bit about your background at home, with pets or other animals?	Would you use an alternative to dissection? Why or why not?
What have you learned about the human body?	What did Mr. G tell you about how these cats were killed?	How did Mr. G introduce dissection to you?	Should children be around animals?	Have you ever dissected anything before? What was that like?

Will you be tested over this information using the cat?	Was knowing how the cats were killed important to you?	Does dissection make you feel nervous? Why?	Why should children be around animals (or why not)?	Do you think there are other ways to learn this information?
What do you hope to learn from this class?	Why was it important for you to know that (or why not)?	Do you feel excited about dissection? Why?	What did Mr. G tell you about how the cats were killed?	How do you feel about the (upcoming or previous) dissection?
Could you identify these structures in the cat?	Could you dissect a cadaver?	Is desensitization important?	How did that information make you feel?	Was the experience like what you expected?
What is your favorite part about dissection? Your least favorite?	Does the idea that this is a dead animal bother you?	Why is it important (or why not)?	Has this experience changed the way you view the cat?	What is the best/worst part about dissection?
To assess teacher expectations of student knowledge	To assess degree of discontinuity between students conceptions and ecology	To discover extent to which students are desensitized by dissection	To assess degree of difference in student views of animals with organisms in dissection	Overarching research question

I asked some of these questions more than once. In the first and final interviews, I asked students how they felt about the cat used in dissection, so that I could gain an understanding of how their conceptions changed over the year. I also asked them how they felt about each dissection as it occurred over the year. This gave me a sense of the changes that they were experiencing, and also enabled me to document how their expressions of emotion changed. For example, consider the changes in one student's view of the cat. In September, Elaine said: "I know it's already dead, but it's weird opening up something that you live with, or, it's a living thing, and it's part of your family, and then you have to cut it open and see what's going on..."

Elaine's view of the cat in April: "I think that it's being used as an educational tool and not as much as like a cat, I just see it as you know, this is what you're here to learn..."

Time Frame

This research was conducted over the course of an entire school year, during which time I was involved with the classes, as a participant observer. I observed all of the classes which involved dissections (see Schedule, Chapter III), and attended lectures once a week. My interviews with the students were coordinated with the major dissection sessions planned by the teacher (see Schedule, Chapter III). The decision to spend a full year in the field was an important one. I needed to document changes in conceptions over the course of the experience of dissection, which required being involved with the class for the length of the school year. Also, because of the sensitive nature of my questions, I needed to establish a relationship of trust with the students. These students were willing to discuss personal matters, such as emotional reactions to dissection, with me because I spent many months with them, and became an accepted part of their community at school. I participated in dissections with them, answered questions, helped with study guides during class time, and was also a recognizable figure on the Riverhill campus throughout the year. I sometimes filled in as a substitute teacher, when needed by the school during the year. The students recognized me both as a professional in the school, and as a researcher. My relationship with each student in this study was friendly, engaging, and respectful at all times.

Access

This study required gaining access to the classroom, which I did by writing to the Headmaster to inform him of my interest in the school as a research setting. He forwarded this letter to Mr. Gibson, who wrote to me and invited me to meet him and discuss the research. I visited the class during the last week of August, and introduced

myself to his students. I explained that I was a doctoral student and that I would be conducting my research in their class. I asked for volunteers who would be interested in participating in the year-long interviews. Thirteen students responded, from two different classes. Six students from Mr. Gibson's period 3 class responded, out of a total of 13 students. Seven students from his period 4 class responded, out of a total of 14 students. I provided them with copies of both the student consent form and the parental consent form, which I asked to be returned the following week. Interviews began on September 18, 2002, and continued for eight months, until May, 2003. I began my observations during the first week of classes at Riverhill, and continued until seniors had presented their final portfolio projects for the year, in late April. I ended my research at this point because the students had no more dissections in class after this time, and I felt that I had spent a sufficient amount of time in the setting to begin work on the analysis of the data.

Sources of Data

I utilized in-depth personal interviews, observations, and both reflective and reflexive journals as sources of data. The interviews were conducted using a set of questions which I developed through a constant comparative method of analyzing transcripts of the data in an ongoing fashion. Observations were recorded daily, during my time spent in the classroom. I circulated the room, taking notes of what I saw and heard during dissections. My observations were especially helpful in creating rich descriptions of the students, adding dimensions that I could not have understood in interviews alone. I did not maintain a specific structure for the observations, other than to note the comments and behaviors of the students who participated in the study. At times I observed behavior that indicated a different reaction than students talked about in

the interviews. For example, in the interviews, Lucy said, "I was actually more into it than most people... I was all right with it, it was just totally different than what I expected..." But her behavior told a different story, which I was able to record through my detailed observations of her standing to the side, watching others perform the dissections. Maxwell notes that observation is a useful tool because it "enables you to draw inferences about someone's meaning and perspective that you couldn't obtain by relying exclusively on interview data" (Maxwell, 1996, p. 76).

After I recorded my observations in class, I used both reflective and reflexive journals to clarify what I had seen and heard. I used the reflective journal to comment directly about what I saw and heard in class. In it, I asked what was going on in the setting, and how the participants expressed emotions and made sense of their classroom environment. In the reflexive journal, I made note of what I thought was going on in the setting, related to my personal thoughts and opinions about events that happened in the classroom. This was the place where I could record my subjective thoughts, without inserting them into the description of the setting. By doing so, I was able to separate my bias in the research, and I allowed the descriptions of the participants themselves and their actions to emerge through my observations.

Participants

Seidman (1998) notes that the word a researcher chooses to use to describe the person being interviewed communicates important information about the researcher's purpose in the interviews, and her view of the relationship (p. 8). *Subject* implies a hierarchical relationship in which the researcher may appear dominant. *Informant* is a term often used by anthropologists, because they are being informed about a culture, but

in this study I wanted to avoid the negative associations of the word. *Respondent* or *interviewee* is also not appropriate, because it does not convey the sense of actively reconstructing experiences, which was the focus of this interview process. The term best suited to this research is *participant*, which captures both the sense of active involvement that took place in the in-depth interviews, and also characterizes the respect and equity that I tried to build in my relationships with the students (Seidman, 1998, p. 8).

I also viewed the students as participants during my classroom observations. During dissections, I would circulate the room, answering questions about the location of anatomical structures, and at the same time I listened to their conversations and comments about the activity. As a participant observer, I was involved with the students in their classroom on a daily basis, and I had to establish myself in a relationship of trust. This trust was important, because of the sensitive nature of my questions. I wanted students to feel comfortable with my presence in the classroom, so that they would be encouraged to tell me about their personal, emotional reactions to the activity.

Triangulation

Triangulation involves making use of multiple sources of data, as described above, which “reduces the risk that your conclusions will reflect only the systematic biases or limitations of a specific method, and it allows you to gain a better assessment of the validity and generality of the explanations that you develop” (Maxwell, 1996, p. 76). I was able to manage my bias, and separate myself from the research process as much as possible through the triangulation of my data. I also gathered rich descriptions of the experiences of the participants because I used several different types of data sources. Triangulation essentially means that the researcher can cross-reference and compare data

within a setting, while also ensuring a higher degree of validity, due to the multiple views of data sources in the study. For example, in this study, I did not rely only on interview responses as data. I also utilized journal entries and observations, which provide other insights and explanations for behavior and responses of the students.

Analysis

Posner, Strike, Gertzog, and Hewson (1982) first defined the conditions necessary to bring about a change in conception in science learning. These are:

1. There must be dissatisfaction with existing conceptions.
2. A new conception must be intelligible (it must make some sense).
3. A new conception must appear plausible (it must seem like it could be true).
4. A new conception should suggest the possibility of a fruitful research program.

The authors report data from student interviews to show that these conditions for change are required for both individuals as well as scientific communities.

Although much research has been subsequently undertaken to clarify and refine them, no one has challenged these initial conditions as being essential for conceptual change to occur. Research has shown, however, that the process of learning is not as rational or as linear as early literature seemed to assume. The conceptual change model was revised to include other factors which need to be considered as part of the conceptual change process, including social and motivational factors. These are collectively known as a learner's conceptual ecology (Hewson, 1992; Demastes, 1995).

Tyson, et al. (1997) propose a multidimensional interpretive framework for conceptual change, and advocate viewing the learning experience from an ontological, epistemological, and social/affective perspectives. They include a student's goals,

values, beliefs, and self-efficacy as part of the learning process, and they note that the largest proportion of empirical studies that research conceptual change do not overtly consider the influences on changes in students' conceptual knowledge; rather, they only document the changes in conceptual knowledge (Tyson, et al., 1997, p. 399).

Sinatra, et al. (2003) discuss the role of a student's intentional level constructs, such as epistemological beliefs about science and their personal cognitive dispositions in learning controversial topics such as evolution. They found that intentional dispositions to evaluate one's thoughts and beliefs, and a willingness to consider change, may both affect a learner's understanding of a topic (Sinatra, et al., 2003, p. 522).

All of this research stops short at including student emotions as part of the learning process. Some of the terminology hints at its presence, but emotion is largely ignored, perhaps because the scientific pursuit of knowledge is generally assumed to be objective. In controversial topics, such as dissection, I believe that emotion is a critical part of a student's learning. I examine student responses using the four conditions necessary for change to occur (Posner, 1982), to which I will add the emotional dimension.

The five conceptual change conditions I use in this study are:

- C1) There must be dissatisfaction with existing conditions.
- C2) A new conception must appear intelligible (it must make some sense).
- C3) A new conception must appear plausible (it must seem like it could be true).
- C4) A new conception should suggest the possibility of a fruitful research program.
- C5) Emotional responses must be considered as part of the learning process in dissection.

I have added the fifth condition, and I have qualified it as related only to dissection, because the activity evokes emotional responses that influence student conceptions. I believe that when students interact with animals, there is a natural emotional connection which should be recognized. I am interested in how students express that connection, and how it relates to their conceptual understanding of dissection. These emotions may be directed toward the development of ecological literacy. I explored student emotional responses through in depth interviews, using five ecological principles as a lens.

The principles I have used in this study are:

- P1. A student should understand that he or she is connected to the nonhuman world, through emotions and relationships with pets or other animals;
- P2. A student should show respect for all creatures, both human and nonhuman;
- P3. A student should understand that the value of an animal's life is not measured by its usefulness to human beings;
- P4. A student should appreciate the beauty and diversity of the nonhuman world, and should only kill to satisfy vital needs such as hunger;
- P5. A student should be able to recognize the danger in excessive human interference with the nonhuman world.

My analysis of the transcripts of interviews with the students, and my observations of them in class, was completed using a constant comparative method (Creswell, 1998). Initially, I read the transcripts looking for patterns or themes to emerge from the data. This process is known as "open coding," in which the researcher looks for

properties within the data that will dimensionalize the category or theme (Creswell, 1998, p. 57).

Student responses to interview questions were grouped into four major themes during the open coding process:

- 1) Conforming, desensitization, cat as a learning tool or object, emotional reactions;
- 2) Form and Function, anatomy and physiology, skills, hands-on learning;
- 3) Horror, defilement, death, pain, sensitivity;
- 4) Respect, reverence for life, overpopulation, treatment of animals, appreciation.

Following this initial coding of the data, I used key words from the five conditions for conceptual change and the five principles of deep ecology to further examine the responses. These key words are presented in Tables 2 and 3. This step is known as “axial coding,” in which the researcher uses a coding paradigm to explore causal conditions and specify strategies that identify the context for this phenomenon (Creswell, 1998, p. 57).

TABLE 2: Key words used for coding of responses from themes 1 and 2:

Conforming, Desensitization, Form & Function:

C1	dissatisfaction: wanting to learn more
C2	intelligibility: <i>tool, senses</i> , hands-on before starting
C3	plausibility: <i>true</i> , hands-on after starting, touching concepts
C4	future research, careers, feeling “like a scientist”
C5	emotion, desensitization

TABLE 3: Key words used for coding of responses from themes 3 and 4:

Respect, Overpopulation, Sensitivity:

P1	Self & non-human world: speciesism, pets
P2	equal right to live: <i>respect</i>
P3	well-being as value unto itself, independent of usefulness: learning tool, overpopulation
P4	beauty and diversity decreased only to satisfy vital needs: <i>appreciation</i>
P5	human interference is excessive

At this point in my analysis, student responses were coded according to the conceptual change conditions (C1, C2, C3, C4, and C5), and the deep ecological

principles (P1, P2, P3, P4, and P5), which helped me identify the categories of conditions and interactions that influenced the process of learning in dissection. A step-by-step explanation of my analysis of the data would be as follows:

First I transcribed each interview, usually on the same day that I had conducted it with the student. I was able to record my reactions to their comments in my reflexive journal at the same time. I read the interview transcripts, usually two or three times, so that I became familiar with the student's voice and phrases. This continued during the school year, as an on-going process (open coding). After a couple of months had gone by, I started to see patterns and similarities in the comments that students were making. It was at this point that I began to organize the responses into the four major themes listed above. After I had categorized them in this way, I read them again, this time looking for key words or phrases to "tease out" the similarities and connections that I was noticing among the responses (axial coding).

Finally, I grouped the specific responses together, using the key words as organizers, and I began the process of comparing each response to the five conditions for conceptual change, and my five principles of ecological literacy. I tied each response back to my conceptual framework, and analyzed it by asking how the response did or did not demonstrate the conditions and principles that I used. Once I had completed this step, I was then able to synthesize the responses and create a picture of each individual student. My final step consisted of writing out themes and responses together, comparing them with my conceptual framework, and developing the rich descriptions of each student that are reported in Chapter IV. My theories and conclusions are presented in the Chapter V

of this project. Further hypotheses are discussed in the Implications chapter, in which I present models of classrooms incorporating theoretical results from the study.

Ethical Issues

During the course of this study, I had the responsibility of protecting the confidentiality of the participants. I did this by assigning pseudonyms to the students, the teacher, and the school. The list of pseudonyms was maintained by me alone, and will be destroyed upon completion of the research project. Participants had the option of saying things “off the record” during interviews, which did not find their way into the final account of their stories. None of the students dropped out during the research process. All thirteen students participated in all of the interviews, and were members of Mr. Gibson’s class for the entire school year.

“A qualitative researcher conveys to participants that they are participating in a study, explains the purpose of the study, and does not engage in deception about the nature of the study” (Creswell, 1998, p.132). Because of the sensitive nature of this inquiry, I was aware that some of the students might be uncomfortable expressing their true emotions, especially when they were in conflict with the goals of the class. In order to alleviate this potential discomfort, I talked openly with students about the goals of my research, and allowed them to review findings and provide feedback. My relationship of trust with the students was also an important factor in managing this possible risk.

Before the interviews began, I obtained consent from the students and their parents, using signed consent documents. Sample permission forms are listed as Appendix A.

Limitations

One limitation of this study is the influence of the researcher on the setting or individuals studied, a problem generally known as *reactivity* (Maxwell 1996, p. 91). This is a condition in which the researcher's opinions and beliefs begin to shape the development of questions and observations of the participants. Eliminating the effect of this condition is impossible in qualitative research, in which the researcher is the instrument used to gather and organize the data. However, the goal is to understand this influence and use it appropriately, rather than attempt to eradicate it altogether. This was a particular limitation in this study, in which interviews were the primary means of data collection. I managed this limitation by utilizing a reflexive journal, so that my bias and interpretations could be kept as clear and as separate as possible. In it, I wrote about my own feelings and reactions to dissection, so that I could recognize them more clearly during my readings of the interview transcripts and classroom observations. I tried to keep my opinions out of the analysis of the transcripts of student interviews.

I also did not discuss my personal views of dissection with the students at any time during the school year. If I had done so, I would have influenced the responses of students, who viewed me as a professional authority figure in the classroom. This could have compromised the validity of the results. While I did have friendly relationships with them, I was always aware of the potential effect that my opinions and comments could have on the students. I was careful not to disclose my personal thoughts in order to control this reactivity in the research setting.

A second limitation of this study is the small sample size. Because the goal of qualitative research of this type is to generate rich descriptions of student experiences,

small size is mandatory. Large numbers of interviews and transcripts become unwieldy for the researcher. However, one of the strengths of this type of research is precisely its focus on small numbers of participants. In this way, the rich, detailed descriptions generated by the study “enables readers to transfer information to other settings and to determine whether the findings can be transferred because of shared characteristics” (Erlandson et al., 1993, p. 32).

Another limitation is the fact that the students in this study chose to enroll in the Anatomy and Physiology class at Riverhill. They knew that the course involved a year long cat dissection, and most of them looked forward to the experience. Because of their high level of interest and motivation, most of the students in this study had not only prepared themselves for dissection before the class began, but in many cases signed up for the course specifically because of the dissections. These students may not represent the general population of students in science, and their reactions to dissection may be different than those of students who take biology because it is a requirement.

CHAPTER III

SETTING THE STAGE

Introduction

Before presenting the results of this study, it is important to set the stage, allowing the reader to become familiar with the school, the classroom, the teacher, and the students who participated in the project.

In this chapter, I first present the schedule of dissections and my interviews of the students, followed by a description of the school, and Mr. Gibson's Human Anatomy and Physiology class at Riverhill. Next, I present a description of Mr. Gibson, his teaching style, and his views on dissection.

Finally, I introduce the thirteen students who participated in this study. Short vignettes are presented in order to briefly introduce the reader to each student, followed by an in-depth description of each built upon their responses to interview questions.

The results pertaining to conceptual change are presented, along with conclusions about conceptual change, in Chapter IV. Results and conclusions pertaining to ecological literacy are presented in Chapter V.

The schedule of dissections for the class is listed below, along with the dates on which my interviews with the students took place:

Syllabus and Schedule of Interviews:

2002

September

18) Interview 1

22) Dissection: Introduction and Integumentary System

October

6) Interview 2

15) Dissection: Skeletal System

November

3) Dissection: Muscular System

17) Interview 3

December

8) Dissection: Nervous System

2003

January

20) Dissection: The Eye

February

10) Dissection: Endocrine System

March

1) Interview 4

18) Dissection: Digestive System

April

18) Dissection: Respiratory System

30) Interview 5

May

Final Practicum

The School

This study was conducted at Riverhill High School. Riverhill is a small, semi-private school in a rural area. Students in surrounding towns attend the school, and day students from outside areas may also apply to attend and pay tuition. This combination of factors results in a school that has high standards for discipline and management. A Board of Trustees supervises the management of the school, and also settles discipline and financial matters. Students may be expelled if discipline infractions warrant. The Headmaster, Mr. White, had been at Riverhill for many years, and was a great influence in the school and in the community. His leadership and direction gave the school a very high reputation in the state.

The quality of teaching at Riverhill was superlative as well. The science department ranked among the top schools in the state, and the art department was also highly regarded. Riverhill seniors completed senior portfolio projects, instead of taking finals at the end of the year. They began this project as freshmen at Riverhill, with the help of their guidance counselor and a supervising teacher. Yearly updates were required, and the culmination was a presentation to three members of the community, chosen at random from a pool of volunteers. These projects were often of a high caliber, and were respected by students and teachers. I found that most of the students that I

knew at Riverhill talked frequently about their projects, and seemed very proud of their work. This atmosphere gave Riverhill the feeling of a small, private academy, while also maintaining the diversity of a public high school population.

The total enrollment for grades 9-12 at Riverhill was about 700 in 2003. Classes were small, and were normally taught by one teacher. The campus was spacious, set on a hill, and overlooked a lake surrounded by trees. Soccer and baseball fields were across the street, and were filled with students in practice after classes ended for the day. The administration building was the oldest on campus, with the hallways and classrooms added on to both sides. At the heart of the school was the basketball gym, which had a large stage at one end and bleachers down one side. Riverhill was well known for its high quality drama department, and its plays and musicals were popular with the community.

The Class

Human Anatomy and Physiology was an upper level elective science course, taught by Mr. Gibson. Students were required to have the permission of the instructor or guidance counselor in order to register for the class. The centerpiece of the course was the year long dissection of a cat, through which anatomical structure and physiological function of the human body was taught.

The high school had just completed construction of a new, updated science building in 2003. Mr. Gibson's classroom was on the second floor of the new building. Students sat around tables, arranged in a half-circle facing the front of the room. The front table was a laboratory station, with a sink and faucet, and gas outlets. Dry-erase boards covered the wall behind the front desk, and from the doorway to the back wall on

one side. On the far side of the room were lab stations for the students, with spacious cabinets and storage areas running the length of the wall. In the back of the room were more tables, a storage room, and Mr. Gibson's desk. Windows along the back wall looked out at the administration building next door.

Students were required to participate in dissections in this class. If a student refused to touch the specimen, they had to be prepared to observe and take the same exams as all of the other students in the class. Exams were written and also included a practical portion, in which students identified structures in the cat. The final practical exam was entirely based on the identification of structures, and was cumulative over the school year.

Mr. Gibson discussed his practice of quizzing students following each dissection, the cumulative nature of the learning process in the class, and student preparation for the exercise:

I also find the day before [dissection] I always give them an idea of what we're going in to look at, I always have a list of things to go through and find, I usually give that to them the day before... it's also cumulative, so if we've already done the digestive system and we're in the circulatory system, one of the first things they do is go back and trace the whole pathway, then we move on to the circulatory system... so a little preparation ahead of time...

He added:

I'd say what I find rewarding is when I give them what I call an 'on-the-spot' practicum that they can recall the information... with the anatomy kids they don't have diagrams, everything is from total recall, so, two weeks ago when we went outside and did the respiratory system, and it was cumulative, I went back and did the digestive system and the musculature, and to recall information... and I've just found that over the years I've backed away from diagrams, because I realized kids didn't need them, so they must have something in their long-term memory and seeing the actual specimen brought it out...

This kind of preparation was an important part of Mr. Gibson's teaching:

...so the recall is really good, and kids by now know that before they put this cat away and wash up, I'm gonna quiz them... and it's great, and before the seniors go, everyone will have a cat practicum, and basically I go from head to toe and muscle, bone, I do everything... before we go to the test, I give them a list beforehand saying this is what I'm going to be looking for...

A Typical Day

I usually arrived in the classroom before the bell rang, so that I could greet students as they came in, and so that I could observe their behavior before formal lab activities or lecture began. I remained in the room for both classes I observed (third and fourth periods of the day). On a typical dissection day, Mr. Gibson began his class with a lecture to prepare the students for what they would look for in the cats. Dissections took place during "double block" classes, which were the first periods of the day at Riverhill, and were an hour and twenty minutes long. Lectures usually lasted about twenty minutes, with time left for instructions and questions. Students brought in completed worksheets which were graded and discussed before they began the dissection. The cats were stored in an ice chest, in the storage room in the back of the classroom. Gowns were distributed, and as some students picked up scalpels and trays, others located their cats in the ice chest. Dissections usually took between twenty and thirty minutes to complete, depending on the number of structures to be found and the physical difficulty in finding them. Mr. Gibson circulated the room, helping students identify parts and answering questions. When the groups were finished, he quizzed them on the location of parts, and then clean-up began. Once the cats were back in the box, the remaining class period was devoted to answering questions and review.

This class had a very good reputation among students, teachers, and the administration at Riverhill. During my year of observation in the school, I heard many favorable comments about Mr. Gibson's teaching and the performance of students in the class. All of the students that I talked with thought highly of Mr. Gibson. They recognized the difficulty of the course, and the valuable preparation that it afforded students on their way to college. The text for the course was a college level human anatomy and physiology text, which the students used as a study guide. Class lectures were not directly from the text, because Mr. Gibson used his own typed handouts and outlines. He would refer to the book and tell students to use it when they had questions on homework or during study sessions.

In addition to the cat dissection, students completed numerous projects throughout the year, usually one per chapter or system they were studying. Some class time was used to work on projects, and students presented the completed work to the class.

Examples of student projects:

1. Using magazine pictures, students created collages and identified muscles and bones, origins and insertions, and actions; these collages were passed around the classroom and used as study guides to develop exam questions;
2. Students researched a disease or disorder of the nervous system, eye, or endocrine system, using the Internet and other resources, and presented a report to the class;
3. Students in groups of two identified muscle sequences of the body that create an action, such as chewing gum, brushing your teeth, or throwing a baseball; one member of student groups read the list of muscles as another member acted out the sequence in slow motion for the class.

Students seemed to enjoy working on the projects, and Mr. Gibson often used the information presented by the students as questions in his exams, which ensured that students were invested in the accuracy of their information.

The cat dissection, as the feature of the course, received the most attention from students. It was talked about even by students who had never taken the course, a fact which some of the students in class told me during the interviews. Some students refused to take the course because of the dissection, but many students who did find it to be one of the most interesting activities of their high school career.

The Teacher

In this section, I specifically discuss Mr. Gibson's teaching in Anatomy and Physiology classes at Riverhill High School. In the Introduction, I discuss his teaching style, his sense of responsibility for the students, and his background in dissection. Four themes are introduced and discussed in depth. These themes are:

1. Use of Senses in dissection;
2. Purposes or justifications for dissection that Mr. Gibson teaches his students, including training for medical careers, overpopulation of cats, and the use of educational models. This section also describes Mr. Gibson's views on desensitization;
3. Emotional Reactions to dissection; and
4. Appreciation as a Value, which was the most important part of the concept of dissection that Mr. Gibson hoped to teach his students.

Introduction

Mr. Gibson had an enjoyable and effective teaching style, which he says is partly due to his time spent teaching middle school science. He was engaging, he used humor and personal anecdotes to highlight his teaching, and he seemed relaxed and always in control of the classroom. Students in his Human Anatomy and Physiology classes asked many questions, joked with him before and after class, talked about sports (Mr. Gibson was one of the basketball coaches at Riverhill), and were always involved with the class discussions. His lectures were direct and informative, and he frequently used video clips and other multi-media presentations along with them.

Mr. Gibson knew that it was important for him to guide the students:

...over the years I have had students who, they're reluctant to dissect, but I've found that if I didn't back down, and I didn't give them an out: yes, you can go to the library or yes, you can sit in the corner and diagram, that they always stuck with it, and I've found more times than not, like I say to them, you can be three feet away, but you still need to be peeking in, you still need to know I'm going to give you a practicum on this...

He also added:

I really haven't changed my approach in the past few years... I've tried to handle it like, we're not gonna butcher this thing... we just started to talk about bones, and now you're gonna use this model and identify bones... I know I could totally turn them into butchers... but we do have a little power and we do have a little control... it's my responsibility...

Human Anatomy and Physiology courses had been taught at Riverhill for five years when I met Mr. Gibson. Before that time he taught general biology classes. In seventeen years of teaching, he once told the students, he had never requested a day off for personal reasons, because he loved teaching so much. It was obvious that he cared about the students, calling them "my kids" and going out of his way to make his class exciting and interesting for them: "I think of them as my family, as my kids, and they

were with me, 180 days they were with me, we had mostly good days, we had a few bad days, but we experienced it together...”

Mr. Gibson told many stories to the students about his college experiences with dissection. Some were shocking, such as the description of how he and his lab partners had smashed the heads of cats open on concrete floors, because the lab did not have coping saws for students to use. I asked him about his background in dissection:

I am pro dissection, and I think a lot of that comes from my experience especially at the college level, when I took zoology classes and anatomy classes... for me, to match up what I saw in a two dimensional diagram of a shark, of an eel, of a worm, of a whatever, and then to touch it, to actually experience it, just opened my eyes, made everything more practical, so if I had to trace my history it was really back in college where I became a believer, and then in my teaching I just found that the kids were engaged, they were, I tried to make them take the picture from the book, find it in the specimen, whatever, so I just found that to be rewarding, I think for the kids, and I've done them ever since.

He also told me:

My grandfather was a professor at Syracuse University, of zoology and anatomy, and back in the 20's and 30's, there were none of these companies; he would actually go out and pick up some of these stray cats from the street and he would embalm them right down in the basement, and also during the Depression he was aware that for the money, and I never asked my father how much he made per cat, but he would sell them to the University and use them in his classes, so sometimes I tell that story, to get the kids to realize that these days the chances are they're not walking through town picking up stray cats, but there are companies now where probably the chemicals and stuff... it's a cleaner and better process...

Mr. Gibson frequently made jokes about food, describing the skin “like biting into a Snickers Bar;” the pancreas like a “chicken finger” or “chicken teriyaki under the stomach;” the arteries in the lungs “like cutting through a candy bar to find the peanuts;” the brain like “Jello-pudding type stuff.” I often heard him say to the class, “I get real juiced about all this.”

Using Their Senses

Mr. Gibson wanted his students to have “tactile sensory” experiences with dissection, and encouraged them to use their hands as much as possible: “... this is not a strenuous dissection here, in fact you don’t need a scalpel... this is a tactile sensory... you need to feel with your tootsies...” ; “...you need to apply some force here—manhandle them...” During the nervous system dissection, he told them, “...you will hold this cat’s brain in your hand... this is what I want—tactile sensory...”

Some of the students looked visibly upset when he told them, before the eye dissection: “...you’ll have to cut the eyelids off... and I’ll have you slice right through the cornea...” He reminded students to refer to the handout “before you start ripping this cat’s eye open...” He explained to three girls as they tried to take out the eyeball: “...you do start to core it out, like a melon ball..”

During the digestive system dissection, he told the students, “... don’t be afraid to manhandle this—the cat won’t feel it...”

It was clear that Mr. Gibson felt the tactile sensory experience was important to learning through dissection:

... you do get some what I call butchers, but I have found that the butchers when they dissect are very skilled with a scalpel, and these boys who clown around are actually very good, it’s the weirdest thing... when we take them out or dissect outside, they have the ability to peel back the fascia and the fat, where some kids don’t have that technique... I see this every year... and for some kids for whom academics isn’t their strength, but then you put them in front of a cat, and bang bang bang they can rattle off all the anatomy and they really take the cutting part seriously... sometimes they want to go further and pull the jaws off or something... and there’s got to be a lot of trust...

When I asked him if he had ever considered using an alternative to dissection in his classroom, he said:

No, I've seen them through the program some of these websites you can go on and kind of get an idea and then you can purchase the CD-ROM or whatever it may be, so I've never really pursued that... I think that's one of the things that's missing from some of these programs, it's just the tactile sensory and the smell and that part of it...

Purposes

Before the skinning of the cats in September, he spent time with his students explaining where the cats came from and how they were killed. All of the students took these justifications to heart, and repeated them to me during the course of the year. For example, he told them that "if you go into science, this will be one opportunity to work with these specimens." He also said, "You will get desensitized, and you will get ready for the muscular system."

Mr. Gibson explained that the cat should be viewed as a model: "...another thing I stress is that some of them are going into the medical field, and they need to be prepared for this...you're gonna have to feel, so I try to make that connection to them, and I think it gets them to say, all right, we're using this as an educational model, we're not going to be butchering stuff..."

The issue of the overpopulation of cats was a theme that students repeated to me during the interviews. Mr. Gibson introduced that issue to the students in September:

...I think that one of the issues I bring up early on, that it's almost like the abortion issue or right to life, in that these animals, they were a living thing, but unfortunately a lot of them are not spayed or neutered, so we have a proliferation of them, so what do we do with them, and that's where science is an educator, and he says, let's do it... I try to desensitize them early on, and I hate to use that word, but I slowly lead them in...

The following comments from my interviews with Mr. Gibson clarify his sense of how students should be introduced to dissection, and his reasons for using it in class:

...we were doing the digestive system, so they had to trace everything from the incisors all the way down to the sphincter of the anus, and we realized at first you know they weren't too grossed out, but then they start to see oh here's the pancreas, there's the... and they did get desensitized, but at first it's, you know, but that's something that I dunno... I don't think these kids are gonna go out and start cutting cats' heads open... I think they see it as a learning tool, I hope they would... and so that's why I think it's valuable that there's a lab science that these kids can explore... there's probably kids who still won't get into it... and that's okay, again I think that's part of the process, they've experienced it, they've experienced the sights and the sounds and the smells...

In another interview, he talked about the first day the cats arrive in the classroom:

...I haven't had anyone run out of the room, but I do know, usually by the time the cats get here it's probably September, we start in mid-August, so they don't come until late September, so actually those boxes get put right into the anatomy room and I know whatever lesson I had to do today is out the window, and we talk about it... one of the things I say is listen, this is a part of the course, but you're going to see a cat that was sacrificed... these cats I'm assuming were gassed, so you're going to see the wincing look on their face, and I tell them and then I can open up a bag, and I also tell them they will be in a group, so as long as there's one person who will come over, we kind of claim our cats that day... so at that point I find there are a few who don't come over to the boxes, and they might look and see the face, and some of them are probably making that connection to their own personal pet, and I guess I ought to be more observant, but nobody's gone running down the hallway, and no one has regurgitated on me, but it's one of those things that I don't—it's not like they come into period seven and there's a cat lying in a pan... I just found they have to go a little slow, and then conversely, then we take off the fur, and a lot of these kids are desensitized immediately... I find that you put a scalpel in their hand and you gown them up, and some of the kids put Noxzema under the nose, and all of a sudden the curiosity takes over, 'cause I tell them after we pull back its fur, we do the musculature system, so don't be surprised, you will see the biceps, and you will see all these things... I think the curiosity comes out...

Emotional Reactions

Mr. Gibson emphasized the need for desensitization to emotion, which he told them would happen “the more you work with it, and see it as an educational model versus Fluffy at home.” He said, “You know I hate to, like I said to my biology class last week I said I hate to make you, I don't want you to be an unthinking, unfeeling human being but

I said you need to look at this in a way that after 20-30 minutes will be as an educational tool...”

Mr. Gibson recognized the importance of ownership, which was a key part of the learning process for some students. He also felt that preparation and involvement helped to separate emotions from the experience:

I think I try to keep the focus of the course and how we're using it as an educational model... and we're doing the models, and I try to get it to a point where they're independent... and the preparation counts as a grade, so maybe that separates the emotional... the key thing is ownership, and if they have ownership, then they're more serious...

He was always conscious of his students' reactions, and he tried to help them become desensitized early in the year:

K: Do you think that emotions are an important part of their learning process?

G: Oh yeah, I find, every time, I try not to take it lightly, it's almost like you always have to remember safety first, I, every time I get out those dissecting pans and scalpels, I think you know, I've got this crew over here, and I know so-and-so won't touch it, but I'm aware that there are some who still find it hard...

K: How do you feel when you get one who really objects to it?

G: Over the years I've realized most of them you don't have to hold their hand, but you do have to ease them into the shallow end of the pool...

Appreciation as a Value

Mr. Gibson hoped to teach his students to appreciate the human body, and to value life:

... kids in here, I know that they're out partying Friday and Saturday night, and I won't look at them specifically, but I tell them that what we inhale, what we

ingest, our bodies are taking in these substances... so I guess just that they value life, and really just value these organ systems and what they're doing... in other words that they just value this educational experience...

He also said:

...I think that to see a dead specimen sitting in front of them, they realize that we're not immortal, that there is a finality and that, I've said to them at the cellular level, these organs shut down, so I think one of them would be appreciation... to appreciate what you have, and that if the kidneys go, or if the heart goes, I guess when they open up those cats, that they will value life, that they appreciate it, and I show them quite a few video clips, and some of them are humorous and some of them are pretty serious, but that they appreciate what they've got, that they value life...

After each section that he taught, Mr. Gibson returned to the theme of appreciation for the human body. The students completed projects which were related to structure through the study of disease, illness, and other topics of interest, such as drug use and effects. Many students repeated the word "appreciation" when they talked about what they had learned from the course. I asked him what concepts were most important for them to learn, in his opinion:

One of my main things, and they hear me say the A-word, appreciation, is that, to get an appreciation of just how complex the human body is, and I'd say that's probably the biggest thing... and then from there it all trickles down... and then I suppose the next big thing is just anatomy, structure, and why, how is the structure gonna maintain homeostasis, or keep you alive, so that, I mean that is another big part of it, is, but that's a big concept, but just open the door to structure and function...

Summary

Mr. Gibson wanted his students to have a "tactile sensory" experience in dissection. He understood the need for desensitization to emotions, and he stressed the importance of viewing the cat as an educational model. He explained that dissection would help students prepare for medical training, and he also discussed the issue of

overpopulation with his students, to help them become adjusted to the presence of a cat on the dissecting tray. He believed that curiosity and interest would take over for the students, and that they would become completely desensitized to their emotional reactions over time. The most important concept that he hoped to teach his students was an appreciation for the human body. About animals in education, he said, “We can use them, if we do it with respect... that’s what I love about science—it ties into everything...”

The Students

In the following pages, the reader will be introduced to each of the thirteen students at Riverhill High School who participated in this study. These short vignettes are based largely on my observations of their behaviors in class, as well as comments they made during dissection sessions. They represent an overview of the participants. The results of this study, which are primarily their responses to my interview questions, are reported in Chapters IV and V. Conclusions drawn from the results are also found in these two chapters.

The primary reason for presenting these vignettes before the in-depth results that follow was to introduce the reader to each student without including my analysis of their comments and behaviors. Because these vignettes are based on observations, I wanted the reader to feel as if we were in the classroom during dissections, watching and listening. In this way, each reader can gain a sense of the students before reading the complete stories that are presented in Chapter IV.

Lucy

When the students skinned the cats during the first dissection in September, Lucy said, "I never thought I would actually touch this thing." She sometimes helped the other girls in her group during dissections, but generally Lucy was very quiet, she looked uncomfortable, and she preferred to just watch. One of her lab partners once told her that she could hold the bag, "since she didn't hold anything else."

When they began the nervous system dissection, Lucy exclaimed, "I just want to be a journalist!" She held the cat's brain in her hand that day, which was something she discussed with me in the interviews. In April, during the respiratory system dissection, when her lab partner Rachel said, "Don't pull it; how would you like your arteries pulled?" Lucy replied, "If I'm dead you can do whatever you want."

Elaine

Elaine was usually vocal in class, making comments and laughing with her partner, Emma. For the most part, Emma performed the physical dissection while Elaine watched. During the muscular system dissection in November, Mr. Gibson told the students to find muscle insertions and pull on them to see the effect. Elaine said, "That's freaky." She looked particularly uncomfortable when Mr. Gibson told them they would need to "apply some force and manhandle" the cats in order to get the brain out of the cranium. As they worked, I heard Elaine say, "Oh, these poor cats," and "It doesn't have a face anymore." She talked off topic about work and friends during most of the class period. About the nervous system dissection, Elaine said, "This will be scary."

Everything else is okay but I don't want to cut open someone's brain—I don't care if they're dead.”

In January, during the eye dissection, Elaine was noticeably uncomfortable, and watched rather than participated. Her comments were loud: “Oh my god, I just saw the eyeball;” “It's gonna pop, I can see it jiggling;” “This thing is like, blind, and it's staring at you;” and “I got my eye on you”—followed by nervous laughter. As they cleaned up after this dissection, she said, “Ew, there's cat chunks in the sink!”

In February, Elaine still showed signs of evident discomfort and tended to watch Emma dissect. She joked around during the exercise, and told Emma, “I'll take a picture of you with a dead cat.” Emma said, “Yeah, I'll probably get arrested for animal abuse,” to which Elaine replied, “Who'll see it?” Elaine spent most of the class period walking around to all of the groups, holding a piece of sternum which she showed to everybody. As she watched one of the groups dissect, she said, “It's in a fetal position.” At one point she told Emma, “Don't take apart the skin!” Emma said, “I don't see you doing anything,” and Elaine answered, “Exactly.” When Emma laughed at seeing the rectum of the cat, Elaine said, “Why are we laughing?” At the end of the class period, Mr. Gibson began walking around to quiz students on the structures they found that day. I overheard Emma and Elaine saying to each other, “Just point to the area and you'll be fine.” Neither of them was able to identify all of the structures.

Christine

Christine was a good student, who participated actively in sports at Riverhill. She always worked quietly in class. She would turn to me and grimace sometimes, especially

during the nervous system dissection, but in general she was always professional and studious during the activity. I did not observe her to take the lead in dissection very often in her group, but she usually helped and performed some of the cutting. When her group had finished dissection, I often heard her answering questions as Mr. Gibson quizzed them on the identification of structures. Christine was outgoing, confident, and always very friendly during the interviews. She seemed to enjoy the chance to discuss her feelings about the activity. She watched her partners work quietly during the eye dissection. When her group removed an intact eye, she smashed a little of the aqueous humor out of it, and turned to me and winced, “Ewww...”

Victoria

During the first dissection, I heard one of Victoria’s partners say to her, “So are you going to dream about cats tonight?” Victoria said, “No, I’m going to snuggle my cat tonight, and apologize a hundred million times.” She was always willing to participate, but generally left most of the physical cutting to Rachel (the other member of the group was Lucy). Rachel was often aggressive in dissection, although she was professional about it, and once she cut off the cat’s ear, to which Victoria exclaimed, “You’re mutilating it!” Shortly after this comment, Victoria said, “It’s dead, so we can’t hurt it anymore.” When Rachel began to joke around a little by “meowing” at Victoria, she said, “Stop it! You’re talking to it like it’s alive... it’s creepy!”

As they prepared for the nervous system dissection, I heard Rachel say, “We’ll be doing the eyeball soon.” Victoria answered, “And the brain—we’ll slice its heart out.” They both mentioned how silly it was to have “feelings for a dead cat.” I noticed that in

the interviews, Victoria discussed the brain and the heart as “crossing some people’s boundaries.” I wondered if it would be crossing her own.

Victoria made a couple of disparaging comments about Lucy, who did not often participate in the dissections. Once I heard her say, “She can hold the bag, since she didn’t hold anything else.”

In January, during the eye dissection, Victoria worked steadily with Rachel. They joked around a little bit, and I heard squeals and meows during the exercise. Victoria said, “Ew, is that a chunk of brain?” and she told Rachel to “be a little gentler.”

At the beginning of the respiratory system dissection in April, Victoria picked out a cat from the cooler where they were stored in the classroom, and pulled it out of the plastic bag. Rachel said, “This isn’t our cat.” Victoria said, “Who cares, it’s just a cat—let’s dissect it.” They used the list of muscles and organs to identify in the cat, and at one point, Victoria said, “Ooh, we found some black stuff.” She later commented, “This isn’t bothering me today.”

Jason

Jason seemed to enjoy dissections more than most of the students. He was highly independent, and preferred to explore on his own, instead of working through the list of structures given to the class. In September, I heard him make comments like, “This feels really cool.” I often observed him investigating structures on his own, while his lab partner Jessica helped out and watched. When they dissected the musculature in November, there were a few squeals and moans from some members of the class. Jason said, “Thou shalt not dissect cats? I don’t think so!” and dove into the exercise. He

wanted to open up the tail, “to see what’s inside.” I heard him make remarks like, “That is awesome! I’m sorry—I’m finding that amazing,” and “Note: fascia is cool.”

When they removed the brain during the nervous system dissection in December, Jason held it in his hand and said with a disappointed tone, “That’s it?” He seemed frenzied during this dissection, and rushed through to find structures on his own. He noted that it took 30 minutes of work to get the brain out for a 1 minute observation, and said sarcastically, “It’s appreciation.”

In January, I began to observe Jason being a little more aggressive toward the cat. During the eye dissection, as he poked the cat with the probe, he said, “Die!” In March, during the digestive system dissection, Jason made many remarks: “Ow! It bit me!,” “Gross it went crunch—that’s awesome!,” and “I’m having fun, that’s all—it’s more fun because it bit me” as he cracked the jawbone. He removed the teeth, the “big ones that bite,” and said, “Ha ha, now it won’t bite me anymore.”

During the respiratory system dissection in April, Jason worked quietly with Jessica for the first half of the class period, locating structures and asking questions about them. Then he inserted the probe into the cat’s head, pushing it out through the esophagus. He said, “That’s cool,” and then twisted the probe around in the cat’s head while waiting to be quizzed by Mr. Gibson, who was making his rounds to each table. Jason suddenly stabbed through the skin of the cat with the probe and said, “You f----g cat...” and then saw me watching him. He said sheepishly, “I’d never do that to a *real* cat.” Then he made clucking noises like a chicken, and held up the cat’s intestine: “How’d you like this hanging in your car window?”

Danielle

Despite her ability to perform dissections in a professional manner, I heard Danielle make comments like: “The smell—I can’t wait to get out of here,” and “Oh gross, come on you guys, help out...” In November, Tom (also in her group) was absent from the dissection, and Danielle seemed totally involved, although at one point she said, “I think our cat is decaying.” During the nervous system dissection, she said, “This is traumatic.” And while they worked to remove the eyeball in January, Danielle said, “If it blows up I swear to God I’m gonna scream!” She held the eyeball aloft and said, “I’m so glad I don’t have cats; I’d never look at them the same again.” She looked at me and winced.

Jessica

One of Jessica’s lab partners was Jason, who tended to take the lead in the group and perform most of the dissections. I often observed Jessica helping him. In fact, Jessica and Jason worked steadily, while sometimes the other girl in their group was not even watching.

During the digestive system dissection in March, I saw Jessica cut open the stomach, and play with some of its contents. She turned to Jason and said, “Here, put this on toast.” Then she said, “Maybe it starved to death.”

In April, as they dissected the respiratory system, Jason put a probe through the cat’s head, extending it out through the esophagus. He said, “That looks cool,” to which Jessica replied, “Have you seen those movies where they have the heads up on stakes?”

Rachel

Rachel was usually the one in her group to do most of the physical work in dissection. Her manner was confident, and while she maintained a serious work ethic and was always on task, she also joked around with the other two girls in her group (Victoria and Lucy). For example, I often heard Rachel “meowing” at Victoria as they dissected, which prompted Victoria to add, “You’re talking to it like it’s alive; it’s creepy!”

Before the muscular system dissection in November, I heard Rachel say, “So I take it I’m cutting it open?” in a resigned voice. She cut the ear off of the cat during this dissection, causing Victoria to exclaim, “You’re mutilating it!” Then, while the other two girls held the cat down, she cut off the other ear and said, “It’s wonderful!”

The eye dissection in January was one of the most difficult for many students, but Rachel seemed to be comfortable with it. While she and Victoria worked on locating parts, I heard her say with a small laugh, “Would you stop smushing it!” and I heard her say that the activity reminded her of the movie “The Silence of the Lambs.” During this dissection, I heard her say, “This cat died for you; I wish you would respect it a little more!” Everyone laughed, and Rachel turned to me and said, “How could you teach *dissection?*”

In February, for the endocrine system dissection, Rachel worked alone, because Victoria and Lucy were both absent. She told me she preferred to work alone, because she thinks she does better that way. She worked quietly and was very business-like that day.

In April, before the respiratory system dissection, Rachel and Victoria picked out a cat from the cooler, and when it came out of the bag, they thought they had not chosen

the right one. Victoria said, “Who cares, it’s just a cat, let’s dissect it,” but Rachel said, “I was really getting attached to our cat.” I heard her still wondering if it was their cat throughout the dissection that day. She and Victoria used the list of muscles and organs to locate structures, and I heard Rachel say, “Squeeze the plush and it will be all squish inside.” She also said, “This is the coolest thing I’ve ever seen.” When Victoria worked a little more aggressively with the cat, Rachel said, “Don’t be cruel to the cat for no reason.” Victoria said, “This isn’t bothering me today,” to which Rachel replied, laughing, “Don’t pull it; how would you like your arteries pulled?” As they went down the list of parts to locate in the cat, I overheard Rachel say to the girls in her group, “Pretend we’re learning.”

Emma

Emma usually performed most of the dissections in her group, and she often joked and made comments while she worked. During the musculature system dissection in November, Emma said, “It’d be like a good horror movie if it sat up and went ‘Meow!’” She also said, “Poor thing, hope it had a good life—look at its face.” She generally went right to work with the cat, and she was often the first to pull out structures, such as the brain. On that day, Mr. Gibson said, “Emma is the brain surgeon over here.” She held the brain up in her hand for the rest of the class to see, and Mr. Gibson said, “To think that this little walnut brain powered that cat.”

As they prepared for the eye dissection in January, Emma commented on the newspaper she spread out on the table underneath the dissection tray: “Look how appropriate; there’s a kitty on the front of my newspaper!” In February, during the

endocrine system dissection, Elaine took a picture of Emma “with a dead cat.” Emma said, “Yeah, I’ll probably get arrested for animal abuse.” Elaine asked, “Who’ll see it?” and Emma replied, “The people at the photo place.” It was at this time of year that I began to observe Emma being a little more “rough” with the cat. She and Elaine were hyper and talkative during this dissection, and at one point Emma said, “I want to break his foot off—he’s an empty sack!” When Elaine asked her not to “take apart the skin,” Emma commented, “I don’t see you doing anything.” Another girl in the class took pictures of Emma “kissing” the cat, and smiling through the cat’s intestines as she held them up in the air.

Michael

Michael always seemed comfortable and relaxed in class, and once during dissection, I heard him talking about his new litter of kittens at home. He turned to me and looking over the cat on the table, he said, “Hey, do you want a new kitten?”

Michael was calm during the dissections, and usually did most of the cutting in his group. He and Carmen quizzed each other on structures as they worked. He was casually chewing gum during the muscular system dissection in November, and I overheard the other girl in the group say, as she watched him perform the dissection, “This doesn’t bother me but today it does.” Michael seemed relaxed, and said, “This looks like turkey,” to which the girl responded, “Oh gross, compare it to something I eat!”

For most of the dissections, Michael was quiet, and worked quickly to find the structures in the cat. Carmen was frequently absent, leaving him and the other girl in the

group to do the dissections. I overheard them commenting about her absence, but in general Michael took the lead in the group anyway, and seemed comfortable working throughout the school year.

Carmen

During the first day of the integumentary system chapter, in early September, Carmen asked, “Why are blisters always round?” She was always forthright in her observations, and not at all shy about asking questions in class. However, Carmen was frequently absent. She missed at least two of the major dissections. She was not the strongest student in the class, and while she seemed to truly enjoy the dissections and looked forward to them, her commitment did not match her enthusiasm. When she did take part in the dissections, I did not hear her make any comments at all. She was usually very quiet, studious, and serious about doing the dissections, although when she was in class, she was normally cheerful and confident. Once I heard her say, “I feel like Bill Nye, the Science Guy!”

Alfonso

During the dissections, Alfonso was quiet and serious. He took the lead in his group, and seemed proud of his “surgical technique,” which Mr. Gibson commented on and made an example of for the class. During the muscular system dissection in November, I heard a girl in Alfonso’s group say, “I don’t want to touch this,” and he replied, “Yes, you do,” and proceeded with the dissection. Later, the same girl squealed, “Alfonso, I hate you!” when he got some “juice” on her hair. He was chewing gum

during the dissection, and seemed comfortable and relaxed. During the eye dissection, Alfonso's group was among the first to remove the eyeball, and I watched Alfonso take it out and roll it in his bare hand. The girl in his group had to turn away in disgust when he and the other boy in the group cracked the ribs during the endocrine system dissection in February. Overall, Alfonso was studious, calm, and professional during the dissections all year.

Tom

At first, Tom did not touch the cat, but watched his lab partners, particularly Danielle, do most of the skinning and cutting. As the students dissected outside in late September, Tom said, "We should drape it with a sheet, so we don't see the face, or decapitate it."

In October, during the skeletal system dissection, Tom noticed that the abdomen of the cat they were dissecting looked "pushed in." He turned to Danielle at one point and said, "Did you touch it?" For the majority of the year, Tom was quiet during dissections. I usually did not hear him make any comments, but often saw him working quietly with Danielle to locate structures. He helped cut the cornea during the eye dissection, and did not seem uncomfortable with the activity.

CHAPTER IV

RESULTS

Conceptual Change

In the first section of this chapter, the results of the study are presented, specifically in answer to the first two research questions:

- 1) How do student conceptions of dissection change over the course of a school year? and
- 2) How do emotions influence a student's ability to learn concepts through dissection?

Organization

I have organized the thirteen students along a specific continuum. The student who had the most negative emotional responses to dissection, Lucy, is presented first. The rest of the students are presented in descending order, from those who had to set their emotions aside to participate in the dissections to those who did not seem to struggle with their emotions during dissection. The students, in order, are:

1. Lucy
2. Elaine
3. Christine
4. Victoria
5. Jason
6. Danielle
7. Jessica
8. Rachel
9. Emma
10. Michael
11. Carmen
12. Alfonso
13. Tom

Each student's comments from the interviews are presented verbatim, and are listed along with the five conditions necessary for conceptual change to occur (Posner, 1982). The reader is referred to Chapter I, p. 17 for an in-depth discussion of these conditions. They are:

- C1: There must be dissatisfaction with existing conditions.
- C2: A new concept must be intelligible (it must make some sense).
- C3: A new concept must be plausible (it must seem like it could be true).
- C4: A new conception should suggest the possibility of a fruitful research program.
- C5: Emotional responses must be considered as part of the learning process in dissection.

After each quote, I have listed the corresponding interview: i1, i2, i3, i4, and i5 (see Schedule and Syllabus for the dates of these interviews, in Chapter III). Conclusions pertaining to conceptual change are presented in Chapter V.

Lucy

C1: There must be dissatisfaction with existing conditions.

At the beginning of the school year, Lucy talked about how she wanted to participate in the dissections. In April, she said, "I think that, I dunno, there has to be a little bit of sympathy, but you also have to want to do it, to be able to understand it, at different levels..." (i5) In this quote we can see that her dissatisfaction with her existing conditions was connected to her belief that dissection was a useful tool for learning anatomy and physiology. She felt that she would learn more if she participated in the activity. This dissatisfaction meant that Lucy wanted to replace her old concepts about anatomy and physiology with new ones learned in dissection.

C2: A new concept must be intelligible (it must make some sense).

In exploring this condition, I looked for comments that showed how Lucy's use of her senses in dissection made concepts seem intelligible to her. After the muscular system dissection, Lucy said, "We had to feel for the muscles, and I didn't really feel well that day, so I didn't really get into it... so I just kind of stood there, and watched... but, um, it was interesting, because you could actually see like the difference in like the texture and the color..." (i3) Here we can see that Lucy saw the difference in texture and color, which were intelligible concepts, but she also just stood there and watched, which indicates the difficulty she had in setting aside her emotional reactions.

There were at least two occasions when I observed her standing to the side, and heard her explain that she did not feel well enough to participate. I asked her, "Do you think you got as much out of it, since you didn't touch it?" to which she replied, "By watching other people, not as much as if I had touched it, or felt it, but I did get something..." (i3) However, the concepts made sense to her because "you can't get much out of looking at a picture, because it's not 3-D, it's just flat, and you can't actually see it or ask questions because the diagrams are always so small, they fit on one page, so..." (i3) This kind of sensory input was important to her, and gave her a hands-on understanding of the anatomy and physiology of the cat. In another example, Lucy said:

When I have time to study, I study like the part we haven't like, done in dissection... the terminology from the book, we don't really deal with it in dissection, like we do the parts with the dissecting, so like he has those worksheets where we have the picture of the ear or whatever, and we like label it, and it's easier because you dissected a couple days ago, so you've seen it before, it's not just like a flat picture, you look at it in 3-D, you actually touch it... (i4)

In April, Lucy explained why the hands-on aspect of the dissections made the concepts intelligible to her. She believed that "just reading a book, without the whole three dimensional thing, doesn't really give you the full sense of like, awareness, and

with the cat you're hands-on, and when you're hands-on you tend to take in more with your senses..." (i5)

C3: A new concept must be plausible (it must seem like it could be true).

When I asked her what her favorite part of a science class was, Lucy said, "It's horrible, but, I like the hands-on part, being able to do what you learned, as an example, dissection..." (i1) Later in the year, she explained why:

I like the whole dissecting part, because it's hands-on, and I'm a hands-on person, and it deals with science and I love science, and I like it because like I said if you just looked at a book you wouldn't be able to really... you don't get everything just from reading or from repetition, and with the cat you actually get to be hands-on, and get in depth and involved... and people learn more when they're actually involved instead of just reading... 'cause reading it, yeah, you can store it in your short-term, but when you're really involved it's long-term... (i3)

Because she could actually touch the cat, the concepts had a plausibility that she compared with diagrams in a book. This enabled her to replace old concepts with new ones. She said:

K: Can you see how the systems function together for the cat?

L: Yes... they all connect and help each other...

K: Do you think it's the same for humans?

L: It's like, similar... if you look at the book and you look at the cat, there's definitely a lot of similarities... (i4)

Instead of relying on what the book said, Lucy was able to use her senses to figure out the concepts on her own in dissection. She explained, "I like the whole learning, hands-on, like you read about it, and then you do worksheets, and then you dissect, which gets you further involved, and it's not like you're just reading it... you're not just memorizing it, you're actually figuring out on your own, and you have the guidance if you need it..." (i4) She compared concepts she found in the book with the plausible concepts she learned in dissection.

C4: A new conception should suggest the possibility of a fruitful research program.

For this condition of conceptual change, Posner et al. (1982) meant that new concepts should suggest new research in much the same way that the scientific method should suggest future research possibilities once a hypothesis has been investigated. For this study, however, I have examined whether students felt the concepts learned in dissection would be useful to their future careers or life goals, which they talked about in the interviews. My interpretation in this study is appropriate as a measure of the importance or worth that students assigned to these concepts.

After the nervous system dissection, Lucy seemed to gain confidence in dissection. In the next interview, she said:

Science is definitely my thing, like I always thought science was my thing but now, like if I can do this, I can definitely do just about anything... I can dissect a cat, and like tear it apart, and like hold a brain in my hand... you always like, it could be worse, and there's a lot of input, I got a lot of input from dissecting the cat... like educational input... (i4)

Here we can see that Lucy began to look forward to future science experiences that would build on her experience in dissection. She recognized the educational importance of learning concepts in dissection.

In the final interview, she talked about future research or career goals related to dissection:

K: If you were going to tell a prospective student about this class, what would you say?

L: It depends on what they're doing, like, if their career goal is based on like, the class or whatever... but, um, the dissection is cool, I like it, it's definitely a great way to experience, and it can be kind of sick, but it's fun... (i5)

However, Lucy's personal career goals changed during the year and were influenced by her experience in dissection. She said:

I don't want to be a doctor anymore... just 'cause I dunno, there's, I mean the tough part doesn't bother me, 'cause everything's gonna be hard and you're not gonna get anything easy, meaning like learning everything and memorization and all that, and like the years and years and years that you have to go to school for it, but it's just I dunno, sometimes I just don't want to be put in a predicament where I have to diagnose something and I dunno if I'd be completely sure of myself... because I don't know how doctors do it they diagnose something and they're sure about it... so, like that's the reason why I wouldn't do it because I don't know my certainty level about things... (i5)

Although she talked about her confidence in her ability to dissect following the nervous system dissection, she was less confident in her ability to use the concepts learned in the medical field. A major part of the class was the completion of projects which were usually centered around a disease or disorder of the human body. But this knowledge combined with the concepts learned in dissection were not enough to instill confidence in Lucy.

C5: Emotional responses must be considered as part of the learning process in dissection.

Lucy was grateful from the beginning of the year that Mr. Gibson allowed them to just watch if they preferred: "Yeah, that I wouldn't have to like, go in, helps out a lot..."

(i1) Of the students in this study, Lucy had one of the strongest emotional reactions to the cat. In September, I asked her, "So was skinning it like what you expected?" and she replied, "No, it was easier... it was probably because I didn't have any emotional attachment to that certain cat..." (i2) During the actual dissection, I observed Lucy just watching as her two lab partners skinned the cat. She said, "I didn't think I was gonna touch it, or anything like that, I was like, it looks kind of helpless..." (i2) and she also commented, "I did a little of the cutting and ripping the fur back... it got easier, because I guess I got kind of used to it..." (i2) She felt that she had set some of her emotional reaction aside, which enabled her to participate.

Later in the year she talked about her emotions as a barrier to her learning, which she said she had advanced over: “I was kind of weirded out because I have cats, so I didn’t really touch it, and then the last thing I did was the eye, and I got into it, so, definitely, I have advanced over the whole cat thing, because it’s not my cat, it’s like separation...” (i4)

Here she characterizes her emotional reactions as primitive, or not advanced. She talks about her need to separate her feelings from the cat on the table, and the process of separation or desensitization that enabled her to continue with the exercise. When I asked her if she was ever afraid to dissect, she said: “I don’t know if it was like, fear, but I didn’t want to mess up the cutting, just the whole like, our cat just happened to be black, and I have a black cat at home, so it wasn’t like fear, it was like putting my cat in that cat, and not separating...” (i4)

By the end of the year, Lucy tried to seem desensitized to dissection, although her actions in class told a different story. Despite her claims to the contrary, I did not observe her participating in the dissections very often. Usually, she would stand to the side of her group, watching. And yet in April, Lucy said, “Oh yeah, I was actually more into it than most people... I was all right with it, it was just totally different than what I expected...” (i5)

Elaine

C1: There must be dissatisfaction with existing conditions.

Elaine talked about her interest in the dissections at the beginning of the year. She said, “I want to see what’s inside of it... I think it will be a little more exciting, and I’ll be a little more involved, and I’ll see what’s going on...” (i2) She explained, “I don’t

really enjoy science all that much, but my friends told me Anatomy was a cool class, so...I enjoy doing the animal thing, and I was like, you dissect the cat, that would be interesting, so..." (i1) Her enthusiasm was also evident in the second interview:

K: What would you say is the best part about dissection?

E: I think just opening up and seeing what's under your skin, 'cause you know, you never really get to peel back your skin... I mean, you cut yourself, but you don't like see what's underneath... I want to open it up... I'll be more interested to see the organs and stuff... (i2)

Elaine did not always participate in the dissections, although she was more directly involved than Lucy was. Following the nervous system dissection, she was still eager to learn more:

I was a little skeptical when we opened the head, because it was like, I kind of wanted to see what the brain looked like, and I kind of want to see what the inside looks like but we still, we're still not there yet, so I think I might be a little more pumped when we get to that, but it took a while because we had to do all the muscle actions and there's so many of them that it took so long... they're so hard to memorize... I thought it was okay, but like I wasn't really interested because it didn't really keep my attention, but like, I'll stay interested because I really want to cut it open and I want to see what's inside, I'm really excited about that... (i3)

In this quote, we can see that Elaine wanted to learn more, and was dissatisfied with her existing conceptions (she wanted to add to them by participating in dissection).

C2: A new concept must be intelligible (it must make some sense).

Elaine worked on dissections with her lab partner Emma, and although she tended to let Emma do most of the physical work, she always observed and made comments about what was happening. She described her sensory experience while skinning the cat: "Every once in a while we saw an artery or a vein, 'cause they dyed them or injected them... and it's kind of weird how it came off so easily, like the tissue and you just rip the tissue, I was surprised how easy it came off..." (i2)

Using her senses to explore the anatomy of the cat provided Elaine with “the value of just learning what it’s about and just knowing what’s in there... you know you can see a picture but you don’t know in your head until you actually look at it...” (i5) Here she explains that because she was able to actually look at it, the concepts were intelligible.

C3: A new concept must be plausible (it must seem like it could be true).

Like Lucy, Elaine talked about the value of viewing the anatomy of the cat directly, instead of reading about it in a book. This kind of hands-on learning was important for her to learn the concepts:

K: What has dissection taught you the most?

E: I think the hands-on learning, ‘cause I’m more of a visual learner than I am a person who takes notes and stuff, so it’s really nice to like say this is this and this is what works this, instead of like writing it on the board and like drawing it up there... it helps you learn better... (i4)

Like many other students in this study, the hands-on aspect of dissection appealed to Elaine the most. The concepts were plausible because in dissection, she could be directly involved with learning them.

C4: A new conception should suggest the possibility of a fruitful research program.

Elaine had an interest in how the human body works. In September, she told me, “I didn’t take [the class] for a specific reason, like I don’t want to be something in the medical field, but I thought it would be nice to know how the body works, when you get sick or something it’s nice to know what’s going on...” (i1)

She and her lab partner Emma, who were also friends outside of class, often talked about the diseases and disorders they learned about in Anatomy and Physiology.

However, Elaine's interest in anatomy and physiology was personal, and did not have to do with her career goals:

I'd definitely tell [a prospective student] that even though they're not going into either being a nurse or a doctor, that it's still a good class to take, 'cause you learn about yourself and your body and what goes on, I mean I want to be a teacher or a guidance counselor, but I still enjoyed the class, and he's a really good teacher and you'll learn a lot... (i5)

The new concepts she learned in dissection might not be part of her future career, but they satisfied her interest in learning about the human body.

C5: Emotional responses must be considered as part of the learning process in dissection.

In September, Elaine talked about her feelings about the cat: "I think it's weird, because like, we have cats, and it's like, we have to open one up now..." (i1) She also said, "I'm definitely comfortable with it, I don't really have like, I'm not scared to open it up at all, but I think he leads you into it and he says why we're doing this, it's not just... he also says if you don't want to do it you don't have to, so you aren't pressured into it..." (i1)

She talked about her reaction to Mr. Gibson's discussion about where the cats had come from: "We asked how they died or whatever, and he said they put them in a room and gassed them, and they suffocate to death, and that's why their faces are like that... and everyone was like, in shock... 'cause that's kind of like, torture..." (i1)

She described her experience in the beginning:

I don't know, it was a little more freakier than I expected, 'cause like, Emma dove right in there and she was rippin' the skin off... and I was just like, oh my god, like it was still like, kind of hard to get used to, 'cause Mr. Gibson just kept like, rippin' it back, and I was just like, yeah, kind of watching at first, 'cause I was a little in shock... (i2)

I asked her, “Is it easier now that it’s skinned?” and she replied, “Yeah, that was like the bridge, getting over it, and now it’s the opening of it... it won’t look as much like a cat, unless you look at the face again...” (i2) Here we can see that, like Lucy, Elaine felt that her emotional reaction was something she had to get over in order to participate in the activity.

In the final interview, she said, “I dunno, I’d rather watch than get in there, ‘cause it’s not that like, I’m wicked grossed out by it, but I think I get more out of just watching, and my partner likes to really get in there...” (i5) She also said, “It’s easier for me to watch... I think it’s nice to watch, anyway, like even if it were just Mr. Gibson, letting us watch, like I still think that’s a big thing there, and I have touched it...” (i5) These two comments indicate her strong emotional reactions to dissection, which continued to be a factor in her experience despite her belief in the value of learning the concepts.

By the end of the year, Elaine was able to talk about her ability to set aside these emotions, even though they were still present: “Everyone participates but you don’t necessarily have to touch it, you can just watch, and he respects everyone’s beliefs if you don’t want to do it, and he like pumps you for it before, and it’s okay by the end of the year, and you become like, it’s just a cat, so you’ll get over it...” (i5) Once again she characterizes emotions as something to get over.

In the final interview, she said:

I think that it’s being used as an educational tool and not as much as like a cat, I just see it as you know, this is what you’re here to learn and he points out, I mean he gets into it too, so you’re not afraid to, so I mean he rips things right out and he gets right in there, and I dunno I think he did a really good job of desensitizing, and I don’t think anything was a really big deal throughout the year... (i5)

She also said, "I had my little skeptical views about things, in the beginning, but I don't know, now it's not as big of a deal because we've like opened up the cat so many times, and I think I've gotten to where I'm doing more, and it really does help because he like points to specific examples in the cat, so, it does help..." (i4) In this quote Elaine explains that becoming desensitized to her emotions enabled her to participate in and learn from the activity of dissection.

Christine

C1: There must be dissatisfaction with existing conditions.

Christine talked about her interest in learning from the dissections early in the year:

When it first started I thought it was pretty gross... I have cats of my own and it's kind of disturbing, but I guess as it went on you just start to not think about it, you just kind of do it, and it doesn't smell, maybe because we were outside... it helped, but it didn't smell... it wasn't... as it kept going you just kind of do it and it becomes interesting... once you go, 'cause you're like oh this is what it looks like, and... your curiosity kicks in and you just keep wanting to know what it looks like... (i2)

She was eager to participate in the activity, but she also talked about her emotional conflict with the exercise:

When it first started I was really scared, I was like, and probably a lot of people haven't dissected a cat, and it's kind of scary, it's exciting, and I just think that now it's just so, I think it's fun now, it's easy and it's kind of exciting to you know, see what's going on in different systems, and all that stuff... I think it's a lot more fun than when I first started doing it, just because I'm more used to it, and now it's just another thing that you do for the class and it's part of the class, not something you always have to worry about and think about... and if you always think about it and worry about it I don't think that you'd get as far... (i4)

She talked about her dissatisfaction with existing conditions, which she indicated by her interest in learning more (replacing old concepts with new ones): "I thought the

skin part was pretty boring because it's just skin, but now if you get into muscles and bones and all that...I think it's gonna get better..." (i2)

C2: A new concept must be intelligible (it must make some sense).

For Christine, the ability to use her senses was important in learning concepts related to dissection. At first, she said, "He didn't spend too much time after we peeled back the skin or whatever, he didn't say this is this part, this is that part, I think he just wanted us to open it up..." (i2) But once she did open the cat up, it became a very sensory experience for her: "When you get to actually visualize and see it, and touch it too, I think it kind of helps, you can follow the systems and how they work and how they tie in, I definitely think you can see it..." (i4) She also said, "The eye was kind of interesting, it was really hard to get to, and it was very time consuming and annoying and frustrating, but I like the bigger stuff you can get right in and touch..." (i4) Here we can see that her senses were engaged and helped make the concepts intelligible to her.

C3: A new concept must be plausible (it must seem like it could be true).

Christine believed that the hands-on aspect of dissection could make concepts seem plausible to her. She could prove the truth of the concepts because she could actually touch and see them herself:

I think that you get a lot more out of it, and it's hands-on, so you really get to see what he's teaching instead of just having wrote about it on the board, 'cause I know a lot of students are very visual and they'd rather see it, and you learn better if you see it rather than just writing it down and taking notes on it...I think dissection kind of helps you put the pieces together... (i5)

Christine was not sure whether humans looked the same under the skin, which is a question she would answer for herself by learning concepts in dissection during the year:

K: Do you think humans look the same under the skin?

C: In some ways I guess...I hadn't thought of it... good question... yeah, I think they do... (i2)

For Christine, using a real cat to learn concepts in dissection made them seem more plausible than the use of a model:

I think in some aspects [models can be effective], 'cause if they're just anatomical models of the human I think it applies more than the cat, 'cause you get to see the sizes of the organs are different, and it's a little more real, but if you dissect a cat, the hands-on part of it is better because you get to see it and figure out how the system works, so I think that in the sense that it's not exactly built the same way as a human, it makes a difference... he uses the model a little to show like this is the liver, but he doesn't teach so much from it... (i5)

C4: A new conception should suggest the possibility of a fruitful research program.

Christine wanted to be a sports broadcaster or a journalist. She played basketball, and had a personal interest in how the human body works:

K: Why did you take this class?

C: I took it because my friends said it was a fun class, and I just have an interest in the way the human body works, and also I heard about the dissecting of the cats which I thought was kind of cool, and I might look into that, but I don't know, plus it's just good to have four years of science... (i1)

The new concepts she learned in dissection might not be part of her future career goals, but like Elaine, Christine considered her knowledge of the human body satisfactory for her own interest. She also recognized the value of four years of science as she anticipated attending college.

C5: Emotional responses must be considered as part of the learning process in dissection.

Christine had strong emotional reactions to dissection:

I don't know, I think it's weird, because I know when we first got our cats I was like, oh, I don't want one that looks like my cats, because that's so sad, and mine doesn't thankfully, but... I don't know, I just think that... it kind of intrigues me, because it's like if you grow up with cats, like I've had them all my life, and then all of a sudden to open one up and have no feelings about it..? I don't know, it's kind of weird... it's kind of like this is an animal, and like at first, sometimes it

hits you that this is a real animal, it was living, and it's like the thing that is living in my house, but I don't know, it's weird... sometimes I'm like, oh I feel so bad for the little cat... you just do, but then I guess at the same time, I think it helps knowing that it's not your own cat, that it's just somebody's that unfortunately ended up... (i3)

However, Christine seemed capable of setting her emotional reactions aside in order to learn from the experience of dissection. She said, "You don't really think about it, like once you start, you're not like, oh god, this is like my cat... you just do it, you don't think about it really..." (i1) She also said, "I tried not to look at it, I tried to just cut it open, 'cause when it first comes out of the bag it's just like this whole cat, and then as you go it just becomes, not necessarily a cat, it's just something you're doing... the face makes it worse, so I didn't look at it..." (i2) She explained, "I think that you're more like used to it, and you're not as scared to like just cut parts open, and you're used to touching the cat, you kind of get familiar with it... so it becomes a lot easier, it makes stuff go by a lot faster too..." (i4) In these quotes, we can see that unlike Elaine and Lucy, Christine was able to set her emotions aside, which enabled her to participate fully in the dissections.

When I asked her what she would tell a student who was nervous about dissection, she said:

Most people are nervous the first time, but um, try to put yourself in a group with other people that aren't so nervous so that you can, you know they can do more of the work or you can kind of sit back a little more, but really it's not that bad, you get accustomed to it after the first few times, and it becomes something that you're used to... (i5)

At the end of the year, Christine talked about her experience and her emotional desensitization. In this quote, we can see that her ability to set her emotions aside was an important part of the learning experience:

I think it varies from person to person, but for me, if someone gives you a dead cat and they're like okay, you're going to dissect this, usually your first reaction is oh my god, poor cat, it gave up its life, and I think if you start out with that mindset, you don't really appreciate what's inside, it's not really anything, when you open it up you're not like wow, this is what he was talking about, you're kind of like going through the motions and not really getting anything out of it, whereas if you're kind of emotionally attached to it you have more of an appreciation, you kind of, it means a little bit more... my feelings have faded over the year, you're not so like oh my god this is a cat, but it's something you do now, not something you think about every time you do it... there's still a part of you, even when you take it out of the bag, you're like oh poor thing, it looks so cute, and it's, whatever... (i5)

Victoria

C1: There must be dissatisfaction with existing conditions.

Victoria was an art student, who intended to become an art teacher one day. Her interest in the class was primarily to learn anatomical proportions and dimensions, which she said would help her as an artist. When I asked her in September if she was excited about the upcoming dissections, she answered, "I'm not opposed to it, but it's not going to be like, 'oh yay!'... I've thought about it before, and I knew that it would be part of this class, and it looks kind of gross, but it will be interesting seeing the inside of the body, as opposed to the pictures..." (i1) Victoria talked about her interest in the class as a way to understand more about the human body, and improve her art skills: "My goal is to be able to understand how things work better, that would be, for my art, to see connections and things would be more functional..." (i1)

C2: A new concept must be intelligible (it must make some sense).

The concepts of anatomy and physiology made sense to Victoria as she participated in the dissections. The use of her senses as part of the dissection experience was important to making the concepts intelligible. In this quote, she talks about using her

sense of sight to learn the concepts: “The worst part was getting started, the actual diving into it, but once we were into it, it was kinda cool, seeing all the insides and stuff, and our cat has a broken bone, so we got to see what that looked like...” (i2)

The concepts became more intelligible to her as the year progressed: “I thought it was awesome, especially when he had us stick the fingers in and the probes underneath the tendons and actually move the paws, and also we had a broken paw, so you could see where like things wouldn’t work, and it was really neat to see that you can look at your own and say, oh, that’s kind of how that works...” (i3) Here she talks about the use of her eyes and hands to learn concepts, and how the concepts made sense to her when she compared them with her preexisting concepts about the body.

At the end of the year she said, “The thing about the cat, you see where things are and it’s just a great tool in helping other than pictures and stuff, and yeah, illustrations are great, pictures are great, but actually being able to touch and move things around is a lot different...” (i5) Again, she talks about being able to touch the cat as an important part of learning the concepts. She also said, “Since we get to play with things, like with the muscles and stuff, the tendons, and see how they interact with all the systems we’re learning... the way they work together is even more interesting... we’re going deeper and deeper and it’s more interesting...” Here we can see that the use of her senses made the concepts more intelligible and interesting, a condition which leads to conceptual change.

C3: A new concept must be plausible (it must seem like it could be true).

Like Lucy, Victoria also mentioned figuring concepts out on her own. But for her it was more difficult, as she explained that “when he told us what to do, how to cut it, we

tried to do it the way he told us to... it's much easier than trying to figure it out ourselves..." (i2) She added:

I'm looking for the actual, like what everything looks like, the nervous system is more like impulses and internal stuff that I'm not going to be able to draw, obviously... but it's still interesting to see how things work in your body and how other people work... and you see why animals and humans act the same way, and you see why cats do what they do, and people do what they do, because like, you need sugar, you need to eat, you need to produce a substance, and it's neat seeing why... (i3)

Here, the "actual, like what everything looks like" was connected to her understanding of the mechanisms of physical systems, such as the bodies of humans and animals. These concepts were plausible once she learned them through dissection. Again, she compares her knowledge about the human body to the concepts she learned in dissection.

In an interesting comment, Victoria shows that trusting the plausibility of concepts learned in dissection was not always easy:

K: Do you think humans look the same under the skin?

V: That's actually a question we asked him the other day, if the [cat's] skin was similar to human skin, whether we had the connective tissue underneath, if it was the same thickness, and stuff, and he said he really didn't know... so, we were curious... (i2)

In this quote, we can see that there may have been some question in her mind about whether a cat was the best choice for use as a dissection specimen in a Human Anatomy class. The plausibility of the concepts may have also been questioned as a result.

C4: A new conception should suggest the possibility of a fruitful research program.

Victoria believed that she would make use of the concepts learned in this class in her future career as an artist:

I think it's going to be great, because I'm learning more like, what parts go where and why, and it's so much easier to draw them when you know why they're there... like the shape and function relates to what you're going for... (i2)

She also said:

Learning bone structures and just the whole pieces of the human body is gonna be really important to me in teaching kids how to, 'cause I want to be an art teacher, like how to put things together and orient themselves you know looking at the body, and how things bend and work, and it's just totally given me a new view of looking at people's bodies... (i5)

In these two quotes, Victoria clearly explains that the concepts she learned in dissection would be important to her in the future.

C5: Emotional responses must be considered as part of the learning process in dissection.

Although her reactions were not strong enough to prevent her from participating in the dissection, Victoria had some emotions that had to be set aside. She said: "Since we started, like the first time I prepared myself heavily, like the opening up of an animal, and it wasn't that bad, but the more and more I get into it the smell kind of gets to me, but it's still just you know, muscles and bones..." (i3) She also said, "Dissection, you know, everybody has their own views, but, you know it's not as bad as it sounds, once you start getting the cat open it really is, it doesn't get worse at all, it stays about, you know, the gross factor goes down... you get used to it, and actually you start to get interested in it..." (i5) Here we can see that she knew she would have to prepare herself to set aside her emotional responses, and that after she did so, she felt more interested in the activity:

I was very timid, and reluctant to do it, and like nervous or anxious, in a good way, because I was interested in trying it, but now it's like we've done it so many times that I don't get worked up about it like the day before, and like we get to see the insides and I like doing the insides rather than just the bones and stuff, 'cause we get to see everything inside... (i4)

Victoria had never dissected anything prior to the class. She said, "It was fun seeing all the stuff on the inside... the worst part was just thinking afterwards, you know, ew, I just cut open a cat... but it wasn't that bad..." (i2) Later in the year, she said, "I was really scared at how I was going to be cutting this open... well, now that I've done it, I feel like I've missed out from the beginning... I would definitely do it again, it's very cool to see the insides and how things work, how skeletal, muscle, endocrine, how they all work together..." (i4) In these quotes, we can see that Victoria's emotional responses were a conflicting part of her experience early in the year, but she was able to set them aside.

As the year progressed, the cat became an object to her:

I expected to be really grossed out, to tell you the truth, like, I wasn't afraid, I was just expecting the worst, that way I wasn't totally scared... once I actually started getting into it, it didn't really look like a cat, to tell you the truth... it kind of just looked like plastic or something... it doesn't remind me of the cats at home or anything... I don't really look at it as a cat anymore, it's more like a... something to practice, to play on... (i2)

She explained, "You look more at the cat as like parts, it's parts of the cat, not really a whole cat... considering it's taken apart, it doesn't have a brain, no eyeballs, tongue's ripped out of it, so, you don't really think of it as a cat..." (i4) This point of view helped her set her emotions aside, and look at the cat as an object to be learned from.

I asked Victoria if Mr. Gibson had helped her to set her emotional reactions aside, and she said, "Yeah, and he's seen so many of them, he's totally desensitized to it, and he's really good at helping desensitize people who aren't so, well-adjusted..." (i3) Victoria says that people who are desensitized are well-adjusted, which is similar to Lucy's characterization of emotion as primitive or not advanced. I asked her if Mr.

Gibson made her feel more comfortable about dissection. She answered, "Yeah... obviously if he just kinda handed them out and said, here's a grimacing cat, it's dead, it would not be so nice..." (i1) She talked about Mr. Gibson's introduction to the dissections:

I think Mr. Gibson did it in a great way where he touched upon it in the beginning but didn't really go too in depth, 'cause if you go really in depth with the moral aspect it's gonna, I don't know, upset people, but make people think more about it, whereas if you just dive right into it and not think about it too much then it's a little easier I think... and then once you're into it you can think about the moral aspects, you'll just have a totally different perspective of it... (i5)

In this way, she describes how she set her emotions aside by not thinking about them. She also said:

I think that you can get away with looking at it as just, you know, a piece of meat, I guess, you can get away with looking at it like oh this is wrong and we shouldn't be doing this, but I think that the way that I looked at it gave me an easier way of taking it apart and looking at it for what it is as opposed to what it used to be, or what it should be... (i5)

Again we can see that for her, it was easiest to avoid thinking about the cat as a living creature. In the following quotes, we can see how she concealed her emotional reactions:

K: Are you nervous about dissections anymore?

V: No, not really, not at all, now that we've done it so many times, it's gone away completely... I don't look forward to doing it, because it's kind of gross, but I'm not hesitant, and not really anxious... (i4)

K: So you allowed your emotions to be a part of this?

V: Yeah, to a certain degree, like I didn't let it, I obviously, I have cats of my own, I'm not gonna like I say go home and dissect them, but you know I do look at them and say hm, you know if I opened one of them up today... it's different, but I try not to let myself go too far into it either way... (i5)

Here she explains how she did not let her emotional responses interfere with her dissection experience. In another illustration of her desensitization, she said, "I don't

think of it as ever living, or as dying, so it's probably good in a way, not to dwell on the fact that it was..." Unlike Lucy and Elaine, Victoria participated in all of the dissections throughout the year, because she was able to set her emotional responses aside.

Jason

C1: There must be dissatisfaction with existing conditions.

Jason was very talkative during the interviews, and from the beginning mentioned his excitement about dissection. He felt that his previous experiences had not been sufficient, and he wanted to learn more:

I think [dissection] is cool, I'm really excited about it... we did a fetal pig in freshman bio, but that was more like an end-of-the-year thing, and I'm kind of excited that it's like, right now... last year when we did the fetal pig it was a one day thing, we cut the pig open, we looked through, we identified things, and that was it... (i1)

About his previous learning conditions, which he was dissatisfied with, Jason said:

Some people blow it way out of proportion, you know, the cat's already dead so there's really nothing you can do about it, so you might as well just go with it... I don't see a problem with it... that's a big part of the class I think, and I always... I moved around a lot... I've been to about 5 different school districts, and I always end up, for some reason I'm always stuck in the classes where they go, and they're like well we're gonna do something new this year, and we're not going to do as many dissections, because there's more people this year and we can't afford it, or, so many people don't like it... so I always get stuck in the one where we don't, I never got to do all the fun dissecting... the first dissection I ever did was the fetal pig last year, and that's the first one I ever did... a lot of kids do like, frogs or whatever in junior high, and get to explore things that I never got to, so... I mean, I was really excited about the cat... because the pig was just a day, and also it wasn't great, it took less than the whole class period, so I was excited that the cat was a whole year experience... (i2)

He felt that he had missed out on an opportunity by moving to different schools that did not offer dissection, and he was also dissatisfied with dissections that only last a day. The cat dissection was the reason that he was most interested in the Anatomy and

Physiology class: “Well, a lot of people are concerned about the dissection and that’s like the major reason they wouldn’t take the class, or that’s the reason they would want to take the class, but like me, that’s why I wanted to take the class, I thought that was like the best part, I think it’s fun...” (i5)

Jason expected the dissections to be a fun exploration. He said, “I really like the human body and how it works, and I’m really fascinated with that... it’s something that really interests me...” (i1) His attitude of exploration is also evident in this quote: “I wasn’t really looking (for parts), I was just about removing cat from skin...” Jason’s interest in dissection remained high throughout the year.

C2: A new concept must be intelligible (it must make some sense).

Jason also talked about the use of his senses in dissection: “Nothing I don’t like about it, um, taking the skin off and the parts inside are all, like holding them and actually feeling them... saying that these things are there is one thing, but to prove it is another...” (i1) Once Jason had located organs and structures, he matched them up with his own personal expectations: “The process of skinning it, it was basically how I thought, but the way it looked I didn’t expect it to be that way... everything was kind of gray in color and it didn’t have the appearance of like a picture, but the way we went about it... just like colors and textures weren’t what I expected...” (i2)

Overall, the dissections were enjoyable for him because he could use his senses:

K: Did you have a favorite part about it?

J: When you didn’t have to use a scalpel and you could just dig your hands right under there and pull... (i2)

Jason explained that the hands-on, physical nature of the activity was important because “you get so much more out of it, it’s physically right there in front of you, there’s

no way around it, you talk about it and then you see it, it's right there, it's like a blatant school prop, I dunno, it's the best material, you can't get any more physical than that..."

(i5)

He talked about how the concepts became more intelligible to him because he was able to manipulate parts and learn at his own pace:

I don't know, I don't like the muscle system, it's way too difficult, the terms are four feet long, and you have to remember all of them, and it's so difficult... like when you have different parts like, what is it, the um, rectus femoris, it's in like your leg, and it just doesn't sound like that's where it belongs... just weird things like that... I think I learned what I should have for this unit... the dissection was cool, I learned more from that because it shows you when you pick a muscle you can look and point to it, at that muscle... you can see how the arm, like he showed us how to put your scalpel under it and pull and see how you can move the leg or the arm, the head or whatever, and you can see exactly how it works and what it does... (i3)

He said that every time he was able to use his senses to learn the concepts his understanding was better and better:

The cat's pretty much just, it doesn't really even have a head anymore... we've taken that all apart, it's only down to like the... we've opened up the inside too, now, and looked at it... and the internal organs and all that stuff, we've gotten to see it, and you know... I think that, having taken all that apart we get to understand it better, and every time we do it we get a little better... (i4)

C3: A new concept must be plausible (it must seem like it could be true).

Once Jason could see the structures in the cat, they were plausible to him:

I like hands-on stuff... to tell me about the parts is one thing, but to show me, it makes it that much... I understand the really small, basic parts, and I think it's much more useful when you can see it right there, and like you have a cell, and it'll divide and separate and grow, and to show exactly what's happening and how it works, it makes it, it reinforces the process that much more... (i1)

He explained, "I'm more of a hands-on kind of person... to tell me about something is one thing, but to actually physically show me right there in front of me what

something is and how it works I think is a lot easier... it helps me understand better..."

(i2) He also said, "It makes it easier when you get to physically see what you're talking about, you know it's one thing to say well this is what it is in a book, but then when you actually see like what it is, it makes it..." (i4) Here we can see that Jason felt that the hands-on aspect of dissection made the concepts plausible to him.

C4: A new conception should suggest the possibility of a fruitful research program.

When I asked Jason if he was interested in dissecting in the future, he said, "I think if I ever got the opportunity I would, but I don't feel that the path of my life would lead anywhere where that would happen, but if by chance... I like it, I enjoyed it, I thought it was fun..." (i5) Here we can see that Jason did not think the concepts he learned in dissection would be useful to him in the future, although he enjoyed the activity. His interest was in becoming a music composition major, with a minor in mathematics. In terms of his future career goals, Jason said:

I always thought it would be awesome to be a plastic surgeon, but that's just not something that I think I'd want to pursue because you know the amount of time and the amount of work it would take to get so far, I don't think, personally, it's worth it, and I'm not sure if I'm up to it, like if I have the patience to make it that far, so... I probably wouldn't go there, and the class has made me think that, I was kind of iffy going into it, and now I'm pretty sure that's not going to happen... I guess you can't perform surgery as a hobby, so that would never work, but it would be fun! It's just something that's neat, and I like it, so I'll just continue to watch it on TV, I guess... (i5)

In this quote, he indicates that he may have changed his mind about becoming a doctor because of his experience in the class. However, Jason often thought of possibilities for future research:

One thing Mr. Gibson said I could do is take out, and this would be like a really cool senior project, take different parts of cats, like whatever ones they're working on, and put them in jars, for viewing, so that way you could have the

parts and when you talk about certain things, you just hold up the jar, and there you go... he thought that was a really awesome idea... (i5)

Jason explained why he had been rough with the cat during the respiratory dissection:

What I did, I took a scalpel, and I inserted it into its mouth, and it went down into and out where his trachea would have been, if I didn't already cut it in half... I just wanted to see if it could be done... kind of fooling with the cat I guess... and another thing I did, I hacked the cat's teeth apart... I wanted to see inside... I ripped them right out... the cat's fangs are nonexistent, I wanted to see... I think teeth are kind of interesting, but he never really told us much about that, like he does a little bit, but he didn't really get into the anatomy of the teeth, I dunno... dentistry, maybe that's something I should do... I guess it was just one big exploration with the cat... they wouldn't let me do what I wanted... I wanted to do a kidney transplant between my cat and Danielle's cat, but they said no... (i5)

Once again we can see that Jason thought of his experience as an exploration.

This quote also shows that Jason considered possible future research projects, even though he did not think that he would utilize the concepts he learned from the activity in his career. Most of his research ideas were specific to the class, and did not apply to other areas in his life.

C5: Emotional responses must be considered as part of the learning process in dissection.

In the following quote, we can see some of Jason's emotional response to the cat.

He talked about an idea he had for a the kidney transplant between two cats:

I asked Mr. Gibson if I could do a kidney transplant between two cats; he wouldn't let me... I wanted to take one of Danielle's cat's kidneys and put it in mine... he didn't think that was too cool... he thought it was kind of funny, but... Danielle didn't want to give me the kidney... that was last time, except I didn't really like last time, there was this stuff, I forget what it's called now, it's kind of like netting that keeps all the insides from falling out... it kind of looks like tripe, but that's not what it is... it made me angry, I wanted to just rip it out and throw it away, it was always in the way... it was useless, I wanted to just cut it off... (i4)

His emotions were expressed through in his actions in class, which were sometimes violent. Some of his comments also sounded angry. Jason was the only student who displayed this kind of emotion in class, and rather than set it aside, it seemed as if he allowed it to surface at times while he was dissecting. He did not have any emotional reactions that inhibited his participation in dissection, unlike Lucy and Elaine. He said, "It's kind of funny because as long as I can remember we've always had cats, and now I've got one on the table and I'm cutting it up!" (i3) But cutting it up did not seem to bother him, and his emotional responses did not change during the year:

K: Have you changed the way you think of the cat?

J: No, the cat is physically different, it doesn't have a head, pretty much, but um, and I don't know, not really... I have the same feeling... (i4)

In an interesting comment, Jason describes his emotional desensitization:

Yeah, definitely, like some people were all ew, that's nasty and I don't want to... I'd say that it's not a big part because most people just look at it from an analytical point of view and not really think in depth about the cat very much, I mean in the beginning, when you first start out and you've got this cat lying there dead on the table and everything is still together and there's no incisions or anything, then it's probably a little more there, because that's when people are thinking and it's all fresh and new, and they think to themselves, you know, where this cat was a few months ago before it was on the table in front of them... but once you get going, you start cutting it open and you see, it's almost as if you're playing with a toy, it's almost as if it's all plastic and kind of fake, and they color the veins and the arteries and they make it all, just make you think that it's, I guess it's kind of like you think of it as a little less than, a once living being... (i5)

Like Victoria, Jason was able to see the cat as less than a living creature, which enabled him to set his emotional responses aside during the dissections. He often appeared callous and cruel because of his behavior during the dissections.

Danielle

C1: There must be dissatisfaction with existing conditions.

Danielle was interested in a career in nursing, and her enthusiasm for the class and particularly the dissections was evident from the beginning. When I asked her what her favorite part of a science class was, she said, "The hands-on stuff, like dissection..."

(i1) Her level of interest seemed to increase as the year went on. Her average was one of the best in the class, and she used correct scientific terminology during the interviews when she talked about the concepts she was learning. Her high level of interest indicated that she was dissatisfied with her preexisting conditions and was eager to replace them with new ones.

C2: A new concept must be intelligible (it must make some sense).

Danielle talked about how the concepts became intelligible to her through dissection, although she had to set aside some emotions first: "I didn't think about it at all while I was doing it, and the whole aspect, I wasn't like, oh, I have a cat at home this is gross, it was more like, um, all right, this is a membrane, this is the system, just think about it really like, kind of technical..." (i2) She also said:

I think the first time I dissected I was really nervous about it, because I had no idea what to expect, I mean I had seen bodies and cuts and surgery and stuff, but I'd never done it myself, so I really didn't know how much pressure I was gonna put on the knife if I was gonna cut something, but now that I've kind of learned how thick things are, and how sharp blades are, I kind of have a feel for it... (i4)

Her comment about "having a feel for it" was an indication that the use of her senses was an important part of making the concepts intelligible. She added, "On the legs you could see the arteries, and we actually had to cut one to get through the skin, and he said there was something wrong with it, and visually it was just like a little tube like it

shows in the book, it's kind of cool..." (i2) Here she uses her senses, both tactile and visual, to examine the cat and compare her old conceptions with new, more useful ones.

After the first dissection, I asked her if Mr. Gibson had helped her in dissection, and she said, "Not as much as we thought he would, he just told us where to start, and there was one part where we weren't quite sure what to do so he really like got right in there and showed us what to do, and we did the rest...it was really interesting..." (i2) She said:

I thought it was going to be a lot harder than it was, like on the test where it had the origin and insertion... but it's pretty much logical, like if you think about where the muscle is and where it's attached you can understand how it works... I like the class because it incorporates physiology not just anatomy... I think because he's funny, I remember it more... he has like little stories and he's not boring about it like professional, he kind of gets on our level... that's what I love... (i3)

In this quote she notes that the concepts were logical and made sense to her, and she again mentions the importance of Mr. Gibson's ability to make concepts make sense by "getting on their level." She also said, "The first time we were in here, I had my partners do a lot of it, and Mr. Gibson had to help us a lot, and now when he tells us to make a sagittal cut or a frontal cut, we know exactly what he's talking about..." (i4) In this quote, we can see that the concepts made sense to her, and that she learned new ones from the activity.

C3: A new concept must be plausible (it must seem like it could be true).

Danielle talked about how Mr. Gibson's instruction helped her learn the concepts: "I'm excited... I don't like memorization, and dissection helps with being a visual learner... I like to understand where the organs are and why they work... and he makes lots of food references to help us remember, he likes to 'get right in there'..." (i1) Here

we can see that not only does the hands-on aspect of dissection help make concepts seem plausible, but it was also important to her that Mr. Gibson was there to provide leadership, and to help reinforce learning new concepts through his teaching.

The plausibility of the concepts was reinforced through the hands-on aspect of dissection: “We went too far at one point and we found the um... oh what is it... the serous membrane that wraps the organs and stuff and it was pretty interesting how everything was like Saran wrapped just like he said, and it was really interesting...” (i2) Mr. Gibson provided the comparison for Danielle: he said the concepts were correct, and she proved them to herself in the dissections. In another example of this, she told me:

The best thing from this class is he always goes to previous chapters and says oh, this relates to this, like, not just looking at all the systems separately, just looking at everything together, like how, like how the blood, like runs with hormones, which go to this and that, like tying it all together is the most important part, I think he’s done an awesome job doing that... (i5)

Because the concepts were plausible, she replaced old ones with new ones:

I didn’t think everything was connected as much as it is, and when we like cut through the tissue and stuff, and see all the little tubes or veins or bloodvessels or whatever, and I never knew how like intricate everything was, and I guess now that I see how like the organs all have veins going to them, and how all the systems connect... (i4)

She added:

Even smaller things that we’ve dissected I just never really realized how complicated stuff is, like we’ve had cats before, and like just little problems with their eyes, we had to put eyedrops in or something, and just learning how complicated just the eye is and then the whole system and how everything is connected and it works... (i4)

C4: A new conception should suggest the possibility of a fruitful research program.

Danielle explained why she was so interested in the dissections: “I’m a really visual, hands-on learner, and since this is like a big part of what I want to do, I think it’s

really exciting to finally start rather than just sitting in class talking about it..." (i2) She was interested in becoming a nurse, and she knew that the concepts she learned in dissection would be a significant part of what she wanted to do in the future. The dissection experience reinforced her interest and gave her confidence in her career choice, as she explained at the end of the year:

I'm against like, killing things for no reason, but I mean I think if you're going into the medical field, you have to do that, and if you're not sure, like, I wasn't 100% sure that I wanted to go into nursing before I started this class, and after seeing that I can deal with you know, cutting tissue, or getting in there and looking for something, I mean, and it's not like scaring me, by doing that I know what I want to do now, so, I love it, I have such a passion for it... (i5)

To her, the concepts were useful because of her interest in entering the medical field: "...like cats, and like fetal pigs and stuff, I think you should have to wait and choose to take that class, but I think if you're going for it, in that field, then you need that... I mean if you're gonna be like an English major, there's no reason to cut up a cat..." (i5)

She also told me:

The other day I was looking at cadaver pictures and, um, like even the cat, like the dissections of the cat, looking at pictures, like books on anatomy, versus the real, like, it's a lot different, I think you really need the real aspect, I mean I know it's kind of hard to say, in light of trying to save more cats, but I think you need it, I mean you're gonna see that if you go into the medical field, like people all cut open, so, it's good to be exposed to it, I guess... (i5)

In this quote we can see that Danielle had the ability to remain focused on her future goals, and that she knew the concepts she learned in dissection would be an important part of that future.

C5: Emotional responses must be considered as part of the learning process in dissection.

As we have seen, Danielle wanted to participate in dissection to learn concepts related to her future career goals in medicine. However, despite her high level of interest, she had some emotions that needed to be set aside to participate fully in the activity: “Before we started he brought in a bag with a cat in it, showed it to us, picked it up, so it’s not such a shock when we see the dead cat on the table...” (i1) She also said, “Well, if he didn’t agree with it, it’d be sketchy, but he’s passionate, and enthusiastic—he enforces us...” (i1) This quote again shows how important Mr. Gibson’s leadership in teaching dissection was to Danielle. She said:

You’ll feel different when you start it, I was a little nervous before we started it, but like, that stuff doesn’t really bother me, but just because I had never done it I was nervous, but one, like I mean he’ll stand right by you if you’re nervous, or like help you with the scalpel, or whatever, and once you get used to it, you’ll be in there like it’s nothing... (i5)

Here we can see that she had to “get used to” the exercise, which indicates her need to set her emotions aside for dissection. Danielle already had some exposure to dissections, which may have helped her set those reactions aside: “..it wasn’t really anything out of the ordinary and I’ve seen it done before so it wasn’t a big shock... it was on a Discovery type thing, not in person, but... and I’ve seen lots of operations and stuff, so it didn’t really gross me out as much as other people...” (i2)

In this quote, Danielle says that she tried to look at the cat objectively, and compares her dissection experience with that of a surgeon:

I try not to think about it as like, oh it’s a poor little cat, it’s like you know how in surgery they cover up the whole body, except for the part they’re working on, so that you don’t like see the face of this person, I just look at it really objectively, like it’s fine the pancreas looks like this, it should be here, and just like read down the sheet, find what we need to... (i4)

When I asked her if she thought her emotional reactions had been an important part of the learning process, she answered:

I think definitely, like, that's really important because when I first started I have to admit I was a little like, wary of cutting anything, and um, like Mr. Gibson had to help us out, but now like, I think being a doctor, you definitely have to desensitize yourself, you have to think about it as now I have to go in there and fix this or that, like not as oh this is a guy with a family what happens if I mess up, you just have to do what you have to do... I think now that I understand you can look at things like that, and it's not being like, inhumane, you're doing it because you have to, that has made me want to do nursing... (i5)

In this comment, we can see that Danielle was aware of the need to desensitize herself from her emotions to participate fully in the dissections. She added: "I think the appreciation that I gained is just as important as being able to be emotionally desensitized a little, to it..." (i5)

Jessica

C1: There must be dissatisfaction with existing conditions.

Jessica was enthusiastic about the dissections from the beginning of the year: "I was excited about it (dissection), I'm kind of into that stuff a little bit, so... I just couldn't wait to do it..." (i2) She said, "I think it was excitement for me in the beginning... nervous kind of, not really knowing exactly what the insides looked like and stuff, just kind of very excited to get going..." (i5) She commented on her dissatisfaction with previous dissections: "I think I'm just looking forward to knowing how it (the nervous system) looks... I know that impulses are sent to the brain, but I don't really know how that is, and you look at it in eighth or ninth grade, but they didn't really go into depth and tell us exactly what happens..." (i3) This dissatisfaction enabled her to replace her old concepts with new ones learned in dissection.

C2: A new concept must be intelligible (it must make some sense).

Jessica seemed to have good skills in dissection, and rarely asked Mr. Gibson for assistance. Like Danielle, she talked about the importance of Mr. Gibson's leadership in teaching dissection:

I thought it would be like, easier, to take the skin off, but he didn't really tell us like about that little cob-webby stuff, and it was interesting to have him show us different ways to skin it... (i2)

It was kind of hard to get the scalpel through and stuff, but it was fun to actually be doing it and stuff and be able to get stuff done... (i2)

He came and showed us a couple of different ways that he showed if we were going too deep, and getting into the muscle, which we were... he showed us how we can stick our hands in to push the cob-webby stuff back, that would make it a lot easier... (i2)

Once she was able to use her hands and other senses in the dissection, the concepts became intelligible. She explained, "At first you don't really know exactly how to do it, and you're worried about whether you do it right or wrong, or how deep to cut and stuff, but now you kind of know that you can't just stab into it, but you know that you can like get your hands in there and stuff...like pull things back if you need to..." (i4)

Like Lucy, Elaine, and Christine, the hands-on aspect was the most important part of doing dissections for Jessica. She felt that even middle school students should dissect because "it gives them like, early hands-on experience..." (i5) The use of her senses as part of dissection made the concepts intelligible, and facilitated conceptual change.

C3: A new concept must be plausible (it must seem like it could be true).

In the following quote, Jessica talks about how she compared the concepts learned in dissection to the anatomy and physiology of her pet cat at home. In it, we can see that

she believed the concepts she learned in dissection and replaced old concepts with new ones:

K: Do you look at your cat at home differently now?

J: Yeah, a little bit, I always seem to think of my cat here I cut open, and like wow all that stuff is in there, too... (i4)

Jessica often talked about hands-on learning, which she liked “because it will show you in detail what it looks like in real life...” (i5) She also said, “I just really like doing the dissections... dissecting the cats and stuff because it’s a hands-on experience about what it’s like, I mean we read it in the books, they show us what the muscles look like and stuff, but to get to actually see what they look like in a living thing...” (i3) Here we can see that for Jessica, the hands-on aspect of dissection made the concepts seem plausible. Because of this, Jessica did not feel the need to reinforce her learning with information from the book. She said, “... usually I don’t study... the dissection kind of like lets you see what things look like and stuff...” (i4) She also said, “For all the chapters that we’ve done, the bones and muscles and stuff, and like the digestive and nervous, it gives you hands-on, it shows you what it actually looks like in real life, like obviously it’s more and bigger and stuff in our bodies, but it’s generally what it looks like...” (i5)

Again she talks about how she compares the plausible concepts learned in dissection with her existing conceptions:

K: Could models be as effective?

J: I think it possibly could, but like then it doesn’t look exactly like it does on those torsos or whatever they are, and just like doing the cat in dissections and stuff gives you like, exactly pretty much what it looks like, and like I always thought of the appendix like it stuck out, but in the cat it’s just this little tiny loop... (i5)

She talked about the new concepts she learned, which enabled her to replace old concepts: “Before I never really thought about like, how [the cat’s] lungs have like, more lobes than we do, how everything is just put in there and stuff...I didn’t like give it a second thought, I just thought about the outside, how nice the fur looked...” (i5)

C4: A new conception should suggest the possibility of a fruitful research program.

Like Danielle, Jessica was interested in a career in medicine: “In the eighth grade I wanted to be a veterinarian, I wanted to just like help them (animals) out...I want to be a doctor now...I just really like helping people...” (i3) In a quote that is strikingly similar to one of Danielle’s (see p. 98), Jessica said, “I don’t know like, um, an English teacher probably wouldn’t be like ripping up a cat you know, but like, someone in our profession might possibly have to do that...” (i4) Here we can see that Jessica felt that the concepts she learned in dissection would be an important part of her future career goals.

C5: Emotional responses must be considered as part of the learning process in dissection.

Jessica did not seem to have any negative emotional reactions to dissection: “I really didn’t dislike anything too much, everything was fine... but looking back, I knew none of these muscles, like I knew the biceps and triceps, but like I didn’t know where they were, and I was like, I know what that does, I know where it is...it’s just, wow...” (i3) In this quote, we can see that she experienced positive emotions of wonder and joy at learning new concepts in dissection. She did not have the need to set these emotions aside, unlike Lucy, Elaine, and Christine. They were a useful and positive part of her learning experience.

However, she talked about having negative emotions about dissection prior to her experience in the class:

K: What would you tell someone who is a little nervous about the dissections?

J: I'd tell them that like, just wait until you start it, 'cause, I was excited and nervous and stuff but then like, two years ago I did not want to take the class at all 'cause I smelled it, and it was horrible, so just like to kind of take it as you go along, wait until you actually start to find out what it's like... (i5)

Here she indicates that even for someone as positive and focused as she was, there may be some emotions that still need to be set aside to enable full participation in dissection.

Like Victoria, Jessica talked about the cat as an object, and as a tool for learning, which helped her set her emotions aside. She said, "I was never really attached to it, but now I see it more as like us being able to look at like natural systems than like a cat..."

(i4) She added: "I think like we now have, like this is our cat and this is like our parts to it and stuff, it makes me miss my own cat, but um, like, I just kind of understand it more and stuff..." (i4) Her emotional reactions were set aside before she enrolled in the class, so she did not go through a similar process of desensitization during the year. Her experience in dissection was positive, and facilitated conceptual change:

I think if someone didn't have any emotions toward it at all, it would just be like there's the stomach and there's the small intestine, and like me, when we did that unit, I was like, oh, that's the stomach and that's the small intestine, and like the esophagus and the esophageal sphincter, and the other sphincters, and I was just really interested and stuff, and like I wanted to know more, about like where everything was connected and like how it was... (i5)

Rachel

C1: There must be dissatisfaction with existing conditions.

Rachel talked about her previous experience with dissection in middle school:

Well, in my middle school we did a worm and clams and things, things you can't really screw up, but um, I think it's beneficial as long as you know what's going on beforehand, like if you go in without any insight as to what's going on, completely blindfolded, you're not really going to learn anything... like if you're going straight into dissection with nothing previously about how things work and what's there, you're just gonna be like, what the heck is this... and I think that's why a lot of people are immature about it, like when they don't know anything, like, it's the people who slack off and don't know their anatomy and physiology that are just playing around, 'cause they don't know what to do... (i5)

Here we can see how Rachel talked about the dissection experience. She had prior knowledge about dissections and the human body, as we shall see. She was serious and studious about learning the concepts, and she says that it is the students who don't know what they are doing who are likely to behave in an immature fashion. Rachel often talked about her experience in dissection as a privilege, and she thought everyone should appreciate it in the same way. She was dissatisfied with her preexisting conceptions, because she wanted to replace them with new concepts she would learn in dissection.

C2: A new concept must be intelligible (it must make some sense).

Because she had some prior knowledge about anatomy and physiology, concepts made sense to Rachel from the beginning. She said:

I remember last year in biology, we dissected a fetal pig... she asked for volunteers for dissection, except there were a little too many, so we had jobs assigned to us, like dissector, helper, observer, and writers and all... and I was assigned to be a helper, but it kind of turned out that I was a dissector anyway, because there were people who don't like dissection, so... but, um... I still remember like every single part of it, because we were doing like the digestive system and you could see the liver and the larger intestine, and you could see like where the esophagus was, and it was really cool... like in the pig, it was much more like, you don't have to go through the skin and the muscles, because it's fetal, so you get to just see like the organs that are in there... so it just helped me remember like, a lot... (i2)

She also said, “I liked seeing the inside of the cat... it really helps me learn where things really are, instead of just pictures, which don’t really show you how in depth it really is...” (i2) She talked about how using her senses in dissection made the concepts intelligible to her: “When we dissect through the skin I get a lot better, but when we actually go through bone it’s still hard for me, like with the cranium I didn’t do very well, because it was hard to cut...” (i4) In this quote, we can see that when she uses her sense of touch to “dissect through the skin,” she is able to learn concepts more easily than when the procedure is difficult.

C3: A new concept must be plausible (it must seem like it could be true).

Rachel compared the concepts she learned in dissection with her preexisting concepts about anatomy and physiology:

Last year I learned a lot just by looking at the different body parts and learning about them, and it really helped to have like something in front of me to really show it, ‘cause like pictures in books are so fuzzy that, when you’re actually looking at it, you’re like, oh wow, it really does work like that... because teenagers don’t really believe teachers at first, so once they really see it... (i1)

After she compared the new concepts with her old ones, Rachel believed that they were plausible.

For Rachel, books and pictures were insufficient representations for the real thing. When I asked her if she thought models could be effective alternatives to dissection, she said, “I really don’t, it’s... the plastic models I’ve seen, and then I’ve seen the real thing, it’s just completely different... they try to replicate them but it’s just not workable, you can’t make that be the same at all...” (i5) In another quote, she talked about the importance of learning concepts in context:

I took the book home over the summer, and like it was finals and I asked if I could take a book for the summer, and I read it, and I didn’t retain like anything,

all I remember is like the thyroid gland, and then when I came to class and actually looked at it, it really helped a lot... we took the bones like out of the box, and like you know that either it's femur or it's not, but it's a lot harder because it's out of context... it's like taking one word out of a book, like a box of random bones, but when you're looking at the cat you're like that's definitely a radius or ulna... (i2)

Here we can see that the concepts were plausible once she was able to examine them in the context of a dissection specimen.

C4: A new conception should suggest the possibility of a fruitful research program.

Rachel was interested in becoming a neurosurgeon. Like Danielle and Jessica, she knew that the concepts she learned in dissection would be important to her future career. One of the top students in the class, Rachel took her role as a leader in her lab group seriously: "Lucy doesn't really like to do dissection... I'm not sure she like, supports it very much... Victoria is really kind of just a helper and I'm really the dissector..." (i2) In this lab group, I observed Rachel always taking the lead and performing the dissection while Lucy watched and Victoria assisted.

In the following quote, Rachel talks about Lucy's refusal to dissect. In it, we can see more of her serious attitude about the learning experience in dissection:

He says that if you don't want to you can watch, I mean like Lucy, she doesn't really dissect, she doesn't really like to get in there, but she'll like watch and I'll point to bones and muscles, but she doesn't really do as well, like we're reviewing with her for the test and she doesn't know like where the muscles are or anything, because we had to point at like, collages and she doesn't really know much... but Victoria and I are always like on top of it, and we know like where each muscle is and how it works and all... (i2)

Here we can see that Rachel thinks that Lucy does not know the concepts well because she refused to dissect. This suggests that in Rachel's opinion, participation in dissection is essential to learning the concepts, which she takes seriously because of her future career goal in medicine.

C5: Emotional responses must be considered as part of the learning process in dissection.

Rachel said, “I don’t think he’s trying to make you feel comfortable... no, it’s actually really abrupt I think, like here, you’re going to cut this cat open... I’m not like scared of it or anything, but for people who are, it seems like he’s doing it very... not very sensitive...” (i1) She also said, “It’s gonna happen either way the same way, but I just think it’d be a whole lot nicer if he was trying to be calming about it instead of, so, sudden...” (i1) In these quotes we can see that like Jessica, Rachel had to set her emotional responses aside prior to the beginning of dissections. She indicates that she did not feel comfortable in the beginning, even though she was not scared of cutting the cat open. She explained, “At first when I started like ripping the skin off the cat, I don’t know it seemed... I’m pretty okay with it... it’s not like a big deal to me... it’s kind of hard to do in some places, because it’s hard in some places and you have to get really into it, and it’s very one-on-one with the cat, but it doesn’t really bother me too much...” (i2) As she talks about being one-on-one with the cat, and when she says that it was hard to do in some places, we can see that despite her serious attention to learning concepts in dissection, Rachel felt some negative emotional responses that were part of her learning experience.

Rachel described some of her process of desensitization to these emotions:

It wasn’t really as much like that for me as it was for other students... like they saw it as a pet, but I really didn’t at the beginning, but... a little bit, not very much, um... I think there’s a place for emotion, and to pat the kitty, and another place to cut it up... but... at first I started joking around, like we named it, we named it Fresca, and we were like, I was like oh, what a pretty cat, I like joked around while we were cutting it open, but it was just like, it doesn’t affect me emotionally, ’cause I do see it as a learning tool, and only as that... (i5)

In the end, her ability to see the cat as an object enabled her to set her emotions aside, and learn new concepts in dissection. At the end of the year she said, "I was pretty desensitized in the first place... I really haven't changed too much because I've always thought of it as a learning tool, and I still do..." (i4)

Emma

C1: There must be dissatisfaction with existing conditions.

Emma was not academically one of the top students in class, but she was eager to learn concepts related to dissection. She said, "I like when we do like, you can be involved with it, the labs and stuff... dissection, whatever, I like being involved with it, rather than just talking, I get bored..." (i1) She also told me, "I'm more excited, because I want to see the inside, like the intestines and stuff... I'm just interested in stuff like that... it's exciting..." (i2) Here we can see her enthusiasm about learning new concepts by being involved with the dissections. This excitement continued throughout the year for Emma. When I asked her if she was looking forward to the nervous system dissection, she said, "I'm interested and I can't wait to see when we actually get the brain out, considering it's inside the skull, yeah..." (i3) I felt that her high level of interest indicated her dissatisfaction with old concepts, because she seemed so eager to replace them with new ones learned in dissection.

Emma was dissatisfied with her previous experiences with dissection because she did not like the smell of dissection:

I just remember that the smell made me sick to the point where I missed a day of school, I think it was that, I just got really nauseous, but last year I didn't have a problem with it and I don't get grossed out, so... it would be nice if it smelled really good, but... it's not as bad as it used to be before they changed it, but... (i1)

She talked about her experience with dissection in middle school:

We did frogs in sixth grade and I got seriously nauseous, and I don't know if it's because I just didn't like that stuff and then as I grew up it just doesn't bother me... (i5)

As we shall see, this negative sensory experience was a part of her learning experience in dissection, even though she was eventually able to get used to it. She wanted to replace her old conceptions of dissection with new ones that would be more useful to her.

C2: A new concept must be intelligible (it must make some sense).

For Emma, using her senses to explore the concepts was an important part of the dissection experience: "I think it was cool to see what is actually under the fur... like the cotton stuff, I was like I didn't know that's what that looked like, so... but it was cool to see what it looked like under the fur..." (i2) She added:

Sometimes we were cutting too deep, so or we couldn't cut through, or if we didn't know where to go from where we were, like when we had to cut up the arms and legs, and we had cut the stomach... and he would tell us like, that we needed to get the fur off like around the legs so we could wrap our fingers around the leg... but other than that he wouldn't so much, he'd just tell us what to do... you know, where to go from where we were... (i2)

In this quote she describes how she used her sense to touch to investigate the anatomy of the cat. She did not seem to have difficulty putting her hands inside the cat and manipulating structures, unlike Lucy and Elaine. On the other hand, Emma often talked about the smell of the dissection, which was an unpleasant sensory experience for her:

As far as dealing with it it's much easier, like I'm still not like, all day you smell, and like all I smell right now is rubber gloves and perfumes and lotion because I'm trying to get rid of the smell, but I've enjoyed it and I never had a problem with doing it, I don't get grossed out, so, learning to cut it and stuff, we learn like coronal cut or whatever, and how to keep things neat and not just chop them up, so that they fall everywhere... (i4)

In these quotes we can see how she had to set this negative reaction aside so that she could fully participate in the activity. She talked about how she had gotten used to the smell, but she still did not like it:

I don't like the smell, I'll tell you that much...I've gotten used to it, but I don't like the smell... (i4)

C3: A new concept must be plausible (it must seem like it could be true).

In the following quotes, we can see an example of how Emma's conceptions changed over the course of the year. At first, she did not seem to think the concepts were clear and plausible enough to cause conceptual change. Following the muscular system dissection, she said:

E: I can't remember if he was going to test us on it, I think we would have done it then... but I don't think you can really tell, like the layers, I mean it was just fur and then that tissue stuff...

K: So you couldn't identify much while you were doing it?

E: I couldn't, no... (i2)

She also said, "As far as the cat goes it didn't really help me learn the muscles because it, for me that's not how I learn or whatever, but... I would memorize it... I'd look at it, from a book, especially because it looked the same in the cat... it was just separated by a little piece of white whatever..." (i3) At this point, we can see that she still believed in the plausibility of the concepts presented in the book. She added, "I'm not doing the best, because I don't like to study and it's a lot of memorizing and so... the dissection doesn't really help me... well, it does, but not that I would remember it... it's like more repetitiveness works for me..." (i4)

However, by the end of the year, we can see that Emma believed in the plausible concepts she learned in the dissections, which she compared with the old concepts she learned from the book:

I think from seeing it, it helps me remember better, like if you were just to use the book and give us tests, and not see anything, and use the fake body thing, the torso, and just see it how it runs together and how it's kept together, um, like the greater omentum and like how everything is kept neat in spots, I don't know, but that helps me to see how it's all put together... that's how it's helped me... (i4)

In April, when I asked if she thought a model could be as effective, she answered, "No... I mean you can see, but as far as location goes, it's more exact in an actual animal..." (i5) Her old concepts had been replaced with new, plausible ones by this time.

C4: A new conception should suggest the possibility of a fruitful research program.

Like Danielle and Jessica, Emma was interested in a career in medicine. She told me in the interviews that she wanted to be a nurse. She said, "I want to go into the medical field, so it's interesting to see all the stuff..." (i1) She explained, "When you're in high school and you think you want to go into the medical field, it's better to look at something more realistic..." (i5) She thought that the concepts she learned in dissection would be useful to her in her future career, which made them more interesting for her to learn. This may have been part of her motivation to persevere through the smell of dissection to learn new concepts from the exercise.

C5: Emotional responses must be considered as part of the learning process in dissection.

Emma's behavior during the dissections was enthusiastic, and she usually joked and talked loudly with her partner Elaine during the dissections. In class, she did not seem to have any negative emotional reactions to dissection. However, at the end of the year, she talked about having emotional responses, which she set aside to learn concepts in dissection.

In the following quotes, we can see that over the course of the year, Emma said the dissection did not bother her. In September, she said, "He's been really easy on the

fact that you will get grossed out, and you don't have to, but make sure you're paying attention, so if I were going to get grossed out, I know I wouldn't have to cut the cat, but I don't think I will, so..." (i1) In October, she said, "It's not what I thought it would look like, but it wasn't gross or anything, it didn't bother me at all..." (i2) After the nervous system dissection in December, she said, "We had to cut up the head, which was gross, I mean it didn't really bother me, but it was gross, because you don't like, picture it, but... it was fine..." (i3) In March she said again, "It never bothered me... it doesn't bother me, I can do it... today I grossed Elaine out, 'cause we were doing the stomach, and it was just chewed up cat food basically in the stomach, it was kind of gross looking, and I was cleaning it out and she's getting, she went, oh! But it doesn't really bother me, it's gross, I know it's gross, but..." (i4) She added:

I haven't noticed in our class, no one seems to be so put out with it that they won't touch it, or won't do it... and I thought at first a lot of the girls would be, but I think once you get into it, it doesn't seem to bother you as much, so it's not as gross as it sounds... if your cat's really juicy, and they're starting to dry out, like before you took your cat out of the bag it would drip all over the place but today it's, I mean there's a few drips but it's not as juicy... (i4)

In April, during the final interview, Emma said that the dissection was not that bad: "The dissection, everybody in our class seemed to do fairly well, and even if at first they were, so far as the dissection goes, you don't really have to get into it, just watch, if you don't like that kind of stuff, but it's not that bad... you get used to it..." (i5) She notes that "some days I'm not up to touching it, but I still do..." (i5) In this quote she suggests that there may have been some emotions that she had to set aside, so that she could adjust to the fact that it was a dead cat: "I think if you get too emotional about it you're not gonna get into it and you're not gonna learn from it... and if you don't adjust to the fact that it's a dead cat, um, you're not gonna want to participate, or learn hands-on

like you can..." (i5) Here we can see that Emma thought it was important to set her emotions aside so that she could "get into it" and learn new concepts from the dissections. She explained, "I think if I didn't get into it as much as I have I wouldn't have learned as much, like if I didn't like it, I would have stayed back, I would not have gotten as much out of it as I have..." (i5) She also said, "You can't be so heartless that you'll do this to any cat or to any animal... but I think at some point you need to let go of it so you can get the most out of it for your education..." (i5) In this quote, she explains that letting go of her emotional responses to dissection was an important condition that had to be met before conceptual change could occur.

Michael

C1: There must be dissatisfaction with existing conditions.

Michael said, "I hadn't done it for the last couple of years, but when I did it before, I didn't really know what I was doing; I didn't really understand what was going on..." (i4) He also said, "We did a frog in seventh or eighth grade, but that didn't go too well, because we weren't mature enough and kids would goof around, so we didn't really get past cutting them open..." (i1) He explained, "I know all the kids in my class weren't able to handle it correctly, we didn't do anything then, we just sort of stared at it and poked it with the knives..." (i5) Here we can see that he was interested in learning new concepts in dissection, because he felt that his previous experiences were not satisfactory. His comments clearly indicate dissatisfaction with existing conditions.

C2: A new concept must be intelligible (it must make some sense).

Michael explained how the concepts made sense to him: "At first we couldn't, didn't know if where we were cutting was tissue or muscle, so he came over and showed

us a few techniques, like around the knee area, and some of the more difficult parts... he just showed us what we should do, he did it for a second, and then he let us do it..." (i2) This comment is similar to Lucy and Elaine's comments about figuring concepts out on their own, which made them more intelligible.

For Michael, the use of his senses also helped to make the concepts intelligible: "I liked how we were able to take the muscles apart and we were able to move the hands... the reason I didn't like it as much this time, I dunno, getting the skin off was kind of easy, and this was tougher and you had to get your hands in there more..." (i3) Here he mentions using his hands to manipulate structures in the cat as part of the dissection experience.

Michael talked about the hands-on aspect of dissection, which reinforced concepts he was learning in the class. He said, "I didn't like it as much then but I like it now because we're learning and we're getting more hands-on stuff and that reinforces what you're learning when it's hands-on... it definitely helps us when we go into the cat after he teaches us something..." (i4) He also said, "I think it's, that you need to reinforce what you teach through physical things... things like diagrams and stuff, it doesn't work as well as the cat would because you actually get to see it and touch it, and somehow it works with everything that's in the body..." (i5) In this quote, Michael talks about actually seeing and touching the cat, which made the concepts more intelligible to him and enabled conceptual change to occur.

C3: A new concept must be plausible (it must seem like it could be true).

Michael said:

I was a little nervous at the beginning of the year, because I thought it would be a little difficult, but I like how he has the same system, every time he starts

something new he says, he says he has the “meat and potatoes” of everything, and I liked having just to know the facts and stuff and all the other stuff that’s not really important that can confuse you, there’s none of that, you just need to know what’s on the sheets and you’re okay... (i5)

Here we can see that Michael enjoyed having the same system of learning in dissection, because he trusted that Mr. Gibson would tell him what he needed to know about the dissections (“what’s on the sheets”). I did not find any comments in Michael’s interviews that clearly showed his belief in the plausibility of the concepts, but I thought that his comment about trusting Mr. Gibson’s instruction indicated that he found the concepts plausible enough to replace his old concepts with new ones. At the end of the year he mentioned having learned new concepts: “I understand more this year how everything sort of is intertwined...” (i4) He added, “At the beginning of the year, he was sort of emphasizing how intertwined everything was in the body, like if one thing shuts down then it’s gonna affect the rest of the body... through dissection we get to see everything, how everything connects and works together...” (i4)

C4: A new conception should suggest the possibility of a fruitful research program.

Michael did not have an interest in a career in medicine, but he played football competitively and had a personal interest in learning about human anatomy and physiology. He thought that the concepts he learned in dissection would be helpful to him, even though they might not be a part of his future career goals:

You’ll get a lot out of anatomy even though it’s not one of the courses that looks as good to colleges like chemistry or physics, you learn a lot about your body that you didn’t know before... I’ve taken a lot from the class that is actually sort of helpful... (i5)

C5: Emotional responses must be considered as part of the learning process in dissection.

Early in the year, Michael talked about setting his emotional responses aside to participate in the dissections: “I wasn’t sure whether it would bother me or not since I have cats at home... but once you get in there, and you’re not really looking at it, you just focus on the area you’re working in, and you get past the idea that it’s an animal...” (i1) For him, this process of desensitization did not seem to take very long: “I don’t know why I just got past the idea, I’ve been around cats since I was a little kid, and I’ve always really liked my cats... (i2) Here we can see that he was able to separate his emotions for his pet cats from the one used in the classroom. He said, “I guess I’ve got the idea that this is just for science...” (i2) He also said:

M: I think it sort of made it worse for people in the beginning, knowing where the cat came from, and what their background sort of was, thinking about how they died sort of shocked some people, knowing they were gassed, and their faces just froze like that...

K: Did it help you to know that?

M: It didn’t bother me, really, I basically knew what happened... (i5)

The emotions he felt for his pet cats also made the dissections seem more exciting to him:

At first I wouldn’t say I was so much nervous, I was interested to see what this is gonna be like, and now I don’t get as... I still enjoy doing dissections, but I felt a little different about it at first, it was sort of, it was exciting... like this is the biggest thing we’d ever done, we had done like frogs, and fetal pigs, but of course we have cats in our house, and... (i4)

Michael also talked about how Mr. Gibson’s leadership helped students set their emotional reactions aside: “I think he sort of comforts people because he’s done this before, so if we have any problems, he’ll be there to help us, or if we don’t want to do it, he’ll probably accept that someone might not want to do it...” (i1) He does not talk

about himself in this quote, but it does indicate that Michael was aware of the potential problems that emotions might cause for students beginning the dissections.

Michael talked about the importance of being desensitized to emotional responses during dissection. In March, before the digestive system dissection, he said, “We’re getting into more, like we’re getting into different parts of the cat, it’s a little more vivid, especially like with the eye, and it’s sort of important that we’re able to handle what we’re doing, if it’s the eye or the digestive system...” (i4) Here we can see that he thought the experience was “vivid” and that it was important for emotional responses to be under control. He explained, “I think it would have been very hard for us if we weren’t able to get over the, how gross it can be at times... we’ve done this like eight times now, and it would be horrible if we had the same mental aspect as we did the first time... it’s really important to get over what you’re doing...” (i5) In this quote, Michael’s comment about “the same mental aspect” as the first time indicated that he knew his emotional responses in the beginning had to be set aside in order to participate in the dissections.

In the following quote, we can see how Michael talked about being desensitized to his emotions: “I thought I responded better than I would have; I thought it was gonna be gross and I didn’t think I would be able to do it as well as I did, but once I got doing it, it wasn’t too bad... I’m more comfortable now, because we did something... I don’t think we can get much bigger than a cat, so the next dissection won’t be as big a deal...” (i2) Now that he had his emotions under control, he thought that future dissections would not be difficult for him.

Once his emotional responses were set aside, Michael did not see the cat used in dissection as an animal any longer: “At first I felt sort of bad that we were opening up something that was probably alive a few months ago, but now I don’t look at it that way anymore... I really don’t look at it as a dead cat anymore, I see it for the learning experience in class, and for the digestive system and so on...” (i4)

Carmen

C1: There must be dissatisfaction with existing conditions.

In the first interview, Carmen talked about her interest in dissections: “I took biology last year... we dissected fetal pigs, which I thought was interesting... I liked it a lot... I’m all about the dissecting... I think it’s like the best way to learn... I like to get my hands in there... I dunno, it’s, from a book, you can’t see everything... I like dissecting...”

(i1) She explained why she wanted to participate in dissections: “I guess just to further my knowledge, to know more about the body and how it works... I’m kind of curious...”

(i1) Carmen said, “I really don’t know anything about the nervous system, which I think will be really cool to learn about... I only know the basics... I would like to get into that more, I think it will be interesting...” (i3) This quote shows how she was dissatisfied with her preexisting level of knowledge, and that expected to replace her old concepts about dissection with new ones.

C2: A new concept must be intelligible (it must make some sense).

For Carmen, the use of her senses was an important part of the learning process:

K: Was skinning the cat like you expected?

C: Oh yeah, it was definitely interesting... just how like, strong the skin was held on to the body...

K: What was the best part?

C: Just seeing how everything was connected... I think it was interesting... learning how to skin it was cool, too... (i2)

She also talked about the hands-on aspect of dissection, which helped her make sense of the concepts. She said, “I’m just a hands-on type of a student, and kids benefit from that, not so much from working with a book, I mean some kids learn from that, but you need to get it from all aspects, and touch each kid, I think is what’s most important...” (i5)

In March, she described how the concepts became more intelligible to her as she worked through the dissections:

I know, like I know how to tear away the fur from the muscles, or how to look for things, ‘cause like at first, like when I, I don’t know it just looked like a bunch of mesh, but now I can almost start to see the different organs, and you know, recognize where everything is, and I don’t know it’s just for me, somehow it’s easier, ‘cause it’s like pretty much all the same color, but for some reason it’s easier to recognize now... (i4)

Here we can see that her sense of sight was particularly important to her learning experience. Because the concepts made sense to her, we can also see that she was able to replace old ones with new ones learned in dissection.

C3: A new concept must be plausible (it must seem like it could be true).

Carmen had preexisting concepts about anatomy and physiology because she read books given to her by her mother, who was an EMT. She compared the old concepts she learned from the books with the concepts she learned in dissection. The following quote shows that she thought the new concepts were plausible: “I mean, looking at the books and everything and all the gruesome pictures is just exactly what the cats are... it’s pretty cool...” (i5)

C4: A new conception should suggest the possibility of a fruitful research program.

Carmen did not have an interest in a career in medicine. Her curiosity about the human body came from her exposure to her mother's EMT books and from her pets:

My guinea pigs died, and that was what really got me interested in like medical stuff, 'cause my guinea pigs died and I wanted to know why, and like my mom tried to explain as best she could because I was like only 5, and she gave me a medical book to look at because I was curious about the insides and I wanted to see the insides so she gave me her medical book, because she's an EMT... so it had all the pictures in it... (i3)

She was interested in the dissections, but she did not indicate whether she thought they would be important in her future. I inferred that they would be because Carmen was a dancer, and was often absent from class because she took part in dance competitions around the country. Her future career goal was to be a Rockette, like her mother had been. She had a personal interest in anatomy and physiology for that reason:

Actually I had a friend who was looking at Anatomy, and I was telling her that um, 'cause she's an athlete, I was telling her that you actually understand what your muscles do, and what you need to do to become a proper athlete and you know to get all that energy, and plus she's interested in that kind of stuff so I was explaining the cats, and you actually get to see what you're actually learning about, which she thought was pretty interesting... (i5)

C5: Emotional responses must be considered as part of the learning process in dissection.

In September, I asked Carmen if she was nervous about anything in the upcoming dissections, and she said, "The stiffness of the cat... the pig wasn't stiff, and I hate stiff things... and the wet fur, that creeps me out, but once we skin it I'll be all set... (i1) Here she mentions being fearful of the dissections, but once she began the dissections she seemed to set this emotional response aside. Although she said, "Sticking your fingers underneath the skin was disgusting..." (i2), she also said, "It was interesting, it was like a different feeling, kind of gross at first, but you got used to it..." (i2) In the following quote she talks about her process of desensitization:

K: Did the fact that it was a dead animal ever cross your mind while you dissected?

C: A little, like when we had to touch it and actually put our fingers underneath and I felt the muscles that were so stiff, you know at first, but... I got used to it... (i2)

Carmen had pet cats at home, but she thought of the cat used in dissection as an object, which aided in her process of desensitization to her emotional responses: "Like I kind of didn't think about it as my own, 'cause I have two cats at home, and I didn't think about it at all, like I try not to get a personal attachment to it... it's just like an object..."

(i5) She explained, "I guess, like I dunno, if you wanted to be a doctor you'd have to learn not to think about it so personally... it's just like an object..." (i5) She also said, "I can't understand some people, they get so grossed out and so attached, and it's like I can separate that, I don't know why that is..." (i5) Unlike Lucy, Elaine, and Christine, Carmen seemed to have a very easy time setting her emotional responses aside to participate in the dissections.

Alfonso

C1: There must be dissatisfaction with existing conditions.

Like Michael, Alfonso was dissatisfied with his middle school dissection experience:

K: What was your dissection in eighth grade like?

A: Well, that was kind of just, here's a frog and see what's inside of it, basically, 'cause it wasn't really a structured class, so it was kind of just, have fun with it... (i5)

This quote indicates that Alfonso wanted to replace his old concepts about dissection with new ones. He shrugged when he said this, as if to say that the dissection was not worth remembering. I thought that his level of interest in dissection was also an indication that he wanted to learn more: "Once you get going more and more you get

used to it, it doesn't smell as bad, it gets more interesting because you get more into elaborate systems..." (i4)

C2: A new concept must be intelligible (it must make some sense).

Alfonso talked about the use of his senses in dissection:

K: Was skinning it like you expected?

A: It was harder... it was hard kind of pulling it apart, it was a lot of work... it was harder because he explained it as, once you get into it, it will be easy to kind of pull it off, but it was tough all the way through, really... it was probably the worst part of the dissection, probably because it was so, more work out of it...

K: Did Mr. Gibson help you?

A: Not really... he did tell us to work on the feet a little more, but we basically did it on our own... (i2)

Here Alfonso mentions how he and his lab partner used their senses to figure out concepts on their own. This process made the concepts seem intelligible. He said, "It was difficult trying to locate the muscles and getting the rest of the skin back..." (i3) He added, "I like trying to find out which muscles you use to flex and extend the legs and arms, and we could actually do that, with sticking the probe in, and... that's about the only interesting, well, more interesting thing about doing that so far..." (i3) In this quote we can see that because he could actually touch the muscles and legs, Alfonso was interested in learning the concepts in dissection.

C3: A new concept must be plausible (it must seem like it could be true).

For Alfonso, the hands-on aspect of dissection made the concepts seem plausible:

"I don't mind it... I feel that you learn better if you have a hands-on perspective or a visual to look at, and doing things by yourself allows you to make mistakes..." (i1) Like Lucy, he enjoyed figuring out concepts on his own, and learning from his mistakes. He also said:

It takes a while to get used to, the smell first of all, and then... I'd say just, it's a lot easier than actually learning from the book, just learning hands-on... you get more of an understanding of where things are, like if it's in a picture in a book you say oh well, there it is, but if you actually have hands-on then you get a better understanding for it... (i5)

Alfonso compared the plausibility of the concepts he learned in books with those he learned in dissections. He said, "When we do the dissection we go over each part of the body before we dissect it, like we went through the integumentary system and we took a test on it before we dissected it... so we kind of recognize..." (i2) He also said, "I think the dissection part is a little more for memorization, 'cause like we did the muscles, we used the cats to identify and it helped us with diagrams and stuff like that..." (i4) He added, "A model only has the basic, you know it has the lungs, kidney, heart, but it doesn't have all the stuff in between, like it doesn't have the mesentery or the omentum, I mean you can find, you can locate the parts like the large intestine, but to actually see it and see actually how it is in real life, you get a better understanding..." (i5) Here we can see his belief that actually seeing the structures in dissection made them plausible and facilitated conceptual change.

C4: A new conception should suggest the possibility of a fruitful research program.

Alfonso was interested in a career in medicine. In the interviews, he did not mention his future goals, other than to tell me that he wanted to go to medical school. He knew that the concepts he learned in dissection would be an important part of his career. I also thought that he indicated this to me through his behavior in class. He was quiet and serious during the dissections, and seemed to be a natural leader in his lab group.

C5: Emotional responses must be considered as part of the learning process in dissection.

Alfonso did not seem to have any negative emotional responses to the dissections. He said that Mr. Gibson brought a preserved cat specimen to school in September, “threw it there and said this is what we’ll be doing... he had us pass it around the room and take a look at it... maybe to kind of jump into it, instead of just waiting...” (i1) He explained that Mr. Gibson told them, “If you have a problem you’re gonna have to at least learn on the cat, and you don’t have to touch it, but you have to know where all the stuff is, and that was about it...” (i5)

While Alfonso did not seem to require time to get used to dissection, he was aware that other students might have some reservations about the activity: “People have said they’re grossed out, and they don’t want to cut it...” (i1) He said, “I don’t think you can really change how people perceive things... once they have their mind set, especially about dissection, if you don’t you don’t, and if you do it, you do it... I mean no one’s gonna force you to hold a scalpel and do a cat...” (i5) In this quote, we can see that Alfonso indicates his own mind was already set before the dissections began. He explained that “the cat’s, you know, already dead, and basically, I dunno... I mean it would be good to like touch upon it the first day of class, say if anyone has a problem with it or whatever, see where everybody stands, but after that I think you’d get a good feeling for everybody...” (i5)

Any emotional responses had already been set aside. Alfonso said: “Well for me, it wasn’t really a sad thing... considering for me, we’ve basically taken everything out, and you know, handled everything, I think it’s really not that big of a deal anymore...” (i5) However, in a comment that was similar to one made by Emma, Alfonso talked about what it would be like to have a negative emotional response to dissection:

K: Would an emotional reaction change anything for you?

A: Um, it might, I mean I might not have been as much hands-on as I was, but there'd be a creepy part of it, if I did have an emotional reaction to it, I wouldn't have been as hands-on... (i5)

Here we can see that even though Alfonso did not experience a process of desensitization during the year, he was aware of the possible effect that emotions could have on his learning. He felt that emotions would be "creepy" and would prevent him from fully participating in the dissections.

Tom

C1: There must be dissatisfaction with existing conditions.

As we shall see throughout the results of this study, Tom was not like most of the students in this study. He did not seem to have an interest in the class beyond getting a grade and moving on to Chemistry his senior year, and he never showed much enthusiasm for the dissections. He represents an average student who participates in dissection because they have to for the grade, and as we will see, he did not show signs of significant conceptual change. When I asked Tom what he thought about the dissections, he said, "Not sure... I guess, just getting it over with I guess..." (i2) His responses in the interviews were short and usually did not explain much about his perspectives on the activity, although they are interesting. Tom thought that the dissections were repetitive, although he had not performed any dissections before. He said, "I'll probably remember that for a long time, that I dissected a cat, but, that's like the only thing I've dissected before so... so if somebody asked me if I've dissected before I'd say I've dissected a cat..." (i5) He added, "I liked the eye, but, a lot of the other stuff you did before, you know like you learned that stuff before in elementary school, so it's like a repeat of what you learned before... (i5) This was the only quote in which Tom expressed

dissatisfaction with existing conditions, because it was a repeat of what he learned in elementary school. However, Tom did not seem interested in learning new concepts in dissection, either. To him, the exercise was just a part of the class.

C2: A new concept must be intelligible (it must make some sense).

Like Elaine, Tom had a negative response to the smell of dissection. He said, “I don’t know, it still smells pretty bad every time we open the bag, so, I really was never freaked out by it, it was just the smell, it gets on your clothes, your hands...” (i4) His response was not strong enough to interfere with his participation in dissection, however: “It’s not that bad, I don’t think it’s bad... I never really thought it was bad... it kind of smells, like the dissection stuff, that’s the only thing that kind of sucks, but... it’s easy, yeah, I do it... (i5) This was the only time that Tom talked about the use of his senses in dissection. It was unclear to me whether the concepts were intelligible to him, because he did not explain the connection between the use of his senses and the hands-on activity of dissection, as the other students in this study did.

When I asked Tom if Mr. Gibson had helped him with the dissections, he said, “Not really, he just showed us the lines where we were supposed to cut it... he just came over and showed us how to do it, and then gave us the scalpel back...” (i1) Tom participated in the dissections in class, if somewhat half-heartedly. We can see in this quote that he either found the concepts intelligible enough to continue with the exercise, or he did not care enough to worry about learning them correctly. When I asked him if he thought a model would be as effective as the cat, he said, “It’s probably the same thing... I don’t think it would help me any more looking at the cat than looking at the book...” (i5)

C3: A new concept must be plausible (it must seem like it could be true).

I asked Tom if he was able to recall information when he dissected, and he said, “Not really... sort of, it helped I guess, but I just knew, the picture on the board really helped and that’s what we just went by...” (i2) Tom did not express much concern or interest in the concepts: “I learned a lot more of the anatomy, and like the nerves and stuff, I don’t think we’ve learned about the organs, it just gives you like a visual...” (i4) Here we can see that even though this interview took place in March, and he had been dissecting for almost a whole school year, Tom still had not learned many new concepts in dissection. In the same interview, I asked him if he understood how the systems functioned together, and he said, “Yeah... they all hook to the brain, so the brain helps it all work in the right way...” (i4) It is not possible to infer from this quote whether Tom thought the concepts were plausible, because he did not compare old concepts with new ones, as the other students in this study did. In April, I asked him what the most important concepts were that he had learned: “I dunno, like the eye and all that... I’m not really sure, I’ll probably remember all of it for a long time, yeah...” (i5)

C4: A new conception should suggest the possibility of a fruitful research program.

When I asked Tom why he had enrolled for the class, he said, “Just so I might be able to have a chance to be a doctor... this class is pretty interesting, but it’s not my favorite...” (i3) However, in March, his response was different. He said, “I don’t really wanna be, I don’t think I want to be a doctor...” (i4) I did not think that Tom believed the concepts learned in dissection would be important to his future career goals, even though he never told me what his real goals were.

C5: Emotional responses must be considered as part of the learning process in dissection.

Tom did not understand why some people might have negative emotional responses to dissections: “I don’t see why people can’t do it, like why would people be scared of blood, it’s just blood so why would they be scared of it... it doesn’t make sense, it’s like why don’t you faint when you see Kool-Aid that’s red...” (i4)

When I asked Tom if the dissections had ever made him nervous, he said, “I didn’t really care, no...” (i2) This was a typical response from Tom, but he also made an interesting comment about his experience in dissection: “It’s like when you get a pain, when you cut your finger, you feel it a lot more in the beginning, and then it goes away... it doesn’t really hurt...” (i2) Whether Tom meant emotional pain in this quote remained unclear to me, but it was the most descriptive comment that Tom made about feelings that might be associated with dissection.

Summary

In Table 4, I have listed each student and the five conditions for conceptual change as used in this study. The conditions are:

- C1: There must be dissatisfaction with existing conditions.
- C2: A new concept must be intelligible (it must make some sense).
- C3: A new concept must be plausible (it must seem like it could be true).
- C4: A new conception should suggest the possibility of a fruitful research program.
- C5: Emotional responses must be considered as part of the learning process in dissection.

I have indicated (*) whether each student illustrated these conditions, according to my observations in class and their answers to interview questions. I did so when I thought that the student’s responses were clearly representations of each condition for change. In C1, many of the students talked about how they looked forward to the

dissections, but only Jason, Jessica, Michael and Carmen also included a sense that they were dissatisfied with their previous experiences in dissection. In C2, all of the students thought that dissection was intelligible, and they all commented on the importance of using their senses as part of the activity. In C3, only Emma and Tom did not comment on whether the dissections were plausible. In C4, students who did not think that the knowledge they learned in dissection would be useful in their future career choices were Lucy, Elaine, Jason, Michael, Carmen, and Tom. Finally, in C5, I have indicated that all of the students were able to set their emotional reactions to dissection aside, except for Lucy, Elaine, and Christine.

TABLE 4: Conceptual Change Results

STUDENT	C1	C2	C3	C4	C5
Lucy		*	*		
Elaine		*	*		
Christine		*	*	*	
Victoria		*	*	*	*
Jason	*	*	*		*
Danielle		*	*	*	*
Jessica	*	*	*	*	*
Rachel		*	*	*	*
Emma		*		*	*
Michael	*	*	*		*
Carmen	*	*	*		*
Alfonso		*	*	*	*
Tom		*			*

In the next section of this chapter, the responses of students related to my five principles of ecological literacy are presented. The two parts of this thesis are connected through the descriptions of student emotional responses to dissection. In the preceding section, we saw how conceptual change was facilitated by setting emotional reactions aside during dissection. In the following section, we will see similarities in the

descriptions of emotional desensitization by students. However, the focus in this section will be not on the change in concepts, but on the potential that students have for using their emotions to develop ecological literacy.

Ecological Literacy

In this section, chapter, I present the results of the study pertaining to the third research question, “Do student experiences in dissection reflect ecological principles?”

Organization

Students are presented in the same descending order as used in the previous section of this chapter. In this section, the organization ranges from those students who I felt were more ecologically literate to those who were not as ecologically literate, according to my five ecological principles. The students, in order, are:

1. Lucy
2. Elaine
3. Christine
4. Victoria
5. Jason
6. Danielle
7. Jessica
8. Rachel
9. Emma
10. Michael
11. Carmen
12. Alfonso
13. Tom

Each student’s comments from the interviews are presented verbatim, and are listed along with my five principles of ecological literacy. The reader is referred to Chapter I, p. 33 for an in-depth discussion of the development of these principles. They are:

P1: A student should understand that he or she is connected to the nonhuman world.

P2: A student should show respect for all creatures, both human and nonhuman.

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

After each quote, I have listed the corresponding interview: i1, i2, i3, i4, and i5 (see the Schedule and Syllabus for dates of these interviews, in Chapter III). Conclusions pertaining to ecological literacy are presented in Chapter V.

Lucy

P1: A student should understand that he or she is connected to the nonhuman world.

Lucy felt a strong connection to the nonhuman world, through her pet cats. When I asked Lucy if skinning the cat was difficult, she said, "It wasn't like it was my pet, so, it wasn't really hard to cut it and rip the fur off of it." (i2) However, Lucy often talked about her own cats, and her need to separate or set aside her emotions in dissection. She said, "I wanted to do it, but the cat we picked up just kind of looked exactly like my cat, so it was kind of weird, but, I, um, this definitely helps with the test, and quizzes..." (i5)

She added:

I think just like, if we had a different cat or whatever, like a different color or whatever, then in the beginning I would have been fine, but just one that looked exactly like my cat... the whole generalization thing, where like, going to class I was excited about it and I really looked forward to it and I wanted to do it, but the only thing that really stopped me was just the similar... (i5)

When I asked Lucy if she thought it was important for kids to be around animals, she said, “Yeah I think it’s important... they learn different things when they’re around animals, like when you’re around animals you learn kindness and gentleness and responsibility, and just like, the companionship... and I always talk to my cat...” (i3) Here we can see that feelings of kindness, gentleness, and responsibility were part of her connection to her own cats.

Lucy’s connection to the nonhuman world was strong, and yet she believed her emotional responses had to be set aside to fully participate in dissections. When I asked Lucy if she could dissect a cadaver, she said she did not think she could because “I don’t know, because like, I don’t interact with animals all the time, I don’t like talk to them, but I interact with people all the time, I have like... more familiarity with people...” (i2) In this quote, Lucy says the opposite of the previous quote, in which she said she always talks to her cat. She may have contradicted herself because she wanted to appear advanced or scientific.

Another way that Lucy described her connection to the nonhuman world was in her comments about the nervous system dissection. She said, “I cut open the cat the first time we dissected, so... the only thing I felt weird about was when we had to go and cut open the brain, and... the eyes...” (i3) She added:

I don’t know, like, the whole brain thing, holding the brain in your hand, I’m kind of freaked out a little by it, ‘cause that’s a brain, and it’s scary... it makes me kind of nervous and I don’t know why... I can’t really elaborate on my feelings... it makes me feel weird to know that I’m going to be holding a cat brain, like I never realized that I would be holding a brain or an eye, or even a heart, in my hands... (i3)

She also said, “I think holding the brain... it might be difficult, but my goal is to hold it, take it out, and hold it... it’s neat, but it will also be hard, to put out your hand and

hold it... like we're ripping the cat apart..." (i3) In these quotes, we can see that Lucy projected a sense of herself onto the cat in dissection. The brain, heart, and eyes are cultural symbols of humanity, and are represented in religion and mythology around the world. Lucy felt a connection through these symbols to the nonhuman world, which was represented by the cat used in dissection.

In the following quote, Lucy describes this connection. She said, "You can see like the circle of life, how when you open up the cat, the chance of finding a dead mouse or something like that, so you can definitely see like the food chain... you can see it's not us on the table there, so you can see that humans are like more superior to them..." (i4) Interestingly, we can see here that while Lucy did feel a connection to the nonhuman world, she also believed that humans are superior to other creatures.

P2: A student should show respect for all creatures, both human and nonhuman.

Lucy showed respect for the cat used in dissection, probably because she had such a strong connection to her pet cats. She said, "Like with the cat, it's not just a whole big joke, you definitely need maturity just to sit there and dissect and actually learn from it, because rather than look at it as like a toy or whatever..." (i5) I did not observe Lucy making jokes or laughing at the cat during dissections, even when her lab partners did so. In another example, Lucy said, "I think when we get into actually cutting the organs and stuff I might be a little slow doing that just because it is, I do have a cat for a pet, but the skinning part wasn't really that bad because it wasn't, it wasn't taking apart the insides, destructing how it was..." (i2) Here we can see that Lucy believed that the dead body of the cat deserved some respect, and that she was reluctant to destroy the body by dissecting it.

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

As we have seen, Lucy had difficulty setting her emotional responses aside. However, as the year progressed, she described the cat as a tool for learning. She said, "I don't think it's a problem, it's a tool for learning, so I'm all for it...I've always been about the whole learning thing..." (i4) She also said, "With something like this, you have to get used to it, so you can actually use it for its purpose, which is just to learn..." (i4) In these quotes, we can see that Lucy thought the cat was valuable as a tool for learning. This way of thinking enabled Lucy to bypass her fear that cats were being taken from people's homes: "I kind of figured because it was like a science thing that it wasn't just, oh, rip the cat out of someone's house, you know, so I kind of figured it was like the SPCA and that cats are overpopulated..." (i5) In her comments, we can see that Lucy measured the value of the cat's life in terms of its usefulness as a tool for human learning, even though she was not able to set her emotional responses aside and treat the cat as an object during the dissections.

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only for good reason.

In examining this principle of ecological literacy, I looked for the justifications that Lucy applied to the use of cats in dissection. I felt that this was a representation of the amount of appreciation that a student had for the nonhuman world. As we have seen, Lucy felt connected to the nonhuman world through her pet cats, and we may assume that she appreciated the nonhuman world as a result. However, she often talked about an issue that the students in this class call the "overpopulation" of cats, which was a

justification for using the cats in dissection that Mr. Gibson gave the students at the beginning of the year. He told them that because there are too many cats, some end up in humane shelters, where they are killed and may be sold to schools as dissection specimens. Because her perception (reinforced through Mr. Gibson's instruction) is that many cats do not have homes, and lead lives of pain and starvation, she thinks that using them for dissection would be the lesser of two evils:

I understand the viewpoint where there are these people who are trying to like, make it so there isn't an overpopulation of animals, 'cause there's always, there's always something that's overpopulated that you have to cut back on, so it doesn't get too overpopulated... it's a responsibility but it's also a hard thing to do because of animals most people have for pets... (i2)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

Students in this study did not always express an understanding of this ecological principle. However, some students made comments that I thought indicated the potential for understanding the danger in excessive human interference with the nonhuman world. These were students who talked about larger issues connected to the dissection activity going on in the classroom. Lucy provided one of the best examples of this kind of comment:

I dunno, like, you get to look at the overall picture at a different perspective, like there's more than everything seems, and there's definitely a reason for everything, and like, cats definitely overpopulate everything, so like the whole animal control definitely needs to step up a little bit, because like if we have enough cats to like, give so many away to schools and stuff like that, then that's kind of sad, because those are cats that could be adopted but they aren't, so... that's definitely overpopulation right there... I think it's cool that, in a way, that there's more cats so that we can do this, but I also think it's kind of like, you know, kind of, not really a waste, but not really that healthy, or that... 'cause there's definitely other things... I just don't want to seem like, mean or anything when I said that... (i5)

In this quote, Lucy describes her feelings about human interference with the nonhuman world, in this case specifically having to do with the control of cat populations. In her opinion, it is the responsibility of humans to care for cats, and she shows here that she is sensitive to greater issues when she says that using cats as dissection specimens because there are too many of them is “not really that healthy.”

Elaine

P1: A student should understand that he or she is connected to the nonhuman world.

Like Lucy, Elaine felt an emotional connection to her pets at home, which she called part of her family:

I know it's already dead, but it's weird opening something up that you live with, or, it's a living thing, and it's part of your family, and then you have to cut it open and see what's going on... and the face is so freaky of it 'cause the way they gassed it and everything... the tongue is hanging out and like, the eyes, and it's scary looking... (i1)

She also said:

It would be weird not having a dog, because there's always someone there, when you're doing your homework it always comes over to you and like crumples all your papers and is like, just there, and you're not used to not having one... it's important and it also teaches you responsibility when you're younger... even if it's just like a fish, you still have to feed it... I think it's like another person in the family... you have to care for someone, even when you're little, you have to learn to take responsibility... (i3)

In these quotes, we can see that Elaine associated feelings of responsibility can care with her pets, and that she treated them as companions. Her emotional connection to them was strong, and is evident in the following two quotes:

I looked at my dog, and I was like, if they do this to dogs... and he said they do, and I was like, oh my god that's even worse... and I said would you do this to a human, and he was like, I think I would... I was like, oh my god, that's awful... (i2)

I think like, an animal, it's still hard to do an animal, let alone, it's like sitting next to your friend in class and be like, I could open you up and peel back your skin... that's like, no I couldn't do that... weird... you think about the life they've lived, and you're like, oh my god, to peel their skin back... (i2)

In April, she reflected on her emotional reactions:

I mean it's not like it's only a cat, I would never, I mean I don't think I could ever do a human, but cats are very similar in the way they look, so like, it was just like a barrier at first, but after that, it just kind of died down... I think he helped you do it, I don't think he forced anything on anyone, and I think you just become like, it's okay... because we do it so much... (i5)

Here we can see that Elaine thought that humans and cats were similar. This statement is an indication of a connection that she has made to the nonhuman world, through her relationship with her pet cats. She describes this connection as a barrier to her learning in dissection. By the end of the year, we can see that Elaine is desensitized to her emotional connections: "I definitely, you still think about your dog or your cat, or whatever, but I still think it's an educational tool and you think about it differently like nowadays, it's different..." (i5)

Elaine shows that she did feel connected to the nonhuman world in these quotes, and that she tried to set this emotional connection, which she describes as a barrier, aside to fully participate in dissection.

P2: A student should show respect for all creatures, both human and nonhuman.

As we have seen, Elaine had strong emotional connections to the cat, and described her pets as part of the family. I thought that this indicated her respect for the cat used in dissection. However, her behavior in class was not always respectful. She joked and laughed with her partner Emma during the dissections, which may have been a way for her to conceal her emotional reactions. She said, "I think we made a joke about

it after, it's not as, not dramatizing, but it's not as major as it was before, 'cause I mean if we've already opened it up, then we already know it's definitely like, we don't have to look at it like that anymore..." (i2) Here we can see that making jokes helped her see the cat as an object, which lessened her feelings of responsibility toward it. Elaine may have felt that the dissection was disrespectful to the cat, and she experienced a conflict of emotions because she had to participate in the activity.

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

Because Elaine valued her pet cats, as we have seen, it is possible to infer that she also thought the cat used in dissection was valuable as an individual entity. She felt that the cat on the table could be the same as her cats at home. She said, "When I hold my dog or cat at home, like I look at it and I'm just like, I know what's in it now, and I can visualize..." (i4) Here we can see that she applies the concepts she learned in dissection to her pets at home.

Like Lucy, she sees the value in learning concepts in dissection, and she transfers this value to the cat specimen. To participate in dissection, she separated the value of her pet cats at home as companions from the value of the cat on the dissecting tray. She measured the value of the cat used in dissection as a tool for human learning: "I don't think I see it as much as a cat anymore... it's more of a learning tool now that I see it, and think about it..." (i2) She added, "It's not as much a cat anymore, it's more of looking at what we're learning about..." (i2)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only for good reason.

Elaine talked about her need to justify dissection: "It's nice that he reiterates the fact that they're not just killed for the heck of it, you know, there's overpopulation and he's backing up his reasons, so it was nice... (i1) She added, "Like a lot of them are strays, or like, it's not just like they grab cats and then kill them... he gives you a reason, so it's nice..." (i1) In the following quotes we can see that Elaine used these justifications to resolve her emotional conflict. She said, "Well, he said there was overpopulation, I knew that they weren't just randomly being killed, so that was okay, it was a little more comforting than just saying that we take cats and kill them..." (i2) She added, "It's easier that he says that... they're not being wasted though, so they're being used for educational purposes, it's not like you're just killing it for the fun of it... it's okay..." (i2)

Here she says that she thinks the cats in humane shelters are not wasted when they are killed for use in dissection, and she says that it's okay because they are used for education. Elaine justifies killing these cats because she values the pursuit of human learning. However, she also says that if the cats were killed "for the fun of it," she would not be able to justify their deaths. This indicated her level of appreciation for the nonhuman world. For Elaine, there had to be the condition in place that there were too many cats (overpopulation), which meant the cats ended up in shelters by necessity. This justification was "a little more comforting" to her than killing cats exclusively for use in dissection. She also said:

I think that once kids realize that the cats weren't just killed for the heck of it, you know, they'll start to realize that it's okay, it's a learning tool... so I mean, he definitely pointed that out, he didn't say like, this is your cat next door, and it was out so we killed it, he definitely pointed that out just to let you know, and I think that was a good thing to know, because you know it was either, you knew the

reasons why it was killed or why it was already dead, so it kind of desensitized you a little bit... (i5)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I did not find any comments in Elaine's interviews that directly related to this principle of ecological literacy. Although most of the students in this study did not see a connection between the environment and dissection, I include this principle because I feel that it is an important part of the concept of ecological literacy as I have defined it (see Chapter II). The fact that most of these students did not see a connection indicates an area in which they can be taught, using ecological principles in science classrooms. For example, given Elaine's sensitivity to her pets, which she transferred to the cat used in dissection, I think that she would have been receptive to learning about connections she could make to specific ecological principles that strengthen relationships with the nonhuman world.

Christine

P1: A student should understand that he or she is connected to the nonhuman world.

Christine also felt a strong connection to her pet cats at home:

If it were my own cat it would be hard because... I missed one of the dissections and I had to do it in another class, and the other class, their cat looked just like mine, and it was so much harder to do it, it was so much harder because my cat's all black and this cat is all black, and I was like, I can't... it was just so much harder... you kind of put two and two together, you make the connection, and the same thing with another cat that is just a cat that you know like a friend's cat, it's kind of hard, but... (i5)

Here we can see that she transferred her emotional connections to the cat used in dissection, which made the experience difficult for her. She describes her connection to

the nonhuman world through her pet cats clearly in the following quote: “We had a lot of pets when I was little... we’re just cat people...we’re cat loving people... I’m big on cats, they’re my favorite... we talk to our cats and they talk to us... our cats have different personalities, and every animal has a different personality, and I know ours do...” (i3)

P2: A student should show respect for all creatures, both human and nonhuman.

Christine participated in every dissections, and she seemed to enjoy her experience in class. Perhaps because of her relationship with her pet cats, she demonstrated a high level of respect toward the cat used in dissection. I did not hear Christine joke about anything during the dissections. She seemed serious about the activity, and she commented on people who were not as respectful: “There are some people that are just like whatever, they’ll rip everything out, just, whatever comes out, and everything’s meant to come out, and it just doesn’t matter, and then there are some that are just like, oh I don’t want to take out its poor little liver, or I don’t want to cut its poor little lung, and all that stuff...” (i5)

Like Lucy, Christine also felt respect for the dead body of the cat, and she did not want to see it desecrated. In the following quote, Christine describes how she felt during the muscular system dissection:

I don’t know I guess, it’s kind of like he tore our cat apart... he really did, like we were just... I think it’s like, ‘cause it’s an animal, you don’t want to like pull it apart, you know ‘cause you see it and you’re like I don’t want to rip off all its fur, and like he comes over and he just rips the whole thigh off, and he’s like this is this muscle, and it’s really in here... (i3)

P3: A student should understand that the value of an animal’s life is not measured in terms of usefulness to human beings.

As we have seen, Christine felt a connection to the nonhuman world through her pet cats. She felt that the cat used in dissection was the same as her cats at home. This was an indication that she thought the cat used in dissection was valuable as an individual entity, in the same way as her cats at home. She had to set this sympathetic response aside to participate in the dissections: “I was like, oh, this is a dead animal... I don’t know, it’s weird, ‘cause you see it and you’re like, oh wow, this animal was, ‘cause it kind of looks fake, like when it first comes out it kind of looks fake, but then you have to think that this was really alive, and now it’s just dead, it’s just a dead cat... it’s weird to think about...” (i2) Once she was able to see the cat as an object, she talked about its value as a tool for human learning: “You know that there’s overpopulations of cats, like there really are cats and dogs, so many of them out there, and it’s sad, but, especially if you have your own cat, it’s really sad to think about, but, I think that it’s kind of neat at the same time that you can use an animal to learn from...” (i5)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

Christine learned to appreciate the human body from doing dissections in this class. In the following quote, she describes how she applies this knowledge to her life:

I think you kind of have a better appreciation for the systems in your body and also like the way your insides are protected, and even when we did the brain and stuff, you kind of have more appreciation for how hard it is to have a trauma to your brain or get to your eyes, shows like when people get in accidents obviously when you have like brain trauma it has to be like a really strong force because it’s so well protected, you kind of appreciate more... (i4)

It is clear in these quotes that Christine thought that the appreciation she gained for the human body was a sufficient justification for using the cat in dissection. In April, she said:

I kind of think, I think in eighth grade, seventh grade, you start learning about the different systems of the body, digestive system and respiration system, and now, like [Mr. Gibson] always says, you'll have a greater appreciation, and I think that you have a greater appreciation for the way that your human body works, I think that I surely never realized the importance of every single thing, how awesome it really is, and really everything your body can do, and I think that's something I'll take with me, just knowing that you kind of know how things work and why they work, and how they're keeping you alive, and just how your body keeps you alive... (i5)

We can see here that Christine has separated the cat from her learning, because even when she begins to talk about the cat, she immediately transfers the concept to the human body. It almost seems as if the cat is not part of her thought at this time of the year. When I asked her what values she had learned from dissection, she said:

I guess when I dissect I don't really think about like the values of what's in the cat, like the values of the liver or the heart, or anything like that, I mean you can be grateful for the heart so you can be alive, but I think that he does push a lot how much you have to value like, organs that you maybe don't think so much about like your gall bladder, or even your liver, say, and he does kind of teach you how to, or teach that everything is important in its own way, maybe not so much as like your heart or your brain or something like that, but you kind of learn that everything kind of plays a role, and it reinforces that a lot... (i5)

In these quotes, we can see that Christine thought that learning from dissection was a good reason to kill and use the cats. She was a good example of a "successful" dissection experience, on a pedagogical level. She felt a connection to the cat in the beginning, which was set aside so she could participate in the activity. She was eventually able to think of the cat as a tool for human learning. She learned to appreciate the human body, and transferred the concepts she learned in dissection to her life. She did not allow her emotions to stand in the way of her learning, although she continued to talk about them throughout the year. However, I thought that because of her sensitivity to the cat, and her strong connection to the nonhuman world, she might have been receptive to learning more about ecological principles during dissection.

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

Christine, as we have seen, did not have an unpleasant experience in dissection, and she was able to justify the use of the cats as tools for human learning. She did not think that dissection was an excessive human interference with the nonhuman world.

Christine thought that the appreciation she learned about the human body was worth the life of a cat, but I also thought that she had deeper emotional connections to the cat that could have been explored and used to develop ecological literacy. She said:

You kind of feel that you know, I think it's kind of interesting, just because you're like, here, this thing used to be living, and I think it's kind of cool that, I guess you're looking at the insides of a cat and how it works and to find out more about what humans do, and these cats, they're sacrificed so to speak to better improve human understanding and knowledge of things, and I guess I kind of look at it like that... (i5)

Victoria

P1: A student should understand that he or she is connected to the nonhuman world.

Victoria thought it was important for kids to have pets:

I think it's very important, it teaches responsibility towards other life, as far as like if you never had an animal you might not be like, social with other people ... it teaches you like, nurturing, whether you're a guy or a girl, it's like you take care of another life, you have responsibility for keeping that animal alive, although it doesn't always work out, but you're still trying, you know... and if you don't go through that then you're missing something later in life... you respond to them and they respond to you... you learn to tell if someone's angry, and you can tell when a cat's angry... you're not conversing with words, but you can definitely communicate feelings... (i3)

In this quote she talks about creating a connection to the nonhuman world, through a mutual response and communication with animals. However, like Christine,

Victoria was able to set her connection to the nonhuman world aside to participate in dissection:

I don't really look at the cat that we're dissecting as like, there's no real relationship to me for some reason, which is odd... I don't know why, but growing up with cats and like ones that you've gotten as a kitten and you've watched them grow... you learn their personalities and stuff... this cat doesn't really have a personality, so you can't really, like, you can't feel bad... (i3)

In this quote we can see that she separates the connection she felt for her pet cat from the one used in dissection. She also says that this sensation is "odd," which is interesting because it almost seems like her ability to disconnect herself from the cat used in dissection is a surprise to her. Her connection to the nonhuman world was not useful to her during dissection, because she saw the cat as an object. She explained:

I guess it's the whole life barrier, 'cause it's dead and you never met it when it was alive, maybe if it was your pet and you were dissecting your pet it would probably be different, but you don't know this cat and it's been dead since you met it, so you can't really nurture something that's already gone... you kind of disconnect yourself, and you move away from the whole nurturing aspect, as much as you go for the curiosity of it... (i3)

Like Lucy, Victoria identified with the cultural symbols of the heart, eye, and brain. She explained why she was a little nervous about this in the following quotes:

Yeah, because that's like crossing some people's boundaries, like with muscles and bones it's one thing, but messing with brains and hearts and livers, it might be a little different... (i3)

[Mr. Gibson] said we're going to be taking the eyes out, we'll be cutting them right out, and then we're gonna be fiddling around with the skull and the brain and stuff like that, which I'm a little nervous for, but I'm not freaked out... (i3)

She also said, "I don't know, maybe it's because you see a lot more symbolism of the emotions with the heart and the brain, it's more like a sacred thing, not like your bones..." (i3)

Her use of the word sacred indicates the importance of these symbols to her. Culturally, they represent the human centers of emotions, intelligence, and the soul. She transfers her connection with these symbols to the cat used in dissection.

P2: A student should show respect for all creatures, both human and nonhuman.

Victoria said, "I think that at first I was timid, and I'd poke it and prod it, but now that I'm used to it, and it really doesn't look like a cat anymore, it's a lot easier, and I'm a lot more into it, like hauling stuff out and being rough with it, not quite as rough as he is, but..." (i4) As we have seen, she was able to disconnect herself from the cat used in dissection. In the following quote, she says that she doesn't feel much respect for the cat used in dissection, because it has become an object to her:

I have a lot more respect for my cats at home, not as much respect for the piece of cat that we are still dealing with, so, the more we dissect it the rougher we're getting with it, the more we're just trying to get the parts out, look at them, we're not really concerned about stuff being in the way, like Rachel just lops off the ear 'cause it's in the way... I guess it's less respect toward that cat, but toward other cats, I look at them and go, hmmm, I know where your brain is... so I don't look at that cat like it could be my cat, but I do look at my own cat and say it could be the one on the cutting table... (i4)

When I asked Victoria what values she thought were being reinforced through dissection, she said, "Probably a respect for life... obviously you're not gonna go home and chop up your own cat, but just seeing how things work together you can appreciate your own body and other animals and it just kind of makes you think about it in general..." (i5)

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

Victoria believed that the cat used in dissection was valuable as a tool for human learning. In the following quote, she states clearly that she measures the value of the cat used in dissection in terms of its usefulness to human beings:

I think it probably gives it greater worth, 'cause you know cats, they live and they die, it's just a part of life... at least this cat is teaching us something that we normally wouldn't know, if we hadn't done it, so... it actually gives it more worth, because I don't know what the cat's life was like before, but the impression I got from Mr. Gibson was that it probably wasn't very good, considering they were gotten by the SPCA or wherever, so like I figure maybe this is its second chance to give something back, instead of being a pet or whatever... (i4)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

As we have seen, Victoria thought that human learning was a good reason to kill and use the cats in dissection. She said, "It's not a cruelty thing, we're not just taking people's pets and gassing them, and it's not like painful and stuff, it's for a good cause... the cats wouldn't be better off any other way..." (i1) She also said, "They're overpopulated, and if they're just gonna starve to death or get diseases, might as well use them for educational purposes..."(i1) In the following quote, she describes how this justification helped her see the cat as an object:

I think about it [being dead], but it doesn't plague me or anything... it died for a good cause I guess, and it would have been miserable in life, anyway, living in a shelter or whatever... like if they were just murdering people's pets then I'd have a different outlook, but... the concept of death, I don't really think of it as a dead cat, I think of it as a body we're taking apart... (i2)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

Victoria made a connection between dissection and serial killers:

I think it's probably because we are taught from a young age, things are alive and things are dead, there's no communication after an animal's not there any more, so you can't, well, it's not hurting it... I mean if you're mutilating it for no reason, that would be different, but we're doing it for a good reason—we're learning, so... I think you go into a whole other mode when you're dissecting something as to when you have a pet at home... I mean, some of those serial killers that mutilate animals and stuff like that don't have that separation... they actually say a lot of serial killers start off with animals... and if you can kill a cat you can escalate... and a lot of people actually disconnect themselves and think of people as just... pieces of meat... not living beings... (i3)

This quote shows that Victoria thinks that the separation of her emotional connection to the cat used in dissection is an important part of her learning experience. She had to believe that there was a good reason for doing the dissection (human learning). I include her comment here because it shows that she links dissection to larger issues of murder and guilt. While these are not examples of excessive human interference with the nonhuman world, I think these quotes demonstrate the possibility that she could understand these connections. About the dissection experience, she said:

I feel like a mechanic; instead of building and fixing something I'm taking it apart... yeah, I guess so, it's like a disguise, it masks you so you don't feel like it's just you picking away at this cat, you have a reason... it's different than if you were taking your own cat apart, so the lab coat makes you feel like you have a purpose to do it... (i4)

Jason

P1: A student should understand that he or she is connected to the nonhuman world.

Jason did not seem to feel a connection to the nonhuman world. He said, "I'd probably have stronger feelings towards it if it were a cadaver, 'cause that's obvious it was a human, they're a little higher up on the food chain, I guess you could say, but, not that I eat cats, but... I guess emotion is there, but it's not really..." (i5) He also said, "In

my mind I always separate them (big cats from domestic)... I know that technically they're one and the same, but to me that's kind of the same thing as when you say humans and gorillas, or apes... we're really close but at the same time we're really different... so I kind of look at the cats like that..." (i3)

Jason did not have an emotional attachment to pet cats, as many other students in this study did. To him, they were easy to separate:

I have a cat... my parents have two cats... my cat's about this big, and the cat on the table is about twice as big, so it's kind of hard to look at it as kind of... it's kind of hard to compare the two... they're both cats, but that one is like 3 times the size of my cat... and for some reason I think it would be weirder, like if we were dissecting a dog, I think it would be weirder than if we dissect a cat, because, I could be wrong, but it seems like there are way more different breeds of dogs, dogs seem to be more individuals, more closer to human form than a cat... I mean cats are just, they're all just four legged little fluffy... cats... you know, I only know a couple different breeds of cats... other than that they're just a cat, there's really no... a lot of people just sit there and you can name like different breeds and types and there's more diversity in the dog world, but cats are just cats... (i3)

In this quote, we can see that Jason thought dogs were similar to humans, and that cats are "just cats." He did not feel connected to the nonhuman world, because his focus was on his connection to humans and creatures that are similar to humans. I thought that Jason would have responded to instruction about connections to the nonhuman world, if he were taught from an ecological perspective.

P2: A student should show respect for all creatures, both human and nonhuman.

Jason's actions in class were often disrespectful toward the cat. He characterizes his own behavior as a sickness: "I just think it's cool hacking at it, but, that's my own, sickness..." (i5) He was often very rough with the cat during dissections, and sometimes he purposefully mutilated it. Because he never felt a connection to the cat, he did not have any negative emotional reactions to the exercise. He treated the cat as if it were an

object, and he did not show respect for it during dissections. He said, "I feel more like a surgeon, it's cool, you get to cut it open, the only thing is sometimes you really hack at it, whereas a surgeon, you have to be really careful how you cut and you gotta sew it back up..." (i4)

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

Jason thought the cat was valuable as a tool for human learning. He said, "I have cats and I don't think it's a problem... it's like if you kill a cow and you eat it, or a chicken, it's no different I wouldn't think, this is a cat that was going to be incinerated anyway, it was gonna die, it's just a matter of where the dead body went to, it just went to a learning experience for me and my peers..." (i4) In this quote we can see that Jason thought the cat's life was not valuable until it was used for educational purposes. He added:

I don't feel either way really, it's just... I don't know, like, I guess I'd feel different if it was my cat, but it's not... I don't really know the life story of the cat, I would assume it was a stray... it was given to an educational cause, so... I'm not like, oh poor kitty, it wasn't some little old lady's house cat, and they just burst into her door one day and took it away, slapped it on the table and said here, cut it open... I don't think it was like that... (i4)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

In the following quotes, we can see that even though Jason did not seem to have a connection to the nonhuman world, he still needed to know that there was a good reason to kill and use the cats in dissection:

I'm sure that there's common misconceptions that people, or just things that people think up in their heads and then make themselves believe is true, but I dunno at our age and our maturity level, I think that common sense should say

that this isn't, you know, if it was really that wrong they wouldn't let us do it, you know, this wouldn't be happening, especially in this country, if that was something really that unethical... I don't think that it's really a big concern, it's probably something that should be skimmed over but then move on... (i5)

I don't think that the anatomy department would give us something inhumane to dissect... so, I'm not worried about it... even if we were dissecting a cadaver, it was, they didn't just go out and kill somebody and say here, cut this guy open... it's not like that... especially a human being, if they donated themselves, that's what they wanted to do with it, and I'm sure some people will tell you the cats don't have that choice, they didn't choose to be on the table, but... (i3)

He explained, "[Mr. Gibson] told us how it was gonna go, and what we were gonna be doing... he told us that we would be dissecting it, and then he said it's like a moral issue, about the cat, that like, we didn't just kill the cat, like oh you didn't kill an animal so we can just poke and prod it..." (i1).

Jason also gained an appreciation for the human body: "Well, it kind of made me think that really, how the human body works in all these small intricate ways and how we really take it all for granted, and if we'd stop and think about what the body's doing, wow, that's a lot to handle for just one being, and it's kind of amazing..."

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

The following quote shows that Jason was aware of the ethical issues surrounding dissection. He also makes a connection between dissection and Nature. He believes that because Nature cannot control the population of cats, humans should take the excess and use them as tools for human learning. He does not think this is excessive human interference with the nonhuman world:

It doesn't bother me... I don't look at the cat on the table as something that lived in a home and ate food and walked around, comforting some little old lady... sometimes the cat is just a tool and it's almost fake... I don't know

anything about the cat, it just showed up one day in a plastic bag, so...I mean, I know in the back of my mind that it's real, but I don't think of it as that... it doesn't affect me, I'm not like, oh poor cat, and how awful... some people get upset about it, but it's not like they take 400 random cats and just say okay now you're gonna be like an anatomy prop... it's like, there's enough of them, it's like if you didn't do something like that, or like I don't think Nature can control the population of them, and be quick enough... I think when you have cats in litters, and like 5 to 12 of them at a time, it kind of, can be a problem... (i3)

Danielle

P1: A student should understand that he or she is connected to the nonhuman world.

Danielle relates the cat used in dissection to herself, which indicates a connection to the nonhuman world:

I see it as a cat but I kind of relate it to even myself, like anything, any mammal that has a body similar enough, like four legs and two eyes, look like humans, relatively like the body cavity is kind of similar, so, I guess I still think of it as like an animal, but while I'm doing it I just try to forget about like, this was once alive, I try to avoid like the emotional aspect of it... (i4)

Although she talks about this connection in this quote, Danielle did not have difficulty participating in dissections. Her experience was positive, and she was able to disconnect herself from the cat used in dissection.

P2: A student should show respect for all creatures, both human and nonhuman.

In the interviews and the classroom, Danielle showed respect toward the cat. She said:

I know like, he hasn't lessened my respect for life or anything like that...I mean I don't know, my appreciation for life has definitely gone up... I don't know, I don't pay too much attention to the small, like I pay attention to animals, but like, just a lot of the different things that we've talked about like I definitely have more of an appreciation and respect for cats, I respect them a lot more, the way everything is... (i5)

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

To Danielle, the cat was valuable as a tool for learning. She said, "I don't mind it at all... I'm pretty indifferent to it... it's good for the learning experience... after all, they're bred specifically for it, or if there's a huge overpopulation problem, then why not use them for science?" (i1)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

Danielle believed that she needed to be exposed to dissection because she was interested in a career in medicine. She said, "I don't know I just think of it as it's dead, it's not like we're hurting anything, and it's kind of sad the way they do it, kill it, but I don't know it's to further someone's knowledge and taking advantage of something that's already dead..." (i2) However, like Jason, it was important for Danielle to know that there was a good reason for killing and using the cats:

I'm not one of the people who think that like cats or animals are so much lower than humans and if we choose to use them for whatever purpose it's okay, but I mean I wouldn't do it if I didn't know that the cats are from like an overpopulated place and they're starving anyway, I guess I think that if you're gonna go into a field like mine it's important that you see the insides of stuff so that you know, and but I'm not like just go out and dissect just to do it, I'm like, do it where they have it, like at school or whatever... (i4)

Danielle also gained an appreciation for the human body. She explained:

You don't really understand like how complicated things are or how like, how organized it is in there, like you think like when I thought of like the abdominal cavity before we started I thought it was like everything all bunched together, and like if you cut it open it would all fall out, but like you really get an appreciation when you see how well the body is put together... (i5)

Like Christine, Danielle immediately transfers her knowledge of the cat to the human body:

It does a lot more for me than a flat picture in a textbook, like I never understood like, you see the picture and everything's all lined up, like you could lay it out on a tray and it would be in the right position, like the kidneys are way in the back, I never realized how tightly everything is in there, and I really have a better appreciation for like how when you fall or you get hit by a car, how like your body is made and how we are to protect it... (i4)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

In the following quote, we can see that Danielle was also able to make a connection from dissection to larger issues, in this case religion. I have included her comment here because it suggests that she would be receptive to learning about ecological principles during dissection, to help her understand these connections:

I guess Mr. Gibson did a pretty good job explaining it when someone asked like where do they get the cats, do they like pull them out of someone's yard or something, like a lot of the times, it's like cats that are starving and dying, and stuff, and they're raised for just the purpose, but like I dunno, it's kind of opinion I guess, and it's kind of where you stand on religion too, because I know people who don't believe in it because like it's God's creation or something, so, um, I don't know if you should talk about it, it might cause problems, but, the way he said it, it didn't...he just touched on it like real frankly, you know, if you're not comfortable holding the knife, if you don't want to do it you don't have to, but you should watch... (i5)

Jessica

P1: A student should understand that he or she is connected to the nonhuman world.

Jessica had a very practical outlook on dissection. She seemed content to take the dissections for what they were, at face value, and did not offer in depth explanations of her feelings. Jessica talked about her pets at home: "With my dog and my bird now, I'm thinking wow, they have the muscles as we do, like they're really similar to us, and I

never thought of that before, growing up, of anything...” (i3) In this quote, we can see that Jessica transferred her knowledge from the cat to her pets at home, but I did not think that she felt connected to the nonhuman world through them. This does not mean that she did not care about her pets; it means that she did not talk about her emotional connections during the interviews. As we shall see, her comments were often shorter than many other students in this study.

P2: A student should show respect for all creatures, both human and nonhuman.

Jessica said: “I kind of really respect cats now, especially my cat at home...” (i5) This was the only time that she mentioned respect. Jessica’s lab partner was Jason, who was often disrespectful to the cat during dissections. However, Jessica was quiet and studious in class, and I thought her behavior indicated her respect for the cat in dissection.

P3: A student should understand that the value of an animal’s life is not measured in terms of usefulness to human beings.

Although Jessica did not say that she thought the cat was valuable as a tool for human learning, I got that impression from watching her behavior in class. She was interested in a career in medicine, so she knew that the concepts she learned in dissection would be useful to her later in life. She did not seem to question the fact that the cats were meant to be used as tools for learning: “[Dissection] is just natural, so, it’s not really that big of a deal to me...” (i2) In this quote we can see that Jessica thought dissection was an acceptable fact of life.

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animal only with good reason.

Jessica thought the cats were better off being killed than living as strays:

“Obviously they were alive and stuff and most likely strays or whatever, and that’s why they killed them and stuff...” (i5) For her, dissection was a good reason to kill and use the cats. Again we can see her acceptance of this fact in the following quote: “It’s too bad that it’s dead and stuff, but you know, all things die, and it’s sad and you can’t really help it though, and stuff so, and it’s just part of the way of life...” (i2)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I could not find any quotes that indicated whether Jessica recognized the danger in excessive human interference with the nonhuman world, but considering her acceptance of the death of the cats as natural and part of the way of life, I thought that she would not see a connection here. When I asked her what she thought about how the cats died, she said, “It was sad, but it happens...” (i2) I think that instruction in ecological principles might help Jessica develop stronger connections with the nonhuman world.

Rachel

P1: A student should understand that he or she is connected to the nonhuman world.

In the following quote, we can see that Rachel identifies herself with a cadaver, and she also justifies the death of the cat used in dissection:

K: Could you perform a dissection on a cadaver?

R: Yeah, I could do it, but I think it would be a little different... when I first look at it, I’d be like oh, I’m cutting up someone’s like, husband, or wife, but then you get down to it and you realize it’s there for a reason, for you to learn...

K: How is the cat different from a cadaver?

R: I don’t know, I just think, if the cats are overpopulated anyway, and they would be suffering from starvation and I don’t know, whatever’s out there, whereas, people are... I wouldn’t donate my body, ‘cause I wouldn’t want to be diced up, but I could do it to someone else... (i2)

When she thinks about dissecting a cadaver, as we can see here, she connects herself to images of family. However, there is no connection to the cat used in dissection. Rachel was able to justify its use and see it as a tool for human learning. In the interviews, I did not sense that she felt a connection to the nonhuman world.

P2: A student should show respect for all creatures, both human and nonhuman.

Rachel was interested in a career in medicine, like Jessica and Danielle, which may have motivated her to take the dissections seriously. She said, “If they were joking about it I wouldn’t learn as much...” (i4) She also said, “I feel respect for the human body yes, but not necessarily for the cat in general...” (i4) In this quote, we can see that her sense of respect was directed at the concepts she learned, and because the cat was just a tool for human learning, she did not feel respect toward it. She explained:

You learn a lot of respect for the human body along with the animal body, it’s like, I’m crying, what does that mean... I’m hearing you talk, what does that mean, how is that working... it’s really a thing about appreciation more than anything, you really get to see how to appreciate what’s going on in your body, ‘cause it’s just natural to go without, like, uh, what is the word he uses, um, sensory adaptation, like it’s just you go without thinking, taking completely for granted, but then you look at something in anatomy class and it’s like, wow, you really appreciate what you never have before... (i5)

P3: A student should understand that the value of an animal’s life is not measured in terms of usefulness to human beings.

Rachel thought the cat was valuable as a tool for human learning:

I don’t think about it at all... I have connections to my horses and my dogs and all, but when it comes to cats, I don’t really... I’ve only had one cat before and after three days I threw it into the lake... I was really young... so, uh... it was like a really really old cat and I didn’t like it very much... but I really do like cats, but when I went into the room I don’t really have a connection... I just don’t really think that, it’s not really an animal it’s more like an object, it’s a tool more than anything... it’s not like a cuddly thing that you’re going to go home with, it’s more like a tool that you use for learning... (i2)

In this quote, we can see that she disconnects herself from the cat used in dissection, and because of this she can see it as an object. She measures the value of the cat in terms of usefulness to human beings, and she compares the cat to a plastic model and to hamburger meat in the following quote:

I don't think it's something you can tell someone, I think it's over time you learn one way or another, or you feel something or you don't... you can't tell someone not to feel or what to feel, it's just they have to learn that it's not the cat they come home to every day, and that it's a tool you are using for learning... it's just like the plastic ones he used to show us the human brain, except that it's actually real and right there in front of you... I think it's just kind of immature to relate it, to relate this cat to your own cat at home... it's just, I dunno, how do I say this, you, it's like... if you see, if you own a cow, and then you look at your hamburger the same way and you start patting that, it's just the same thing, it's... yeah it's a cow, but it's in a completely different form... it's all in context... it saddens me though, a lot of people are really interested in the human body, like I know one of my friends, she's a vegetarian, and she won't take anatomy even though she'd really like to, because of the dissection... many people are like that... (i5)

In the following quote, she says that the cat's life would have been wasted if it were not used in dissection: "We're actually doing this for a reason, we're actually learning from it, it's not a waste of a life, it would have been wasted anyway, it would have been already terminated, but we're putting it to use, taking something that would have been a waste and buried, and we're using it..." (i5)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

When I asked her why she thought Mr. Gibson took the time to tell the class where the cats came from, she said, "To make sure we know they're not stealing cats from houses and running away with them or anything..." (i1) She added, "They put them in a gas chamber, and that's why they have that look on their face... they were

suffocating...” (i1) Rachel reflected on this information: “I think that probably relaxes people, to know that they’re not their pets at home, being stolen away from children, and being cut up here, it’s people, like things that were going to be killed anyway, so I think it relaxes a lot of people knowing that...” (i5) Here we can see that it was important for her to know that the cats were killed for a good reason. She thought dissection was a justifiable use of the cats, and she did not allow her emotions to interfere with her learning. Rachel shared her view of students who refuse to dissect: “It just disappoints me that they don’t get the same feelings that I do now, like appreciation of the human body and such, whereas just because they don’t want to use this tool, it’s kind of upsetting, they don’t have the same options open to them because of their feelings...” (i5)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

In the following quote, Rachel connects her experience in dissection with difficult ethical situations that she says people should “get over” instead of worrying about:

Of course it’s okay for them to pursue alternatives, but, well, I dunno, like I’ve heard one of my friends, she’s going to college and she wants to be a veterinarian very badly and the first day they made them chop off the head of an animal or something just so like, to see if they were really gonna go through with it... it’s like, you’re gonna be in situations, so get over it... so like for my friends who don’t take it, one of my friends takes it but, to tell them that you’re dissecting cats you get this strange sort of reaction, they’re all absolutely sickened by it, they think it’s like the most disgusting thing they’ve ever heard of... it’s just amazing how many people don’t take the class just because of dissection... it’s like they’re scared of it or think it’s unjustified... it’s something you’ll always remember... (i5)

For Rachel, dissection was useful and justified as a tool for human learning, and she did not see an connection between it and excessive human interference with the nonhuman world.

Emma

P1: A student should understand that he or she is connected to the nonhuman world.

Emma said, "I'm not a deep person, I don't tend to think like that, I just kind of, whatever... um, I didn't realize how similar they were to us, so in the dissecting I've learned that we're similarly formed as they are..." (i4) In this quote, we can see that Emma made a connection between herself and the nonhuman world. She expressed it in terms of anatomical similarity:

I think a cat seems to be all mushed together, like, we have chickens, and it doesn't seem as complicated when you clean them out to eat, as the cat does, and the cat's all squished together, and to open it up and to look at it and to learn where everything is is kind of neat, because you don't really pay attention to that, and it's almost the same as you, so... it's neat to see... (i4)

In the final interview, talked more about this connection:

I learned that they're a lot like us, as far as their internal anatomy... but... and that they feel what we feel, like they feel pain, it may not be like a heartache or anything, but, as far as how everything works in their body it's the same as ours, so they're gonna react the same way we would, so if we hit them, they're gonna feel it, like if someone hits us we would feel it... (i5)

Understanding that the cat would feel what we feel is a form of connection to the nonhuman world, which could be used to develop ecological literacy. However, when I asked her if she could dissect a cadaver, she said: "Yeah, if they were dead, yeah, I think it would be, where it's a person and not a cat... I think I would be more comfortable doing it on an animal than on a person... I could do it on a person, but I think I'd be more uncomfortable with it..." (i2)

P2: A student should show respect for all creatures, both human and nonhuman.

Emma did not mention the word respect in the interviews. I thought her behavior during the dissections was often disrespectful toward the cat, because she often made jokes about the cat during dissections. However, in the following quote, Emma says that animals should be treated nicely, which shows that she is aware of the importance of treating animals with respect and feeling responsible for their care:

I do know it's a big thing, because my church I work in the nursery, so the kids, they know a lot about animals, and that's something they learn like, what's the cow say, and they'll say moo... as far as getting them to learn and memorize things, and they know you are talking about it, so I think at that age they can know what you're talking about... and it's important to know that animals should be treated nicely, so if they're raised with them they learn responsibility... (i3)

I have included this comment here because it shows that Emma thought of the cat used in dissection differently than other animals. To her, it was an object that did not require respect.

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

Emma thought the cat was valuable as a tool for learning: "I don't think anything of it, we've already like, the cat is dead, there's nothing we can do about that, and it's used for scientific things, so we can learn, and I think that's better than just throwing it away... I never, nope, not sensitive, at all, I don't care... and if that's part of me not liking animals, I don't know..." (i4) In this quote, we can see that Emma does not think the cat is valuable until it is used for human learning. She measured its value in terms of its usefulness to human beings.

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

Emma thought that dissection was a good reason to kill and use the cats. As we have seen, she thought that the cat was valuable as a tool for human learning. She said, “Lots of kids might think they were just randomly killing cats, but they’re actually taking cats who were gonna be put to sleep anyways because there’s too many cats, and nobody will take them in, so... I think that, because some people just think it’s just cats, not homeless cats, or, cats that are sick, so it helps, it helps them...” (i5) In this quote, we can see that even for a student like Emma, who did not feel a strong connection to the nonhuman world, and who did not experience negative emotional reactions to dissection, it is still important to have a justification for killing and using the cats in dissection.

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I could not find any comments from Emma that relate to this principle of ecological literacy.

Michael

P1: A student should understand that he or she is connected to the nonhuman world.

Michael had pet cats at home, but he was able to separate them in his mind from the one used in class:

I think I can handle it... I have a lot of cats and I like cats, but I think when you’re in class you’re getting all this information but you can’t relate it to anything, and then doing dissections, you can see where things are and how they are working, so you get a better picture... people just have to get past the idea that you’re cutting something open and enjoy it for the better of the class... (i1)

Michael said that his connection to cats made the dissection more interesting for him. I asked him if he thought using a model would be as effective:

It would be effective, but it wouldn’t be as interesting, and usually to reinforce something it needs to have... in psychology they say that for a person to really

learn something and to have it stick they need to have some sort of connection to it, or have some sort of deeper interest into it, and I think staring at a model for a while doesn't really have the same effect as the cat would... it's more interesting because a lot of us have cats... I've got kittens now... (i5)

Here we can see that Michael did have a connection to the nonhuman world, through his pet cats, but it did not make the experience difficult for him, as it had for Lucy and Elaine.

P2: A student should show respect for all creatures, both human and nonhuman.

Michael's behavior was respectful toward the cat during dissections. He was quiet and worked steadily in class. He compared his experience in this class with his middle school dissection:

M: Kids were laughing when they picked out their cats, or like, this cat is cute, but nothing like throwing stuff around or mutilating the cat...

K: Did they do that in seventh and eighth grade?

M: Yeah...

K: Did you?

M: No, I was one of the more mature ones... (i2)

He added:

I do still see some people kind of poking around at it... they'll still poke around a little bit, but I mean they'll still get done what they need to get done... kids [this year] were able to handle it a little more maturely, they actually did clean up time, before we didn't do that... and we actually took something from it instead of thinking oh, this is just a dead animal we're poking at... (i5)

In these quotes, we can see that Michael felt respect for the cat, and that he equates this with maturity. He was disappointed with his middle school dissection experience because students behaved disrespectfully toward the cat.

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

Because he was able to see the cat used in dissection as a tool for learning, Michael measured its value in terms of its usefulness to human beings. He said, “I see it as more a learning thing for us than as a cat...” (i2) He also said, “I used to like cats a lot, but it doesn’t really bother me, I know it’s just for school and for learning, so that’s why it doesn’t really bother me...” (i3)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

As we have seen, Michael thought dissection was a good reason to kill and use the cats. He also talked about learning to appreciate the human body as a result of doing dissections:

At the beginning of the year, he was sort of emphasizing how intertwined everything was in the body, like if one thing shuts down then it’s gonna affect the rest of the body... through dissection we get to see everything, how everything connects and works together, and now I sort of have more of an appreciation about how everything works in our body... (i4)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I could not find any comments from Michael that relate to this principle of ecological literacy.

Carmen

P1: A student should understand that he or she is connected to the nonhuman world.

When I asked Carmen why she thought some students might have trouble doing dissections, she said, “Because we all have pets at home, especially cats...” (i2) She explained, “I tried not to look at it... until like the end... ’cause I didn’t want to like, think about it the whole time... kinda creepy... because we all have pets at home, especially

cats...I have two... it doesn't really affect me..." (i2) In this quote, we can see that her connection to her pet cats made her feel "creepy" about the dissection. This indicates her ability to connect herself to the cat in class, through this relationship with her pets.

However, she also says that this connection doesn't really bother her, and she is able to separate the cat used in dissection and treat it like an object.

P2: A student should show respect for all creatures, both human and nonhuman.

Carmen did not mention the word respect during the year. She treated the cat as an object: "Just look at it as like a doll, like an object... I think it's easier too now that we've opened it up and you have the flaps open, and the skin, and you don't really look at the face... it's just a doll, it's an object..." (i5) She says here that she doesn't look at the face, presumably because that would cause her to feel an emotional connection to the cat. Instead, she ignores the face and treats the cat as an object that does not require respect.

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

Carmen talks about killing the cats for use in dissection as torture, which indicates that she might think they are valuable as individual entities that can feel pain. However, she thinks the cat is more valuable as a tool for human learning: "I kind of look at it as educational and less of a torture thing... I think some people think of it as torturing the cats, but I think it's more just for our knowledge and education... I look at it that way..."

(i2)

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

Carmen thought that human learning was a good reason to kill and use the cats. Even though she was able to see the cat used in dissection as an object, she still needed to have a justification for their deaths: “I mean these cats, he explains how these cats are overpopulated and I dunno...I guess, that we weren’t just taking them from someone’s house and killing them...” (i5)

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I could not find any comments from Carmen that relate to this principle of ecological literacy.

Alfonso

P1: A student should understand that he or she is connected to the nonhuman world.

Alfonso’s comments in the interviews were brief, and he did not elaborate on his feelings about the cat. Even when I probed with different questions, he still did not offer many in depth responses during the interviews. Because of this, I cannot be sure about his feelings or connections to the nonhuman world. I did not find any comments that related to this principle of ecological literacy.

P2: A student should show respect for all creatures, both human and nonhuman.

Alfonso said, “I think a lot of people are nervous about [doing dissections], they don’t want to because it’s a dead animal...” (i1) He also said: “Well, some people think you’re still kind of toying with it, and that it’s not respectful, but I mean some people like animals a lot, I mean I love animals, but if it’s dead, then it doesn’t really matter in a way...” (i2) To him, a dead animal does not require respect. However, his behavior in

class was not disrespectful. I thought this was because he had an interest in a career in medicine, so he valued the concepts he learned in dissection.

When I asked him if he thought a model could be as effective, Alfonso answered, “I suppose... it probably would be, but I guess the kids or whoever’s taking it wouldn’t have the respect they would for sort of a live animal, or a real animal...” (i5) Like Rachel, Alfonso respected the concepts he learned in dissection, rather than the individual cat. He said that dissection “taught me to respect the body more and get to know the systems of the body well...” (i4)

P3: A student should understand that the value of an animal’s life is not measured in terms of usefulness to human beings.

Alfonso’s comments during the interviews were short, and he did not offer much detail about his opinions and feelings. In his case, I had to rely on my observations of his behavior during the dissections and my relationship with him in class (outside of the interviews). Because he was always involved with the dissections, he took the lead in his lab group and did most of the cutting and identifying, and he did not make jokes or appear to be off-task for any period of time during the dissections, I felt that Alfonso valued the learning experience of dissection. His interest in medicine seemed sincere, and contributed to his studious attitude in class. Based on this knowledge, I thought that Alfonso would measure the life of the cat used in dissection in terms of its value as a tool for human learning.

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

As I have already stated, Alfonso did not talk at length in the interviews about his feelings. However, I felt that because of his interest in medicine and his serious attitude toward dissection, he would agree with other students in this study by saying that human learning was a good reason to kill and use the cats in dissection.

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I did not find any comments in Alfonso's interviews that relate to this principle of ecological literacy.

Tom

P1: A student should understand that he or she is connected to the nonhuman world.

Tom's comments about death were unique in this study. He did not feel a connection to the nonhuman world, and he tried to distance himself as much as possible from the cat used in dissection. He said, "Pretty weird dissecting a cat, it's a dead thing, but it doesn't really matter... I wasn't really grossed out by it, I just don't really like dead things, feels like they're rotting you know... and you don't really want to touch them..."

(i1)

He added: "It wasn't a problem, it's just, they're decaying, it seems like, I don't really want to touch it... (i1) it just felt like I was cutting something up... I guess it felt like meat or something..." (i2)

I asked him what specifically bothered him about dissecting: "I don't know, just like, getting dirty... it smelled really bad, so, that's about it... it looked like meat... like steak, and pink... I think it's gonna be dirty after it's been inside that bag..." (i2)

K: Does that bother you?

T: Yeah... like, isn't it decaying?

K: I think they inject it with preservative...

T: It's decaying still... (i2)

Tom's aversion to the idea that the cat was rotting and decaying did not diminish throughout the entire school year. He said, "It wasn't bad today, but eventually it will be pretty bad... I'm guessing it will just rot away or something... there'll be like gangrene everywhere, and like green stuff... it wasn't that bad... kind of disgusting, though, it's getting really old..." (i3)

His comments were as graphic toward the end of the year: "It's rotting... it's pretty bad... there's like no skin on it... it doesn't look like a cat anymore..." (i4)

K: Did you ever feel nervous about doing the dissection itself?

T: Yeah, the eyeball one, I didn't like it...

K: How about the digestive system? Are you looking forward to that one?

T: I don't know... it's probably gonna be rotted... (i4)

Tom also made a comment about AIDS:

K: Do you think teachers should talk about the ethical aspects of dissection?

T: Nah, as long as it's clean and stuff, and they didn't like, have AIDS or anything... or like, I dunno, diseases that you can get from an infection... (i5)

In all of these quotes, we can see that Tom obviously did not feel connected to the cat. He felt repulsed and disgusted by it, even though he said it did not bother him.

During the dissections, he did participate, but I also frequently saw him standing to the side, content to allow his lab partner Danielle do most of the cutting. In the following interview, Tom explains more about his feelings:

K: So what specifically about it being a dead animal bothers you?

T: Just it's decaying... that's the only thing that sucks, you know it's decaying, and you keep going through it... so like after four weeks or whatever, you start like, smelling really bad, and you can tell it's not like, the formaldehyde's not like, sticking to it well anymore...

K: So it doesn't have to do with the fact that it's a dead animal?

T: No, that doesn't really bother me... maybe if it were a dead person, that might get a little sketchy...

K: Can you imagine doing a cadaver dissection?

T: No, I wouldn't do that... I don't think I could do that to a dead person... now, a live person I probably could, but not to a dead person...

K: To a live person? Oh, you mean like an operation...

T: Yeah, like if somebody got like stuck with a knife or something, I'd pull it out... I just wouldn't want to do that to a dead person, 'cause it's like gross, they're like, decaying and stuff like that... (i5)

Tom made one comment related to his pet dog at home: "I mean it's not like the cat's gonna remember you... I mean if it was my dog, then I might get a little sketchy around it, but about a cat I wouldn't care... I don't really care about cats... I don't like cats... I'm allergic to cats..." (i5) In this quote, he shows that he has a connection to his pet dog, but that he has no connection to the cat used in dissection, other than to be repulsed by it.

P2: A student should show respect for all creatures, both human and nonhuman.

Tom did not express any feelings of respect toward the cat: "I don't know, I don't really like cats, so it doesn't matter... it didn't bother me... you see a lot of people hit them on the road, too, so..." (i2)

K: Would you have dissected the cat even if he didn't tell you where they came from?

T: Yeah... I really don't care... they get hit out on the road all the time, right? (i5)

When I asked him if he felt like a scientist during dissections, he said, "I don't think so, 'cause like, it's a cat, nothing like, too important..." (i4)

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

Tom did not think the cat was a valuable tool for learning. He said, "I just wanted to get through it and get out of the class... I think they could probably use a fake cat, like

a plastic one and it would probably work the same way, but it doesn't really matter to me... they have an abundant source of dead cats I guess, so, it works out well..." (i5) He also said, "They have a lot of stray cats, don't they? I guess it's good that they're being used instead of just tossed away or something..." (i4) This was the only comment he made that indicated whether he thought the cat was useful to human beings.

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

Because Tom said that "it's good that they're being used," I felt that he would agree with the other students in this study in saying that human learning was a good reason to kill and use the cats in dissection. However, his comments about death also suggest that he really did not care why the cats were killed, because he compared the cat used in dissection to cats killed on the road. In the end, it was difficult for me to determine what Tom really thought about dissection.

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I did not find any comments in Tom's interviews that relate to this principle of ecological literacy.

Summary

In Table 5, I have listed each student and the five ecological principles. The principles are:

P1: A student should understand that he or she is connected to the nonhuman world.

P2: A student should show respect for all creatures, both human and nonhuman.

P3: A student should understand that the value of an animal's life is not measured in terms of usefulness to human beings.

P4: A student should appreciate the beauty and diversity of the nonhuman world, and should kill and use animals only with good reason.

P5: A student should be able to recognize the danger in excessive human interference with the nonhuman world.

I have indicated (*) when I felt that a student illustrated a principle through their responses to interviews and my observations in class. I have also indicated (x) when I felt that a student demonstrated the opposite of a particular principle. In P1, I thought that Lucy, Elaine, Christine, Victoria, Emma, Michael, and Carmen demonstrated a connection to the nonhuman world, usually through relationships they had with pet animals at home. Jason, Danielle, Jessica, Rachel, Alfonso, and Tom did not seem to feel a connection to the nonhuman world. In P2, I thought that Lucy, Christine, Danielle, Jessica, Michael, and Alfonso exhibited respect toward the cat used in dissection. This determination was based on their behavior during dissection as well as their responses to interview questions. In P3, all of the students thought the cat was useful as a tool for human learning, which indicated that none of them illustrated the meaning of this principle of ecological literacy. In P4, I thought that Lucy was the only student who thought that controlling the population of cats was a human responsibility, which she described as "hard" because of animals that people have as pets. She continued to identify with her pet cats, and to transfer this relationship to the cat used in dissection. I felt that she exhibited an understanding of this principle, whereas Elaine, Emma, Carmen, Alfonso, and Tom did not demonstrate an understanding. I thought that Christine,

Victoria, Jason, Danielle, Jessica, Rachel, and Michael demonstrated the opposite of this principle of ecological literacy in their justifications about using the cats in dissection, which they generally felt was unavoidable and necessary. Finally, in P5, only Lucy, Victoria, Danielle, and Rachel made comments that indicated a possible awareness of greater issues related to the environment. None of the other students made comments that showed any such awareness.

TABLE 5: Ecological Literacy Results

STUDENT	P1	P2	P3	P4	P5
Lucy	*	*	x	*	*
Elaine	*		x		
Christine	*	*	x	x	
Victoria	*		x	x	*
Jason			x	x	
Danielle		*	x	x	*
Jessica		*	x	x	
Rachel			x	x	*
Emma	*		x		
Michael	*	*	x	x	
Carmen	*		x		
Alfonso		*	x		
Tom			x		

CHAPTER V

CONCLUSIONS

Conceptual Change

This study was conducted to answer the following research questions:

1. How do student conceptions of dissection change over the course of a school year?
2. How do emotions influence a student's ability to learn concepts in dissection?
3. Do student experiences in dissection reflect ecological principles?

The conclusions in the first section of this chapter are centered around the first two research questions, specifically addressing the area of conceptual change. I present the conclusions related to the final research question in the second section of this chapter.

Organization

After reading the student responses to the interviews, I organized them into the five conditions necessary for conceptual change, as presented in the results section. The following themes emerged during my ongoing organization and analysis:

1. Medical Career Training
2. Disconnection of Female Students from Science
3. Use of the Senses in Learning Dissection
4. Effect of the Nervous System and Eye Dissections
5. Effects of Emotions in Learning Dissection

These themes were developed from my analysis of the responses of students, as compared with the four conditions necessary for conceptual change (Posner, 1982), and

the fifth condition, which considers the effect of emotions in learning through dissection. As I isolated student comments and grouped them into these conditions, I noticed these five themes that emerged and were repeated by many students. I used them to further examine student responses, and discuss the meaning of dissection to the students. The first theme is connected to C4, which states that a new concept should suggest the possibility for future research. In this study, I considered a student's career goal as indicative of their interest in future applications of their knowledge of dissection. The second theme was derived from my analysis of the experiences of Lucy, Elaine, and Christine, and is connected primarily to C5, because the presence of their emotions was a major factor in their experiences. The third and fourth themes are connected to C2, which states that a new concept should be intelligible, or that it should make some sense. Finally, the last theme is directly related to C5, and provides an in depth look at the effect that student emotions have on learning.

In the first section of this chapter, I discuss conceptual change and the need to consider emotions in the model of science learning. Next, I discuss how student conceptions of dissection changed over time. I discuss the five themes that emerged during my analysis of the data. Finally, I include the final grade for each student in the class, to compare with their results in conceptual change.

In the original model of conceptual change (Posner, et al., 1982), a learner's preexisting conceptual framework is restructured when new conceptions are compared with old ones and found to be more intelligible and plausible. This accommodation of new information was assumed at first to be linear and rational (Posner, et al., 1982). However, this model has been strengthened by the recognition of affective components of

learning, which collectively are part of a learner's conceptual ecology (Hewson, 1992; Strike & Posner, 1992; Demastes, et al., 1995). Learning is now described as a non-linear process involving many different influences, including a learner's beliefs and affective position toward a subject. The role of student beliefs and values has begun to be studied (Doster, 1997; Demastes, et al., 2003; Sinatra, et al., 2003). However, although studies have acknowledged the need for examining the effect of emotions in learning (Demastes, et al., 1995; Southerland & Sinatra, in press), there is a lack of studies that directly investigate emotional responses of students in science. The current study was designed to address that gap.

Socio-emotional learning (SEL) programs have been constructed to teach emotional literacy, which provides the skills that students need to reflect on the process of learning, through which they discover not just academic concepts, but who they are as human beings (Cohen, 2001; Elias, 2003). Students in SEL programs learn to feel connected to the classroom community, which in turn teaches them to behave responsibly toward others (Dasho, et al., 2001; Lewis, et al., 1999). The current study builds on the idea of emotional learning, and examines whether dissection teaches students to disconnect themselves emotionally from the experience. The effect that emotional disconnection may have on the development of ecological literacy is discussed in the second part of this chapter.

Conceptual Change Over Time

In Table 6, important aspects of student conversations during the interviews are listed. I have included the primary descriptive words that each student used to describe the cat, for example as a "tool" or as an "object." Most of the students began the year

without using these descriptors in their conversations with me. However, by the end of the year, almost all of them referred to the cat as a tool or an object.

Tom was a unique example, because he did not use any of the descriptive words that the other students used when talking about the cat. I have noted in Interview 2 that he talked a lot about death, which was a consistent theme in his conversations with me. His reactions to the dissection experience are specifically discussed in the second section of this chapter.

“Pets” is listed when students primarily discussed their own pet cats in relation to the one used in dissection. Especially in the early interviews, they talked about their emotional relationships with pets as compared to the cat used in dissection. By the end of the year, only Lucy continued to talk about her pets in the interviews.

Appreciation is mentioned in Interview 5 by six students, and in Interview 4 by three more. This could be seen as a result of the change over time, because appreciation of the human body was a stated goal of Mr. Gibson’s instruction. The students were aware that they should feel appreciation after performing the dissections, as many of them indicated in the interview sessions.

Overall, these descriptors are examples of how each student’s conception of the cat changed over the course of the year. In particular, it is interesting to note that very few students began the year talking about the cat as an object. These descriptive words also indicate the emotional desensitization that was taking place during the year, and enabled most of the students to talk about the cat as an object by April.

TABLE 6: Conceptual Change Indicators

Change/time	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5
Lucy		pets		tool	pets
Elaine		tool			tool
Christine	pets	pets	tool	*	*, tool
Victoria		object		object	*
Jason			tool, object		*, object
Danielle				object	*
Jessica				pets	
Rachel		tool, object		tool	*, tool
Emma				tool	*, hands-on
Michael		tool		*	
Carmen		tool			object
Alfonso				*	hands-on
Tom		death			

* = appreciation

Most students (9) showed an obvious change at Interviews 4 and 5, near the end of the year.

Summary

Almost all of the students in this study experienced changes in their conceptions of dissection over the year. Only Tom did not demonstrate conceptual change of any kind. Some students, like Lucy, experienced difficulty in setting their emotional responses aside to participate in dissection. She continued to talk about her pet cats as late as April. However, most of the students in this study became desensitized to their emotional reactions, which helped them participate and learn from dissection. The effects of emotions in learning and other themes related to conceptual change are discussed in the following sections.

Medical Career Training

Five students in this study (Danielle, Jessica, Emma, Rachel, and Alfonso) expressed interest in a career in medicine. There was a common perception among them that as medical professionals, they needed to be exposed to dissection to prepare

themselves for the graphic events they would face in the field, like incisions, surgery, and the sight of blood and organs. Some proponents of dissection believe that this is an important reason to use traditional dissection in classrooms (Offner, 1993; Morrison, 1992), while others contend that the skills do not apply to the majority of students in secondary schools (Texley, 1992). Mr. Gibson told the students that they would benefit from this preparation at the beginning of the year, and I heard it echoed by many of the students, like Danielle and Rachel, throughout the interviews.

Tom did not have the chance to explore his emotional reactions to dissection in this classroom experience. He felt that he had to participate in order to receive a passing grade in the class, and he tried to cover his emotional reactions and pretend that nothing was troubling him. In September, he said that he wanted to be a doctor, but by December he had changed his mind, because of the negative experience he had during the dissections. Other students may experience a similar conflict.

Studies have shown that medical students often experience the same negative emotions that Tom expressed in the interviews (Marks & Bertman, 1980; Gustavson, 1988). First year medical programs have been constructed with these reactions in mind, including open discussion of student reactions to cadaver dissections (Marks & Bertman, 1980). The focus is on creating compassionate, humane doctors (Gustavson, 1988). Discussions like these should also take place in science classrooms where students are engaged in decision-making about their careers (Allchin, 1991). Students like Tom might then be able to resolve their emotional conflicts, and they might be encouraged to enter the medical and scientific fields (Orlans, 1988; Marks & Bertman, 1980; Gustavson, 1988). Other students, like Danielle and Rachel, who already have an interest in

medicine, would benefit by beginning their training as compassionate, humane doctors before they reach medical school (Gustavson, 1988).

Disconnection of Female Students from Science

Of the thirteen students in this study, there were two girls who were unable to completely set aside their emotional reactions: Lucy and Elaine. They were unable to fully participate in dissections throughout the year. Other students in this study, like Christine and Emma, had strong emotional responses to dissection, but they covered them up and tried to give the impression that nothing was troubling them. For example, Emma said repeatedly in the interviews that dissection did not bother her, but in class she was often joking and laughing loudly with other students, behavior which may indicate that she was trying to hide deeper emotional reactions (Gustavson, 1988).

Dissection may be one example of an activity that marginalizes female students in science classrooms (Dunlap, 1990). This is an area of concern, both in education and in science, in which objective, unemotional thought is emphasized (Keller, 1985; Harding, 1991). Research has shown that male students in science tend to receive support for assertiveness, and that they receive more praise and critical feedback than female students (Jones & Wheatley, 1990; Tobin & Garnett, 1987; Morse & Handley, 1985). Female students overall have less confidence in their scientific skills than male students (Eccles, 1987; Brophy, 1991; Sadker & Sadker, 1985).

There is a need for teachers to allow students to explore and recognize their emotional reactions to activities like dissection, so that no students are left out of the learning experience (Cohen, 2001). This particularly applies to the experiences of female students in science. Because women tend to value different aspects of the learning

environment, and form closer bonds of care and cooperation than men (Shepard, 1993), these values should be taught during their training as science students. Low numbers of women in science may be attributed to the absence of these values in the classroom (Noddings, 1990).

Dissection is an activity that arouses strong emotion, and if no opportunity is given for students to explore them, they may be suppressed. This does not mean that they are completely absent, however, as Christine and Emma have shown in this study. They may still have difficulty in resolving their emotions, and this conflict may contribute to a decision not to enter scientific or medical professions. For example, Lucy began the year saying she was interested in becoming a doctor, but changed her mind before the year was over.

Use of the Senses in Dissection

Dissection is a hands-on activity. It provides students the opportunity to involve their senses in learning concepts of anatomy and physiology. This is one of the strongest arguments for keeping dissection in science curriculums (Berman, 1984; Offner, 1993; Morrison, 1992). Berman (1984) says that dissection gives students a chance to separate and analyze parts, by using their hands and other tools, which helps them assemble the data into new conceptions. Of the thirteen students in this study, ten of them used the term "hands-on" when describing the activity. They thought that the hands-on aspect was the most useful part of the exercise, and they said it was better than reading from a book. All of them described how the use of their senses in dissection made the concepts more intelligible. Even Tom, who showed the least interest in the activity as a whole, said that his skills at dissection had gotten a lot better after he used scalpels and probes to cut the

tissues. Four students, Christine, Victoria, Michael, and Jason, specifically mentioned the sense of touch as important to their learning. Michael, Jason, and Victoria also mentioned the sense of sight, as did three other students: Elaine, Rachel, and Carmen. Also, Tom and Emma both commented about the smell associated with dissection, which was particularly unpleasant for them.

Students had different ways of talking about how their sensory experiences in dissection helped them learn the concepts. I heard phrases like “rip the tissue,” “dig your hands in,” “wrap your fingers around the leg,” “tear away the fur,” “pull off the skin,” and “stick the probe in.” The students connected these sensory experiences with the overall learning experience. In some cases, like Jason’s, students seemed to enjoy ripping and cutting tissues to locate structures. In others, like Christine’s, the sensory aspect was sometimes overwhelming and could be disturbing. Overall, the students in this study (except Tom) experienced a change in their conceptions about dissection after involving their senses in exploration. This study supports the view of educators who feel that the hands-on aspect of the activity is an effective method of teaching anatomy and physiology of organisms (Berman, 1984; Offner, 1993; Morrison, 1992).

Effect of the Nervous System and Eye Dissections

Doster (1997) reports that 41% of students in her study agreed with the statement: “For me, dissecting the head of an animal is more disturbing than the rest of the body,” and 32% agreed with the statement: “When I dissect the head of an animal, I sometimes think about that being done to me” (Doster, 1997, p. 101). Students in this study also had difficulty with the dissection of the head of the cat.

For three students, Lucy, Elaine, and Christine, the nervous system dissection in December was a major turning point. Before this dissection, in the second and third interviews, they still talked about their emotions and had not yet been able to set them aside. Following this dissection, all thirteen of the students described the cat as a tool for learning or as an object, which suggests that emotional desensitization had taken place.

Tom stated that he was interested in a career in medicine in the third interview, and had changed his mind by the fourth. However, he did not seem to have a specific negative reaction to the nervous system dissection.

The rest of the students had already set their emotional reactions aside prior to the second and third interviews. Their responses were unchanged following the nervous system dissection. Key words from student responses before and after the nervous system dissection are listed in table 7.

TABLE 7: Student Responses Following Nervous System and Eye Dissections

Student:	Interview Response (2, 3):	Interview Response (4, 5):
Lucy	2 it looks kind of helpless; 3 I didn't really get into it; I kind of stood there and watched	4 I have advanced over the whole cat thing; it's a tool for learning
Elaine	3 I don't want to cut open someone's brain—I don't care if they're dead	4 now it's not as big of a deal; 5 it's an educational tool
Christine	3 sometimes it hits you that this was a real animal; I feel so bad for the little cat	4 it's just another thing that you do for the class; it becomes something that you're used to
Victoria	2 it's something to practice, to play on	4 it's parts of the cat, not really a whole cat; you don't really think of it as a cat
Jason	3 the cat is just a tool and it's almost fake	4 I have the same feeling; 5 you're playing with a toy... it's all plastic and fake
Danielle	2 it's to further someone's knowledge; think about it like, technical	4 I look at it really objectively
Jessica	2 I was excited about it... I just couldn't wait to do it	4 I see it as more like... natural systems than like a cat
Rachel	2 it's more like an object, it's a tool... it's a tool that you use for learning	4 I've always thought of it as a learning tool, and I still do
Emma	2 it didn't bother me at all; I'm more excited	4 it's used for scientific things, so we can learn
Michael	2 I see it as more a learning thing for us than as a cat	4 I see it for the learning experience in class
Carmen	2 I think it's more just for our knowledge and education	5 it's just like an object (object said 4 times in this interview); it's just a doll (said 2 times)
Alfonso	2 kind of jump into it, instead of just waiting; get us kind of interested in it	5 it's really not that big of a deal anymore
Tom	3 I might be able to have a chance to be a doctor	4 I don't think I want to be a doctor

These phrases show how students in this study became desensitized to their emotional responses, which were typically elevated during the dissection of the head of the cat. The results of the current study provide evidence that students do experience a process of desensitization during dissection. Some educators feel that this process

encourages students to become hardened to animal suffering, and fosters the idea that animal life is cheap (Orlans, 1991; Mayer & Hinton, 1990; Shapiro, 1992). Connections between the emotional responses of students and the development of attitudes toward animals and the environment are discussed in the second section of this chapter. In the following section, the effects that these emotions may have on the learning process in science are discussed.

Effects of Emotions in Learning Dissection

This study investigates the responses of student involved in dissection, which is a controversial and emotionally loaded activity. In the conceptual change model (CCM) developed by Posner, et al. (1982), and revised to include consideration of a learner's conceptual ecology (Hewson, 1992; Demastes, et al., 1995), the role of emotions in learning is not directly addressed. Southerland and Sinatra (2003) state that emotions are too subjective to be considered in research, and they instead focus on the part of conceptual change that is the objective restructuring of a cognitive framework. However, I suggest that in controversial learning situations like dissection, emotions cannot be dismissed. Goleman (1995) also contends that students should be given the opportunity to explore their emotions, by blending lessons on feelings and relationships with topics already taught in schools. In the next section, I discuss how emotions affected the learning process for students in this study.

Of the thirteen students who participated in this study, two were unable to set their emotional reactions aside: Lucy and Elaine. These two girls did not usually participate in the dissections, and were not actively engaged with the material. Their responses in interviews typically compared the cat used in dissection with their pet cats at

home. These emotional connections caused them to feel empathy toward the cat, and it was difficult for them to involve themselves in an activity that they perceived as cruel or painful. Both girls showed evidence of conceptual changes, but their dissection experiences overall were negative. If they had been in a classroom that encouraged discussion of their emotions, both girls could have had a more positive learning experience. They would have learned the concepts more easily, and would have been able to participate in the dissections. Also, they might be encouraged to pursue science majors in college, had they been shown that values like theirs—love, kindness, empathy—can be part of a science curriculum, as Goleman (1995) suggests. Instead, Lucy said she did not want to be a doctor, even though she started the class with an interest in medicine, and Elaine also did not express an interest in future science classes.

Tom also had very negative reactions to death, and did not demonstrate conceptual changes over the year. His participation in the dissections was marginal. Cohen (2001) notes that powerful emotional reactions like this can interfere with the learning process. In Tom's case, the learning process was continuously interrupted by these emotions, and he was never able to engage himself with the material. His case is particularly important to recognize, because Tom represents a large proportion of students in science. He was not a high achieving student, and he participated in the dissections, however marginally, because it was required of him. Cohen (2001) says that an effective way to involve students like Tom in learning, especially in a controversial subject like dissection, would be to encourage him to reflect on his emotions and use them to shape the process of learning. This would entail open discussion of fears associated with dissection, in the same way that first year medical students do (Marks &

Bertman, 1980; Gustavson, 1988). At the same time, Cohen says, students like Tom would learn more about themselves as emotionally complete, responsive human beings (Cohen, 2001).

Christine continued to talk about her emotional responses to dissection throughout the year. However, her participation in the dissections was consistent, and she did not appear to have any difficulty with the activity. Victoria also talked at length about her emotional responses to dissection, but she was able to set those emotions aside to participate in the exercise. The other students in this study were also able to set their emotional reactions aside during dissection, and most of them did not have strong emotional responses to the dissections. The findings of this study suggest that students had to be desensitized to their emotions to participate fully in the dissections. This is in contrast to the type of socio-emotional learning that Cohen (2001) and Elias (2003) recommend for all students.

Final Grades

The final grades in Human Anatomy and Physiology for these students are listed below, from the highest to the lowest:

Danielle	95
Christine	94
Michael	94
Alfonso	89
Jessica	88
Victoria	86
Tom	81
Rachel	80
Lucy	80
Carmen	76
Elaine	76
Jason	74
Emma	74

The final grades are reflective of the degree of interest that the students had in dissection, and also of the degree to which they were able to set their emotional reactions aside. With only a couple of exceptions, they correlate with the amount of conceptual change that I documented in the interviews. Danielle's grade is not surprising, given her interest in dissection and a career in medicine. Christine had a good experience in dissection, and even though she still talked about her emotions late in the year, she was able to set them aside to participate in the activity. Michael, Alfonso, Jessica, and Victoria were able to set their emotions aside as well. Tom's grade is much lower, although not the lowest of the group. He did not show much conceptual change, nor much interest in the dissections, so this grade is to be expected. I thought Rachel would have ended with a better grade than she did, but I do not attribute this to a lack of interest. Perhaps she did not do well on an exam or on the final, either of which could account for the lower grade. Lucy's grade is about what I would have expected, given her emotional reactions to dissection. Carmen was absent frequently, which accounts for her grade. Elaine also had strong emotional reactions to dissection. Jason and Emma were both interested in dissection, but were not strong students, which may account for their grades. In general, the pattern of grades does correlate with my expectations of student performance, given their degree of interest, emotions, and conceptual change.

Teacher Influence

It is important to note that Mr. Gibson had a profound effect on the views of the students in this class. He began the year with a discussion about where the cats had come from and how they were killed. He also told them that they were useful because they were used for the purpose of learning, as specimens in dissection. These ideas were

repeated, sometimes verbatim, by most of the students in this study when I asked them about their justifications for doing dissection. For many of them, it was important that they knew the cat was killed for a good reason. These students trusted their teacher to tell them the truth about the cats, and to guide their experience in dissection. For science teachers, this is a significant finding because it illustrates the importance of the role of the teacher as a guide. The students in this study believed what they were told. I do not think that I could have changed the opinions of these students, once they heard what Mr. Gibson told them about the cats. This was the only way that some students, like Lucy and Elaine, were able to continue to participate in the dissections. Allowing students to openly discuss their emotional reactions to dissection would be an influential part of their learning experience, because the teacher has the opportunity to guide the students in reflection and the development of their understanding and acceptance of their emotions.

Summary

The results of this study indicate that students who have an interest in careers in medicine would especially benefit from discussions about their emotional reactions to controversial subjects like dissection. Female students in this study were more likely to have strong emotional responses to dissection, and two of them (Lucy and Elaine) were unable to set them aside to participate in dissection. These findings suggest that discussion of emotions as part of the learning process in science would particularly help students like these understand their responses and feel supported in their classroom environments. The use of their senses as part of dissection was important to students in this study, and indicates that dissection is effective as a hands-on method of learning. The nervous system and eye dissections were significant because all of the students,

including Lucy and Elaine, talked about the cat as a tool or an object afterward. These descriptors suggest that emotional desensitization had taken place for all students by this time.

The research questions pertaining to conceptual change were:

1. How do student conceptions of dissection change over the course of a school year?
2. How do emotions influence a student's ability to learn concepts in dissection?

The results of this study show that all of the students, except Tom, experienced changes in their conceptions of dissection over the course of the year. This research has also shown that student conceptions of dissection are affected by their emotional reactions. Stronger emotional responses, like Lucy's, tend to cause students to disassociate themselves from the activity. Lucy and Elaine were not engaged with the material, and Lucy decided against a career in medicine during the year. Tom's reaction to death was so strong that it may have inhibited his learning process during the year. The other students in this study were able to set their emotional responses aside to participate in the dissections, but some of them, like Christine, still struggled with their emotions internally throughout the year. The significance of this finding is to demonstrate that emotions should be considered as part of the conceptual change model for science learning. A better understanding of the role of emotions in learning would lead to more effective methods of teaching science to all students, so that students like Lucy, Elaine, and Tom would feel more connected to the material they study.

The final grades for the thirteen students in this study were generally correlated with their degree of interest in dissection, their emotional reactions to the activity, and the amount of conceptual change they demonstrated. Students who were unable to set their

emotional reactions aside had lower grades than those who had a strong interest in the activity. This provides empirical evidence that emotions are a factor in conceptual change, and should be considered in learning controversial subjects like dissection.

Ecological Literacy

The conclusions in this section are presented as an answer to the third research question in this study: Do student experiences in dissection reflect ecological principles? The conclusions in this chapter explore the connection between students' emotional reactions to dissection and the development of ecological literacy.

Organization

After reading student comments from the interviews several times, I organized them according to my five principles of ecological literacy, as presented in the results section. The themes that emerged during my ongoing analysis of the data were:

1. Respect for the Cat Used in Dissection
2. Connections to the Nonhuman World
 - a) Identification with Pets
 - b) Similarities Between Humans and Animals
3. Tom's Reactions to Death
4. Tools for Human Learning

These themes are connected to my five principles, and were the most helpful in my analysis of student responses. The first theme is connected to P2, which states that students should show respect for all creatures, human and nonhuman. The second theme is connected to P1, which says that a student should understand that he or she is

connected to the nonhuman world. The two minor themes listed are also connected to this principle. Tom's reaction to death is unique in this study, and I also found that it was most closely connected to P1. Finally, the theme of cats used as tools for human learning is connected to P3, which states that the value of an animal's life should not be measured in terms of usefulness to human beings. These themes were derived from my analysis of the data, and they provide a framework to explore student responses in depth.

Respect for the Cat Used in Dissection

Respect implies a consideration of the life of another being, and an acknowledgement of the right to live and flourish. Devall (1985) says that if we learn to see organisms as entities with interests and purposes, we will be compelled to respect them as individuals in their own right. This is a reflection of deep ecological principles, so called because they consider not the surface effects of human interactions with the environment, but the deeper causes and patterns of those interactions (Naess, 1989; Devall, 1985). In this study, I examine the deeper reasons behind the emotional responses of students to dissection. As has already been shown, dissection encourages students to disconnect themselves from their emotional responses, and to treat the animal as an object. While all of the students talked about the cat as an object or a tool, some of them displayed respectful behavior during dissections and some did not. I discuss these behaviors in the following section.

Out of the thirteen students in this study, six displayed consistently high levels of respect for the cat, in my observations during class and in their responses to interview questions. These students were Lucy, Christine, Danielle, Jessica, Michael, and Alfonso. Lucy did not participate very often in dissections, but when she did she was very quiet

and respectful. The other five demonstrated a serious, respectful attitude during dissections. Lucy and Christine both felt that a dead body commands respect, and they did not want to see it ripped apart or destroyed. Doster (1997) found that 35% of the students in her study agreed with the statement: "During dissection, I feel like I'm being disrespectful to the animal." Conversely, 48% of the students disagreed with this statement. These items correspond with a belief that moral consideration is not relevant to dead animals (Doster, 1997, p. 103). As an example of this belief, Alfonso said, "If it's dead, then it doesn't really matter in a way..." Although he began the year with this attitude, when I asked him later in the year if he felt more respect for the cat used in dissection, he said, "I love cats, but in general, yeah..." (i4)

Rachel said that she felt respect for the learning experience, but not for the cat itself. Her attitude during dissections was studious, but she could also give the impression of being a little callous, such as the time she cut off the cat's ear for no reason, and she sometimes made jokes about the cat during dissections.

Elaine probably felt respect for the cat, but she was disturbed enough by the dissections to cover it with humorous, sometimes disrespectful comments and behavior during the dissections. Gustavson (1988) notes that according to medical students who displayed similar behavior, "the function of this humor was to reduce stress and to avoid negative emotional reactions to what they were doing in the dissections" (p. 63).

Emma and Jason showed a lack of respect in their behavior during the dissections. Emma tended to joke around and poke fun at the cat, and Jason would often mutilate and purposefully hack at the cat while he worked. Jason said, "that's my own, sickness..." These findings support the idea that dissection encourages students to become

desensitized to animal suffering (Orlans, 1991), and that dissection fosters disrespect for living things (Mayer & Hinton, 1990).

Connections to the Nonhuman World

Orr (1992) says that students will learn that they are part of or apart from the natural world by what is included or excluded from instruction. In my definition of ecological literacy, students should understand that they are connected to the nonhuman world (P1). In the next section, I discuss ways that students in this study expressed their connections with the nonhuman world.

Identification with Pets

If students in this study had pet cats or dogs at home, they often talked about them in the interviews. For some students, this connection resulted in a conflict of emotions during dissections.

Eight students, Lucy, Elaine, Christine, Victoria, Jason, Jessica, Michael, and Carmen, talked about their identification with pets at home during the interviews. Two of them, Lucy and Elaine, had such strong connections to their pets that it was difficult for them to participate in the dissections. Christine participated in all of the dissections, but still talked about her emotional connections throughout the year. This suggests that she was affected by her emotions internally, despite her ability to outwardly participate in the activity. The other five students seemed to have little trouble in separating their pet cats at home from the one used in class. Michael and Jessica even said that their identification with pet cats at home made the dissections more interesting for them.

Noddings (1992) notes that children often learn compassion and empathy through their relationships with pet animals. These lessons are continued into adulthood, by

teaching that there are no sharp distinctions between caring for self and caring for others (Noddings, 1992). Clark (1997) says that these ties of loyalty and friendship to pet animals are important to developing a sense of responsibility toward all creatures, and by extension, to the earth itself. Lucy and Elaine felt compassion and empathy for the cat used in dissection, and it is reasonable to assume that the other six students who talked about their pets also felt these emotions. These students might have been able to develop ecological literacy and a sense of responsibility to the earth if they were encouraged to explore their emotional connections.

Similarities Between Humans and Animals

Two students, Danielle and Emma, did not seem to identify with pets, but they discussed similarities they saw between humans and animals. In deep ecology, “another norm is that, with maturity, human beings will experience joy when other life forms experience joy, and sorrow when other life forms experience sorrow. Not only do we feel sad when our brother or a dog or a cat feels sad, but we will grieve when living beings, including landscapes, are destroyed” (Zimmerman, p. 184). These two students exhibit this kind of connection to the nonhuman world, which could be used to develop ecological literacy.

Doster (1997) found that 43% of students were in agreement with the statement: “As an animal’s body more closely resembles the human body, dissection becomes more exciting.” Sixty-four percent agreed with the statement, “As an animal’s body more closely resembles the human body, I feel like I learn more.” Conversely, 35% responded positively to the statement: “As an animal’s body more closely resembles the human body, dissection becomes more disturbing” (Doster, 1997, p. 93). Danielle and Emma

seemed to find the dissection more interesting because of the similarities they saw between the cat and human beings. This was a connection to the nonhuman world that made their dissection experiences more positive. Tom, on the other hand, found dissection more disturbing and morbid because of his connection to the nonhuman world. The cat was a constant reminder of his own mortality. I discuss his reactions to death in the following section.

Tom's Reactions to Death

Of all the students in this study, Tom was the most unique in his approach and reactions to dissection. He regarded the dissection as “part of the class,” and did not show any strong interest in it over the course of the year. He usually participated in the dissections, but was also content to allow his partner Danielle do most of the physical work. In the interviews, he was quiet and reserved, and I often had to repeat or restate questions in order to get a full response. His comments about death are particularly interesting, however, and point toward a deep connection that was difficult for him to set aside during the dissections.

Over the course of the interview sessions with Tom, he said the cat was “rotting” four times, “decaying” six times, and described it as “dirty,” having “gangrene,” and suspected it of spreading infectious diseases like AIDS. Tom's graphic descriptions of the cat were unique in this study, but the possibility exists that other students would make the same connections. Gustavson (1988) writes about medical students in cadaver dissections: “They associated the intact body with life and health but viewed the dissected body as a representation of the ‘self’ in a morbid condition” (p. 63). Tom projected onto the cat a sense of himself in a morbid condition. Tom's comments about

the cat being “dirty” correlates with Doster’s results. Thirty-nine percent of the students in her study agreed with the statement, “I think of dissection as unclean or dirty.” These students were less likely to have a positive experience in dissection (Doster, 1997, p. 128).

Tom enrolled in Human Anatomy and Physiology because he wanted to take chemistry his senior year instead of physics. He did not have the high interest in medicine that many students in the class had, nor did he have a fascination with the workings of the human body. He was an average student, quiet and shy, and his responses may be seen as indicative of the typical mainstream high school student, rather than the high achieving, above-average student. Tom provides an important counterweight to the results in this study, because his level of engagement and interest were not like the other students in this study. He is a reminder of all the students who participate in dissections only because it is a part of the class, and whose emotions and connections may be deeper than is commonly realized.

Tools for Human Learning

Doster (1997) found that 73% of students agreed that “killing is acceptable if it is done for a good reason,” and no one strongly disagreed (Doster, 1997, p. 79). Similarly, all thirteen students in this study thought that the cats were valuable as tools for human learning.

In Table 8, key words that students used as justifications for the use of the cat in dissection are listed. Nine of the thirteen students talked about the “overpopulation” of cats as a justification for their use in dissection. This was a direct reflection of Mr. Gibson’s instruction (see Chapter III). Alfonso was the only student who did not mention

the idea of overpopulation or that the cat was valuable as a tool for learning. However, based on other interview responses as well as his behavior during dissections, I believe that he also thought the cat was valuable as a tool for learning. This table provides a comparison of the phrases that students used when discussing their justifications for dissection. It is particularly interesting to note the similarities of the phrases, regardless of the positive or negative experiences that individual students had in dissection.

TABLE 8: Key Words from Student Responses (P3)

<u>STUDENT</u>	<u>P3 RESPONSES</u>
Lucy	it's a tool for learning; cats are overpopulated
Elaine	there's overpopulation; a lot of them are strays; they're being used for educational purposes; it's more of a learning tool
Christine	there's overpopulations of cats; it's kind of neat... that you can use an animal to learn from
Victoria	they're overpopulated... might as well use them for educational purposes; it actually gives it more worth
Jason	the cat is just a tool and it's almost fake; it was given to an educational cause... a learning experience for me
Danielle	it's good for the learning experience; if they're bred specifically for it, or if there's a huge overpopulation problem, then why not use them for science?
Jessica	they were alive and stuff and most likely strays... and that's why they killed them
Rachel	it's more like an object, it's a tool; it's a tool you are using for learning
Emma	there's too many cats; it's used for scientific things, so we can learn... that's better than just throwing it away
Michael	I see it as more a learning thing; it's just for school and for learning
Carmen	these cats are overpopulated; I look at it as educational and less of a torture thing... it's more just for our knowledge and education
Alfonso	it taught me to respect the body more
Tom	they have an abundant source of dead cats; they have a lot of stray cats... it's good that they're being used instead of just tossed away

Summary

This research was conducted in order to answer the question, "Do student experiences in dissection reflect ecological principles?" The answer is that student experiences in general did not reflect the principles that I developed for use in this study. Sometimes student experiences reflected the opposite of a principle, such as the

unanimous belief of the students that the life of the cat was valuable as a tool for human learning. However, there were also instances in which the potential for ecological thought and awareness did exist, as was displayed in Lucy's comments about dissection. This potential is important for science educators to consider. These findings also show that there exists the potential for students to develop ecological literacy, which would hopefully lead to a sense of connectedness and responsibility to the non-human world. This may have consequences for the future choices that students make about the environment.

The current study first explored the influence of student emotions, and has shown the importance of including them as part of the model for conceptual change in science learning. The second part of this study has shown that emotional reactions in science learning are part of a potential pathway to connect students with the natural world, and could be used to develop ecological literacy. In the next Chapter, I discuss the implications that this research has for science education and the development of ecological literacy for all students.

CHAPTER VI

IMPLICATIONS

To study the Way is to study the self.
To study the self is to forget the self.
To forget the self is to be enlightened by all things.
To be enlightened by all things is to remove the barriers between one's self and others.
--Dogen

Introduction

Dissection is a complex, highly emotional activity. Even students who enjoy it often find that they must set their emotional responses aside to participate fully and learn from the exercise. Dissection can be a useful, constructive activity if it is taught with respect and understanding. But I think it can also be harmful, when animal specimens are treated as objects to be taken apart. The issue of dissection can be approached from two different levels: pedagogical and personal. On a pedagogical level, we can look at dissection as a tool for teaching anatomy and physiology, that can be used in a number of different ways, depending on the desired educational outcomes for students. On a personal level, however, we can agree or disagree with the nature and practice of dissection. The complexity of this issue is evident throughout the thesis. For example, I personally do not agree with dissection as an instructional technique, but I can discuss its educational merits on a pedagogical level.

In this chapter, I address the personal level of the issue by exploring the connections I see between dissection and ecological literacy. On a pedagogical level, I

conclude the thesis by presenting three classroom models, including a discussion of possible educational outcomes for students.

Organization

In the first section of this chapter, I discuss how ecological literacy can inform a conceptual change world. The bridge between the two parts of this thesis is student emotional reactions to dissection. As I have shown, emotions are a significant factor for some students in dissection. I suggest that emotions should be considered as part of the learning process in dissection. Furthermore, I believe that students like Lucy and Elaine would feel comfortable and supported in a classroom that encourages open discussion of these emotions, so that they can better understand their responses and use them to strengthen their connections to the nonhuman world. Including ecological principles in science curriculums would hopefully lead to the development of ecologically literate students, who exhibit ecologically responsible behavior. In this chapter, I present a full discussion of the implications of these connections to science education. I also discuss educational philosophy, specifically Noddings' (1990) ethic of care, as related to dissection in science classrooms.

In the next section, I present three classroom models:

- 1) a model for a classroom that utilizes dissection as an instructional method, similar to the classroom environment for students in this study;
- 2) a model for a holistic classroom, utilizing alternatives to dissection; and
- 3) a model for a classroom that incorporates emotions in the CCM of science learning.

While I believe that alternatives to dissection should be used whenever possible, I recognize the fact that many science educators still choose to use it in their classrooms.

The first model is designed to address this type of classroom, and its educational outcomes. The second model represents a classroom that offers students the choice to use alternatives to dissection, and also encourages open discussion about the ethical issues related to dissection. The educational outcomes of a classroom like this one are also discussed. The third model is of a classroom that incorporates socio-emotional learning (Elias, 2003; Cohen, 2001) as part of the science curriculum. This classroom builds on the results of this study, by encouraging not only discussion about the ethical reasons for choosing alternatives to dissection, but also by exploring the emotional responses that are part of student experiences in the learning process. This process of exploration is what may be used to strengthen connections that students have to the nonhuman world, and could then lead to the development of ecological literacy. Finally, I present future research questions for this study.

Ecological Literacy in a Conceptual Change World

The third research question guiding this inquiry was: “Do student experiences in dissection reflect ecological principles?” I used five ecological principles as a lens through which to examine the experiences of students in this study. As the research progressed, it became evident that in general, student experiences in dissection did not reflect ecological principles. However, if they had been taught from an ecological perspective, I believe that the students would have been able to understand these principles and apply them to the learning situation. For example, Lucy’s personal identification with the nonhuman world, through her pet cat, was strong enough to cause her visible discomfort in class, and she usually stood aside and watched her lab partners

do the work. An open discussion about the identification of self with the nonhuman world (P1) might have led her to request an alternative to dissection in this class.

All thirteen students in this study believed that the life of the cat was valuable because it was used as a tool for human learning. In order to be ecologically literate, a student should understand that the value of an animal's life is not measured by its usefulness to human beings (P3). This is the opposite of the teaching that students receive in biology classrooms where animals are utilized as disposable tools, are seen as a collection of parts not wholes, and are valued only for their contribution to education. In a case where a student questions the value of the tool being used, as Lucy did in the current study, ecological principles may help them understand their reactions and may contribute to the student's choice to use an alternative to dissection.

Educational Philosophy and Dissection

Many people identify with pet and companion animals as children, and through these relationships they learn that animals respond to us as we do to them (Clark, 1997; Noddings, 1992). For example, Lucy and Emma demonstrate this sensibility in the current study. Other students, like Michael, might have developed this capacity more fully with instruction in ecological principles.

It is only in schools that children are taught to set aside their emotions, especially in science classrooms, where objective, empirical thought is emphasized through the dominant epistemology of objectivism (Roth, 1992; Smith, 1992; Tobin, 1991). The current study has shown that the activity of dissection encourages students to set aside their emotions and treat animals as objects. Noddings asks the question: "What good does it do to have students in biology class draw the digestive system of a mammal and

label its parts if they are not taught to have compassion for the animals they study?”

(Noddings, 1992, p. 127) She notes that children are sensitive to animal response, and that much of this experience comes from caring for pets in the home. The findings of this study support her vision of education:

If schooling is to have meaning for students, controversial issues must be discussed, and they must be discussed with full affect—that is, with attention to the responses of all those involved. The purpose is not so much the development of critical intelligence (although that is certainly one purpose) as it is development of the capacity to hear and respond sensitively. (p. 129)

In my Introduction, I asked two questions: 1) Is it possible for a student to care about animals and still participate in dissection? and 2) Is dissection really necessary for teaching the anatomy and physiology of animals? As I have shown in this study, I believe that dissection does not reflect ecological principles, and does not teach students to be ecologically literate. After my years of involvement with dissection as a student, a teacher, and a researcher, I have concluded that I would not use dissection to teach anatomy and physiology. However, I recognize that this is a personal decision, and I also understand that many teachers believe in the value of dissection, and will continue to use it in their own classrooms. I would hope that when it is used as a tool for learning, teachers will encourage student discussion about the activity. At the least, dissection should be performed with respect, and with full awareness of the emotional and ethical issues involved.

When dissection is approached with an attitude of respect, allowing students to connect themselves to the activity through an examination of their beliefs in a supportive classroom environment, then I believe it is possible for a student to care about animals and still participate in dissection. Classrooms like Mr. Gibson’s are instructive, and

provide students with important experiences related to future career goals in science. However, one way to improve the experience for all students, and to ensure that all students (like Tom and Lucy) are engaged in the material, would be to allow students to openly discuss their views and compare them with the values being taught. They will be able to reach a level of reflection that can help them develop personal values, and hopefully they will become ecologically as well as scientifically literate.

In our current state of educational affairs, we cannot conclude that there are no values being taught. Schools are transferring the values of the modern industrial worldview, and of the scientific and technological society. Devall (1985) states that “schools are teaching by precept and example that values (and maybe facts as well) are all subjective and relative, that it is ‘rational’ to compromise on all issues, and that Nature exists as but a commodity to be enjoyed and consumed by humans” (p. 182).

In these times of environmental concern, it would be wiser to cultivate a sense of connection with the environment, so that all students would learn to feel responsible for its care.

When ecological principles are fully integrated with science instruction, and when emotions are considered part of the learning process for all students, the results will be that fewer students are left out of the learning experience, and that all students will develop a deeper sense of responsibility and care for the environment. As Rachel Carson wrote in her essay “Sense of Wonder”:

I sincerely believe that for the child... it is not half so important to *know* as to *feel*. If facts are the seeds that later produce knowledge, then the emotions and the impressions of the senses are the fertile soil in which the seeds must grow. Once the emotions have been aroused--a sense of the beautiful, the excitement of the new and the unknown, a feeling of sympathy, pity, admiration, or love--then we

wish for knowledge about the object of our emotional response. Once found, it has lasting meaning. (Devall, 1985, p. 190)

Classroom Models

In the following section, I present three models of science classrooms. I discuss the educational benefits and disadvantages of dissection as an instructional method, alternatives to dissection, discussion about ethical issues, and the incorporation of socio-emotional learning in science (Elias, 2003; Cohen, 2001).

1) Model for a Classroom Using Dissection

In this study, students participated in a classroom that used dissection as an instructional method. The premises of this classroom form a model of the learning experience, which I will translate into a model of a science classroom. They are:

1. Students should receive instruction that is intelligible, plausible, and suggests the possibility for future research;
2. Dissection is a tool that is used to facilitate this kind of instruction, similar to other laboratory tools (like Bunsen burners and petri dishes) used in science classrooms.
3. Learning in this classroom is objective, and emotional reactions are not considered helpful.

In this Anatomy and Physiology classroom, students do not have a choice to participate in dissection. If they refuse to touch it, they must still watch and be prepared to take the same quizzes and exams that all other students in the class take. Students listen to lectures and complete exercises to prepare them for dissection, and are quizzed on the location of parts following each dissection session. Students are responsible for knowing structure and function, as well as related physiological topics like disease and

wellness. Exams are written and contain a practical portion, in which students will identify structures in the dissection specimen.

The cumulative effect on learning in this classroom is observed to be as follows: students become desensitized to their emotional reactions over time, and they participate in dissections with lab partners (usually groups of two or three students). There is no opportunity for class discussion of emotional reactions to dissection. Most of the students in the class do not experience difficulty in setting their emotions aside during dissection. However, there are a few students who are unable to completely set their negative reactions aside, and these students usually stand apart from their lab groups, watching others perform the dissections. This results in at least some students who are not engaged with the classroom activity, and probably compounds their negative emotional reactions, to the point that some students are turned away from the possibility of entering the medical or scientific professions. Female students may be included in this category more frequently than male students.

This type of classroom is instructive, and some teachers may find that their personal values are congruent with this kind of instruction. However, the following model includes discussions about student reactions to dissection, which might improve the dissection experience for students.

2) Model for a Holistic Classroom

A holistic classroom would be one in which students are offered a choice between dissection and alternatives, such as computer based dissection programs and simulations.

The premises for this classroom are:

1. Learning is not a linear process, and involves the consideration of a student's beliefs, attitudes, and motivations;
2. Dissection may be used as a tool to teach anatomical structure and function, but students may also choose to utilize alternatives;
3. Open discussion about these choices is important, so that students are able to verbalize and better understand their reactions to dissection.

This type of class may be taught by teachers who favor dissection, since it is considered a valuable tool for learning by some. Before beginning dissection, however, it is important for students to realize that alternative exercises, such as computer simulations of dissection, are available. In a holistic biology classroom, the emphasis would be on relationships among species and with the environment, as well as anatomy and physiology. In a human anatomy class, the emphasis would be on the structural similarities of the dissection specimen to human beings. A central feature of this classroom would be the open discussion of ethical concerns about dissection, emotional reactions to the activity, and other related topics.

In a classroom like this one, students should be taught that science is not the only answer. Southerland and Sinatra (2003) advocate discussions in which students are encouraged to compare their epistemological beliefs with rival explanations. Their potential aversions to controversial topics like dissection can be avoided through discussions about their beliefs and emotional reactions, an approach that Scharmann (1990) calls giving students "a place to stand" between two extremes (p. 98). Teachers should begin by asking students what they know about dissection, both emotionally and

conceptually. Discussions can then take place in which students explore their own reactions and beliefs about the activity.

Students should be supported in their choices about dissection in a holistic classroom. As was demonstrated in this study, students may suppress negative emotions when there is no opportunity for exploration or resolution. When they are presented with a choice and allowed to discuss their reactions, however, students like Lucy, Elaine, and Christine might favor the use of alternatives over traditional dissection. In any case, Southerland and Sinatra (2002) note that discussions like these “may help avoid the negative emotions that can impede instruction” (p. 340), which enables students to be fully engaged with the material being taught.

This classroom is supportive and encourages student discussions, which engages all students and helps them develop their personal value systems. However, dissection is still considered an option in this classroom. For those teachers who would like to omit dissection entirely, and who can incorporate socio-emotional learning in the science classroom, I present the following model.

3) Model for a Classroom Incorporating Emotion

In a classroom where emotions are considered an important part of the learning process, the premises are:

1. Learning in a science classroom involves empirical, objective thought as well as emotional, sensitive inquiry into natural phenomena;
2. Dissection encourages emotional disconnection in students, and is not considered a useful tool;

3. Students should explore the sociological, epistemological, and ideological reasons for their emotional reactions to dissection, and discussions should take place about them.

In this classroom, students are personally involved with the subject of study. Students have some degree of choice in the direction of study, meaning that they discuss the possible outcomes of the use of activities, and the relative importance to their lives. This includes a willingness on the part of the teacher to openly discuss emotional reactions to science, and the benefits and disadvantages of dissection as a tool for learning. This type of open discussion is part of socio-emotional learning (Elias, 2003; Cohen, 2001).

Specific to the activity of dissection, there are many topics for discussion in such a classroom. Sociologically, it is important to discuss with students where animal specimens come from and how they are killed for dissection, as well as the history of the use of animals in science. Students should be aware of improvements in their quality of life that have come directly from the study of animals. This information will cause students to become emotionally involved with the issues, and rather than be dismissed, these feelings should be examined (Elias, 2003). Epistemological reasons for these feelings may be exposed, such as religious backgrounds, family values, and early childhood experiences. In addition, ideological reasons for these emotions may be discussed, including Cartesian dualism and the prevailing objectivism in modern, Western science. Ecological principles like those used in this study should also be included in the discussion. A thorough examination of these themes will result in a student population that is empowered to make their own choices about dissection. They will gain critical thinking skills, and confidence in decision making (Cohen, 2001).

Once students learn to connect themselves to science, through an acceptance of their emotions, it is a relatively easy task to open their minds to the connections they have with the environment. Students will be able to ask, “What then?” (Hardin, 1992). Using their emotional responses to strengthen connections with the nonhuman world will lead to the development of ecologically literate behavior (Devall, 1985; Naess, 1989; Orr, 1992).

Bringing the two lenses of this study together creates a more complete picture of what students encounter during the activity of dissection. Not only is it important to learn scientific concepts, as described by the CCM, but it is also important for students to have a sense of connection to those concepts. Emotional responses cause students to become personally involved with the subject of study. When viewed through this lens, concepts become less abstract and more meaningful, especially to female students. In a conceptual change world, the consideration of each individual student as a responsive, emotionally complete human being will result in fewer students being left behind, and students will hopefully become both scientifically and ecologically literate.

Future Research

The contribution of this research is to a better understanding of the influence of student emotions on learning, and on ways that these emotions can be used to cultivate ecological literacy in all students. I can envision several different directions for future research to build on the results of this study. First, it would be helpful to examine the experiences of female students in dissection more closely. Although current studies suggest that girls no longer hold stereotypical aversions to careers in science than was once believed, statistics show that even when they feel more confident in their abilities,

they choose not to pursue science (Osborne, 2003). The reasons for this are still unknown, and represent an important area for future studies of conceptual change in science learning. Dissection and other controversial scientific concepts are particularly suited to this kind of study, because of the impact of emotional reactions that are part of the experience for students.

Another area for future research would be to investigate the experiences of average or typical students in science. Students in this study were mostly upperclassmen who took Human Anatomy and Physiology as an elective. However, students like Tom, who participate in dissection and other laboratory activities “because they have to” for the class, represent a large population of students in science. These students may experience negative reactions to dissection and to issues of death, decay, and defilement, as Tom did in this study. The effects of these reactions on the learning process for students should be further investigated, so that educators can develop the best possible methods for teaching science to students like Tom. Scientific literacy is certainly a goal for these students, so that they can make informed decisions about their lives in our society. In addition, it is important to consider the development of ecological literacy for students like Tom, because their actions as consumers and citizens will have dramatic impacts on the health of the environment.

It would also be useful to examine the experiences of middle school students in dissection. Although they may not have a fully developed view of the world at that age, their emotions are potentially even stronger than that of high school and college students. This may be an age at which teachers have the most direct influence on the development of ecological literacy in students.

Finally, it would be important to further investigate classrooms that incorporate emotions in their science curriculums, as I have suggested in the model above. Encouraging students to express their emotions, and to learn more about how their reactions connect them to all living creatures as part of the community of life on earth is a step toward developing ecological literacy in all students. Since ecological literacy confers the ability to make healthy, ecologically informed decisions that affect our lives and the planet, students would learn to practice environmentally responsible behavior. Just as scientific literacy is a goal for all citizens, so should the development of ecological literacy be a focus of all science classrooms.

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APPENDIX A:
Sample Permission Forms

Dear parent,

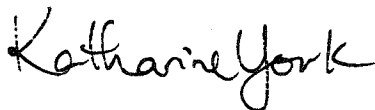
My name is Katharine York and I am a doctoral student at the University of New Hampshire. I am conducting research this year at Coe-Brown Northwood Academy. The purpose of this research is to examine how student conceptions of dissection change over the course of the year. Dissection can be a useful tool for learning science. This study will focus on student reactions in the classroom, as they experience the phenomenon for themselves. It will also include an examination of the teaching methods in the classroom related to dissection, and the reactions of the teacher as part of the process. This research will benefit teachers and administrators who are interested in including connections to ecology throughout the science curriculum in schools.

I am asking your permission for your child to participate in my research study. Participation involves three interviews over the course of the year, in which I will ask him or her to respond to interview questions about their reactions to dissection, in an open-ended manner. The interviews, which will take approximately thirty minutes, may take place either in or out of the classroom, at your child's convenience. Both your permission and that of your child is voluntary. All responses will remain strictly confidential and will only be applied for the purpose of this project. For the sake of confidentiality, I will assign a pseudonym to your child to be used in the study. During the interview process, your child will have the option of saying things "off the record" that will not find their way into the final account. You or your child may choose to end participation in the study at any time.

No risk to your child is anticipated. Every effort will be made to minimize the possible anxiety or stress he or she may experience through participation in the interview process. If you decide to allow your child to participate, I am asking that you sign and return a copy of this letter. Please feel free to ask questions at any time. I can be reached by phone at (603) 942-5173, or by email at york@worldpath.net.

If you have any questions about your rights as a research subject, you may contact Julie Simpson in the UNH Office of Sponsored Research at (603) 862-2003 or julie.simpson@unh.edu to discuss them.

Sincerely yours,



Katharine York, Ph.D. candidate

University of New Hampshire
Department of Natural Resources

Dear student,

Thank you for your willingness to participate in this research.

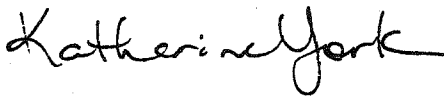
The purpose of this research is to examine how student conceptions of dissection change over the course of a school year. Dissection can be a useful tool for learning science. This study will focus on student reactions in the classroom, as they experience the phenomenon for themselves. It will also include an examination of the teaching methods in the classroom related to dissection, and the reactions of the teacher as part of the process. This research will benefit teachers and administrators who are interested in including connections to ecology throughout the science curriculum in schools.

Your participation is voluntary. Your responses will remain strictly confidential and will only be applied for the purpose of this project. For the sake of confidentiality, I will assign a pseudonym to you. During the interview process, you will have the option of saying things "off the record" that will not find their way into the final account. You may choose to end an interview or your participation in the study at any time. If you do consent to be interviewed, I will ask you to respond to the interview questions, in an open-ended manner.

No risk to you is anticipated. Every effort will be made to minimize the possible anxiety or stress you may experience if you choose to participate in the interview process. I am asking that you sign and return a copy of this letter. Please feel free to ask questions at any time. I can be reached by phone at (603) 942-5173, or by email at york@worldpath.net.

If you have any questions about your rights as a research subject, you may contact Julie Simpson in the UNH Office of Sponsored Research at (603) 862-2003 or julie.simpson@unh.edu to discuss them.

Sincerely yours,



Katharine York, Ph.D. candidate

University of New Hampshire

Department of Natural Resources

APPENDIX B:

Photographs of Students in Dissection

(Students Who Were Not Participants in the Study)

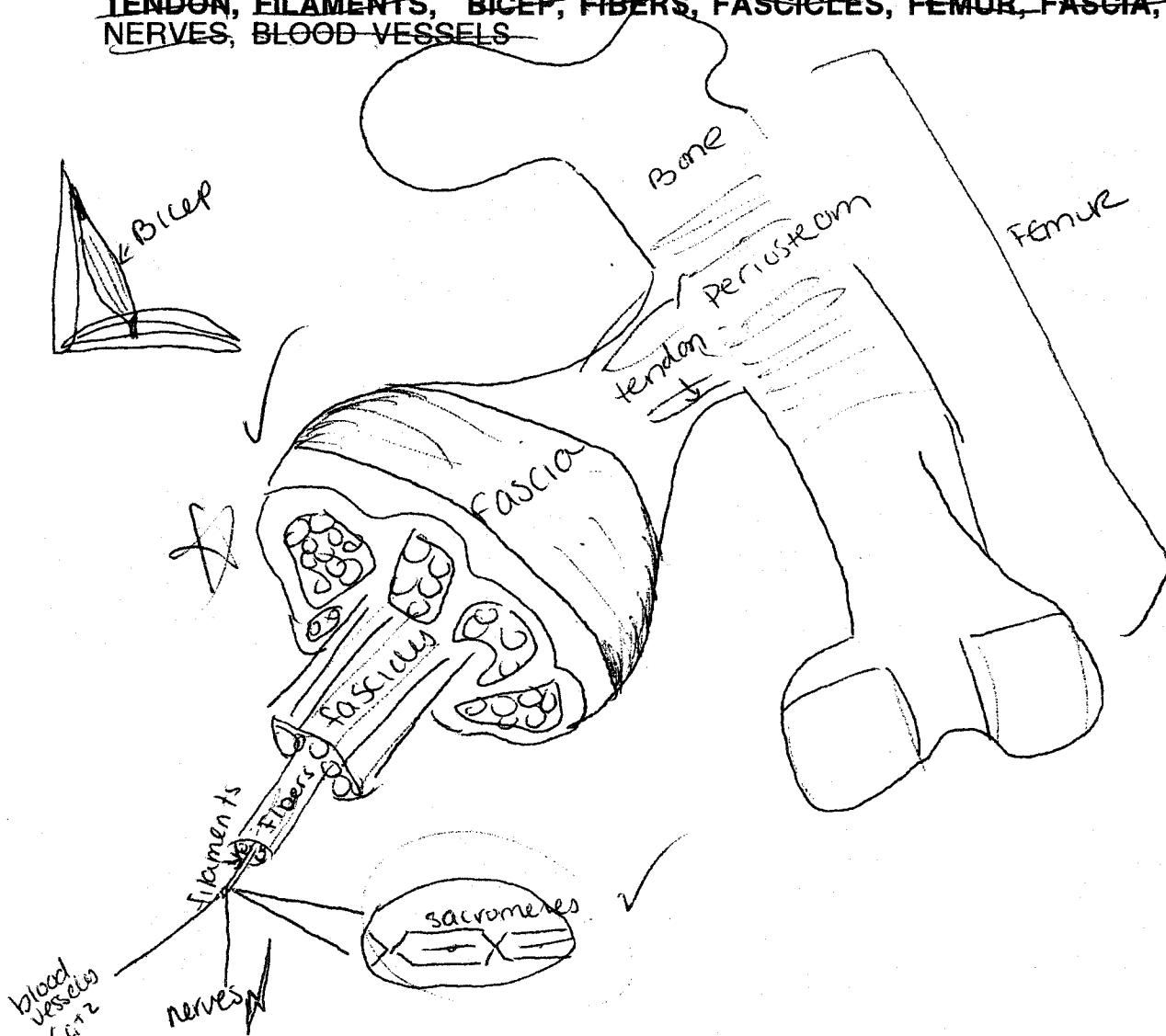




APPENDIX C:
Examples of Student Work

NAME Victoria 10-30-03
 QUIZ MUSCLE ANATOMY AND
 MUSCLES #1-10

USE THE FOLLOWING BOLDFACE TERMS TO SKETCH A DIAGRAM OF THE STRUCTURES OF A MUSCLE: **BONE, PERIOSTEUM, SARCOMERES, TENDON, FILAMENTS, BICEP, FIBERS, FASCICLES, FEMUR, FASCIA, NERVES, BLOOD VESSELS**



***Use a term from above and the ones that follow in parentheses to help identify the structure being described. (smooth, cardiac, skeletal)**

1. periosteum Wrapping around the bone.
2. cardiac Heart muscle, involuntary control.
3. skeletal 400+; example is a Bicep.
4. muscle Made of bundles of fascicles.
5. smooth Uterine contraction during fetal delivery.
6. tendon Connects muscle to bone.

CHP. 7 WRAP-UP VOCABULARY

1. WHAT ARE THE 3 PARTS OF THE COXAL BONE?

1. ~~coxae~~ pubis 2. illium 3. iscium
FROM WHICH PART WOULD MARROW BE DRAWN? illium

2. IS THE SYMPHISIS PUBIS A JOINT? Yes EXPLAIN WHY it meets the the the to coxal bones slightly flexible

3. WHEN AN ATHLETE GETS A HIP POINTER OR STINGER DURING COMPETITION, WHICH PART OF THE COXAL BONE IS AFFECTED? illium

4. WHAT MAJOR TENDON ATTACHES TO THE CALCANEUS BONE? Achilles tend.

5. TYPES OF JOINTS

TYPE OF JOINT	MOVEMENT	EXAMPLES
<u>ball/socket</u>	<u>ALL PLANES/ROTATION</u>	<u>femur/coxal</u> <u>humerus/scapula</u>
<u>immovable</u>	<u>NO MOVEMENT</u>	<u>Cranium.</u>
<u>pivot joint</u>	<u>ROTATION AROUND A CENTRAL AXIS</u>	<u>radius, ulna</u>
<u>hinge joint</u>	<u>FLEXION/ EXTENSION</u>	<u>femur tibia</u> <u>humerus ulna</u> <u>phalanges</u>
<u>slightly moveable</u>	<u>LIMITED MOVEMENT</u>	<u>vertebral column, symphysis pubis</u>

6. USE THE FOUR COLORS SHOWN IN ALL THE JOINT DIAGRAMS TO IDENTIFY THE ANATOMY OF A JOINT:

PINK: ligament; meniscus ~~WHITE:~~
BLUE: joint cavity; bursa; GREEN: articular cartilage
synovial membrane

7. WHICH JOINT MOVEMENT IS PERFORMED WHEN THE FOLLOWING OCCUR?

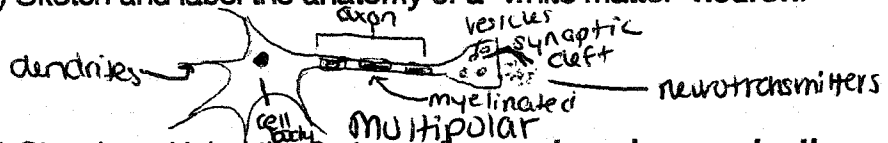
1. Supination "SLAP MY FIVE SOUL BROTHER!"
2. extension KNEE-JERK REFLEX.
3. abduction MALE DOG URINATING
4. plantar flexion STANDING ON YOUR TOES.
5. rotation TURNING A DOOR KNOB
6. adduction SOLDIERS LEG WHEN COMING TO ATTENTION.
7. pronation GETTING A STAMP ON YOUR HAND WHEN ENTERING A SPORTS EVENT.
8. elevation SHRUGGING YOUR SHOULDERS
9. hyperextension "SAY UNCLE!!!"
10. depression POUTING
11. flexion SHOWING YOUR "PYTHONS"
12. dorsal flexion CINDERELLA PUTTING ON THE GLASS SLIPPER
13. circumduction "WHOOPTY DOO!!!"
14. retract SMELLING A DIRTY DIAPER.
15. protract "HIT ME WITH YOUR BEST SHOT!!!"

-3 = 99%

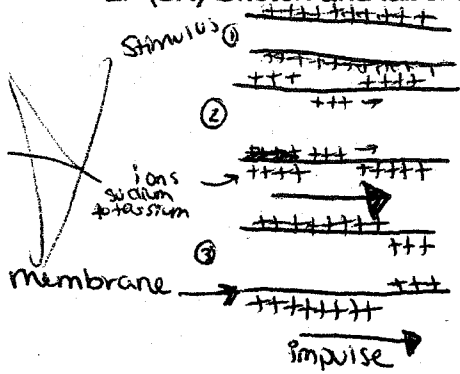
NAME Danielle
 CHP. 9 NERVOUS SYS. TEST

*Practicum:- 2

1. (5X) Sketch and label the anatomy of a "white matter" neuron.



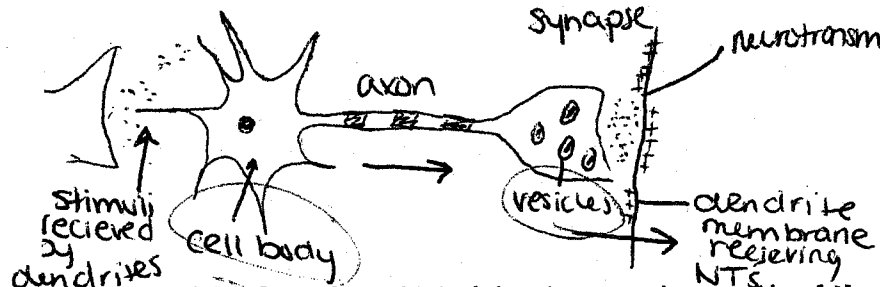
2. (8X) Sketch and label the 3 steps of nerve impulse conduction.



- 1) Stimulus received
- 2) depolarization
- 3) bio-electrical current created
- 4) repolarization
- 5) Domino effect

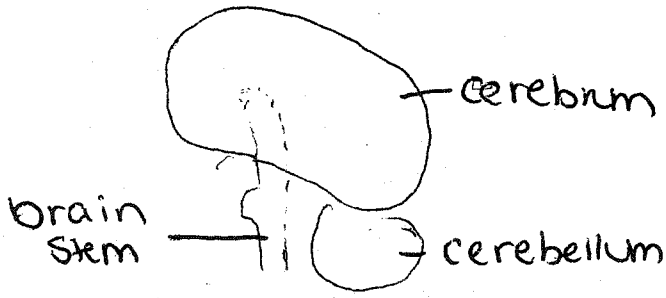
Sulphate phosphate \ominus
 Sodium Potassium \oplus

3. (5X) Sketch and label how an impulse travels from one neuron to another.

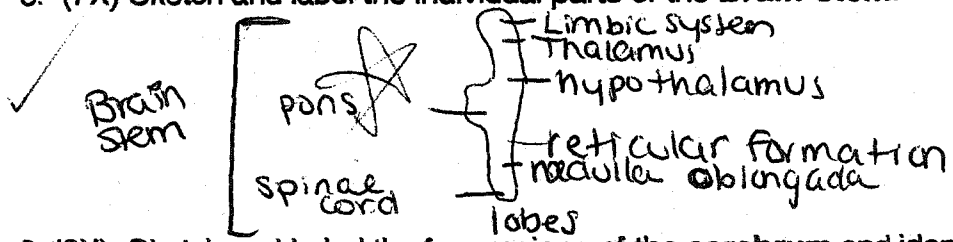


Impulse received by dendrites then follows axon and stimulates the release of NTS from the synaptic vesicles and they reach another neuron's dendrites and the impulse continues.

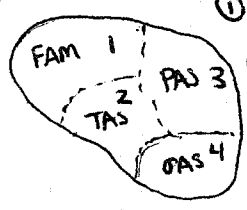
4. (3X) Sketch and label the three major parts of the brain.



5. (7X) Sketch and label the individual parts of the Brain Stem.



6. (6X) Sketch and Label the four regions of the cerebrum and identify the association, motor and sensory areas.



- ① Frontal lobe - association and motor.
- ② Temporal lobe - Association and sensory.
- ③ Parietal lobe - Association and sensory.
- ④ Occipital lobe - association and sensory.

7. (11X) **DEFINITIONS:** Answer as completely as possible for full credit.

- A. 10¹¹ - 10,000,000,000 neurons in the nervous system.
- B. CSF- cerebrospinal fluid. Fills and lines brain, in spinal column. produced by the choroid plexus.
- C. CLEFT- The space between the axon and the next neuron's dendrites. NTs travel across this to relay impulses.
- D. CORPUS COLLOSUM- stretches between the two halves of the brain (cerebrum) and allows communication between the two.
- E. DOPAMINE- produced by the basal ganglia. Inhibitory neurotransmitter. a lack of causes parkinson's disease. Helps muscle coordination.
- F. VENTRICLES- found in the brain allowing CSF and blood to flow through it and the meninges.
- G. CORTEX OF CEREBRUM- contains 75% of neurons; 4mm thick. Top part ~~of cerebrum~~
- I. ANS- Autonomic nervous system. controlled by Cerebellum goes to visceral functions and helps maintain ~~homeostasis~~ and brain system.
- J. CEREBELLUM- sends impulses to help you balance, keep hydrated, and helps coordination.
- K. PARKINSON'S- caused by a deficiency in the amount of dopamine produced. Symptoms include jerkiness in muscles, spasms, and paralysis.

8. (10X) GIVE THE PART OF THE **BRAIN** BEING DESCRIBED. (mid-brain, pons, thalamus, hypothalamus, reticular formation, med. oblongata, limbic system,

- limbic system EMOTIONS/EXPRESSIONS
- hypothalamus MAJOR A.N.S./ VISCERAL CONTROL CENTER
- reticular formation BRAIN'S STATE OF WAKEFULNESS
- pons RELAYS IMPULSES FOR CEREBELLUM
- Thalamus MAJOR RELAY CENTER JUST UNDER CEREBRUM
- med. oblongata TRACT FIBERS CROSS OVER; A.N.S. CENTER
- reticular formation DECREASED ACTIVITY LEADS TO COMA
- ~~reticular formation~~ REFLEX CENTER FOR EYES/EARS; DESCENDING TRACTS
- pons THE BULGE IN BRAIN STEM
- med. oblongata LOWEST PART OF BRAIN STEM CONNECTING TO SPINAL CORD.

Wow!

9. (3X) Name and sketch the three (3) different shapes of neurons?

1. bipolar 2. unipolar 3. multipolar
-

10. (3X) What are at three (3) functions of glia?

1. support 2. kill bacteria 3. myelinate axon

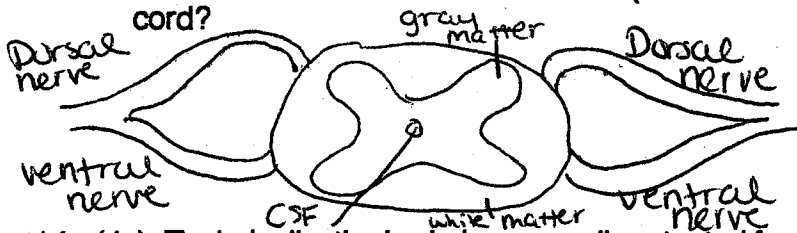
11. (2X) How is the **knee-jerk reflex** different from the **withdrawal reflex** in terms of the neurons involved?

knee jerk only involves sensory and motor neurons.
 withdrawal involves sensory, motor, and interneurons that relay the impulse to the brain for interpretation.

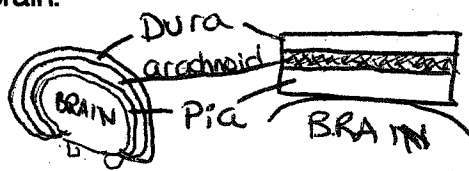
12. (4X) What are two types of **neurotransmitters** in neurons? Give an example of each

1. Inhibitory 2. Excitatory
 ex: morphine = GABA ex: cocaine = glutamate ACH
 dopamine

13. (4X) Sketch and label a **cross section of a spinal cord** highlighting where gray and white matter is located and the roots (dorsal/ventral) nerves take into and out of the cord?



14. (4x) Technically, the brain is very well protected from blunt trauma. Sketch and label the **meninges** of the brain.



15. (2X) How is the **basal ganglia** different from the **choroid plexus** in terms of what they produce? dopamine CSF

The Basal ganglia produces dopamine.
 The choroid plexus produces cerebrospinal fluid (CSF).

16. (3x) Sketch the difference btw. the following parts of the **cerebrum**:

1. convolution: small raised area. 2. sulcus: small indentation. 3. fissure: deep crevice.

17. (3X) What's the difference between a motor and sensory neuron? Where is an interneuron found?

Motor goes from the CNS to the PNS
 Sensory goes from a stimulus to the CNS
 Interneurons are found in the Brain and spinal cord - CNS.

18. (8X) Match the following cranial nerves with what they innervate. * Some may be used more than once!

- B 1. smell
- G 2. taste, tears, expressions
- A 3. muscles of tongue; swallowing
- E 4. equilibrium/hearing
- C 5. taste, tongue, pharynx
- F 6. muscles around eye
- D 7. retina/vision
- H 8. speech, heart, thorax, abdomen

- A. HYPOGLOSSAL
- B. OLFACTORY
- C. GLOSSOPHARYNGEAL
- D. OPTIC
- E. VESTIBULOCOCHLEAR
- F. OCULOMOTOR
- G. FACIAL
- H. VAGUS

19. (1X) What's the main function of the 2 branches (Symp/Parasymp) of the A.N.S.?

Sympathetic / Parasympathetic act as antagonistic nerves controlling actions of organs such as the eye dilation, muscle contraction of stomach, and the activation of salivary glands.

20. (65X) Diagram Identification

05.030 1. Central Nervous System 2. Spinal /Cranial Nerves

1a. Brain 1b. Spinal cord

05.031 D. direction of impulse 1/2. dendrites

3. myelin 7. nucleus

10. cell body 13. synaptic cleft

05.032 A. polarized membrane B. depolarization

C. repolarization / domino effect
 F. depolarization - phosphate/sulfate out G. repolarization - potassium/sodium out

H. direction of impulse 2. membrane

05.033 B. Synaptic cleft C. direction of impulse along membrane

3. cell body 4. axon

5. mitochondria 6. neurotransmitters inside synaptic vesicles

8. neurotransmitter 10. membrane of another dendrite being depolarized

05.034 D. enters interneurons to ^{brain} 2. motor neuron
3. muscle (bicep) 5. sensory neuron
6. spinal column 9. tracts

05.035 A. Sympathetic nerves B. Parasympathetic nerves
c. Brain g. lumbar region

*Give the organ for each number.

1. pupils - eyes
2. salivary glands
3. cardiac heart
4. lungs
5. stomach / pancreas
6. liver
7. kidney
8. intestines (sm, lg)
9. bladder

05.036 Picture A 1. Frontal lobe
3. occipital lobe 4. temporal lobe
5/6. brain stem / spine *
* *

05.038
3. sinuses cavities 4. frontal lobe
5. dura mater 6. arachnoid mater
7. parietal lobe 8. corpus callosum
9. Thalamus 10. Cerebrum
11. Pons 12. medulla oblongata
13. spinal cord 14. vertebra

21. (10x) Research Topics: Provide a basic explanation for any 12 of the Nervous System disease/disorders listed on the side board.

1. Dyslexia - disorder when the brain has problems interpreting written letters on a screen. In cerebrum. Symptoms include depression, difficulty learning, and anger. Treatment - counseling.
2. Bipolar disorder - cerebrum. Symptoms include rapid mood swings between depression and happiness. Limbic system - emotions affected. Treatment includes counseling and/or medicines.
3. Alzheimers - cerebrum - neurons no longer able to relay messages. Symptoms include loss of memory, confusion, eventual death. Degeneration of brain tissue. No known cause, No known cure.
4. Epilepsy - cerebrum - rapid electrical activity on surface of cerebrum causes convulsing and seizures. Could be genetic. Symptoms are seizures triggered by lights, mood change, or without warning. Medicine administered.
5. Stroke - cerebrum - caused by lack of blood to brain. Tissues can die. May lose function on opposite side of body. Can be treated if kid is given immediately. Medication administered. Clogged arteries could be a factor.
6. Nerve Regeneration - uses ~~microscopic~~ ^{microscopic} threads to guide neuron growth back together after trauma. Regain function. Tested and succeeded in lab rats. PNS.
7. Mult. Sclerosis - muscle ~~degeneration~~ ^{paralysis}. Myelin degeneration and loss of ability to use muscle. Cause unknown. Medication administered.
8. Meniers disease - fluid in inner ear. Loss of hearing / difficulty. Treat w/ ~~medication~~ medication. eases range -
9. Concussions - cerebrum - brain trauma, usually a golt to the head. Symptoms include head aches, pain, sensitivity to light. Treated by rest could take anywhere from a week to a month to recover. Swelling/bleedin^g of brain.
10. Bell's palsy - cerebrum facial nerve - face draps as a symptom. NO cure yet. Muscles in face particularly are unable to be stimulated causing that side of the face to droop. Cause unknown. could be genetic.
11. Tourette Syndrome - cerebrum / brain stem - PNS - symptoms include shouting, nervous tics, twitching, mumbling. Treatable with medication and counseling helps. No cure - could be genetic.
12. Schizophrenia (multiple personality syndrome) - limbic system, cerebrum, multiple personalities. Rapid changes in mood. Cause unknown. Treatment - counseling / medicine.

1. HOW DOES THE PANCREAS DEMONSTRATE AN EXOCRINE AND ENDOCRINE FUNCTION?

EXOCRINE- It produces enzymes that aid in digestion.

ENDOCRINE- It produces Alpha and Beta cells that produce insulin and ~~and~~ ^{glucagon} ~~that~~ control blood sugar levels (hormones)

2. WHY ARE THE NERVOUS AND ENDOCRINE SYSTEMS COMPARED TO EACH OTHER?

They both send messages throughout the body to help maintain homeostasis. Nervous uses nerve pathways and Endocrine uses blood.

3. GIVE ONE EXAMPLE OF A NEG. FEEDBACK SYSTEM STUDIED IN THIS CHAPTER.

The parathyroid hormone increases blood calcium. when the level exceeds that of normal, it is called negative feedback when the body starts producing calcitonin to bring the levels down. (↑clasts, ↓blasts)

4. EXPLAIN THE DIFFERENCE BETWEEN THE 2 TYPES OF DIABETES MELLITUS.

TYPE I

Childhood onset - the body does not produce a sufficient amount of insulin. Blood sugar can go too high.

TYPE II

Adult onset - the cells lose sensitivity to insulin - glucose cannot enter the cell.

5. HOW IS GLUCAGON DIFFERENT/THE SAME AS CORTISOL?

DIFFERENT

glucagon makes glucose from glycogen and cortisol maintains blood sugar levels between meals.

THE SAME

they both help control blood sugar levels.

6. WHAT'S MEANT BY AND WHAT CONTROLS "CIRCADIAN RHYTHMS"?

Melatonin is the chemical that controls circadian rhythms. It's produced in the pineal gland. Circadian rhythms are the patterns of sleep and awake in relation to night and day.

7. DEFINE HORMONE AND TARGET CELL.

~~8. HOW ARE LH AND FSH RELATED?~~

Hormones are directed to target cells.

They alert these cells by traveling through the blood and stimulate body functions to help maintain homeostasis.

8. HOW ARE LH AND FSH RELATED?

LH and FSH both help control sex cells / hormones and are active during puberty. Related to reproduction.

DIFFERENT?

LH controls the hormones such as estrogen and testosterone
FSH controls the release of sperm and egg, the actual sex cells.

9. UNDER WHAT CIRCUMSTANCES AND WHEN DO THE HORMONES PRL AND OT SECRETE?

OT- happens when a woman is giving birth to a baby. ↑ uterine contractions.

PRL- happens when a woman has given birth and causes the mammary glands to produce milk for the baby.

10. WHY ARE CALCITONIN AND PTH ANTAGONISTIC HORMONES?

Calcitonin lowers blood calcium (↑ blasts ↓ clasts) but parathyroid hormones increase blood calcium (↓ blasts ↑ clasts) Uses negative feedback.

I.D. THE ROLE OF OSTEOCYTES (-blasts/-clasts) for each hormone.

In calcitonin, the osteoblasts build more bone and clasts do not release so much into the blood. With PTH, the blast's functions are inhibited and the clasts release more calcium into the blood.

11. HOW WOULD THE AMOUNT OF ADH SECRETED DIFFER IN THE FOLLOWING SITUATIONS:

1.) LOST IN THE HOT, DRY DESERT WITH NO WATER

A lot of Antidiuretic hormone would be released so the body would conserve water. It would tell the kidneys to keep as much fluid as possible in the body and not filter it all out.

2.) DRINK A KEG OF SODA?

Only small amount of ADH would be secreted because the body wants to secrete some of that water. It does not need to conserve it because there is already too much.

12. WHAT'S THE RELATIONSHIP BETWEEN GH AND MITOSIS?

growth hormone from the pituitary gland stimulates mitosis and allow the body to grow. Too much → gigantism too little - dwarfism.

13. HOW DOES DIABETES INSIPIDUS DIFFER FROM DIABETES MELLITUS IN TERMS OF GLANDS ACTIVATED AND SUBSEQUENT ISSUES?

Diabetes insipidus happens when the body does not respond to ADH and ^{kidneys} excrete too much water. (30 liters!) Diabetes mellitus has to do with the pancreas and Alpha / Beta cells and problems w/ blood sugar levels because of either insensitivity to insulin or not enough being produced.

14. WHAT ARE 4 ORGAN SYSTEMS EPI/NOREPINEPHRINE EFFECT?

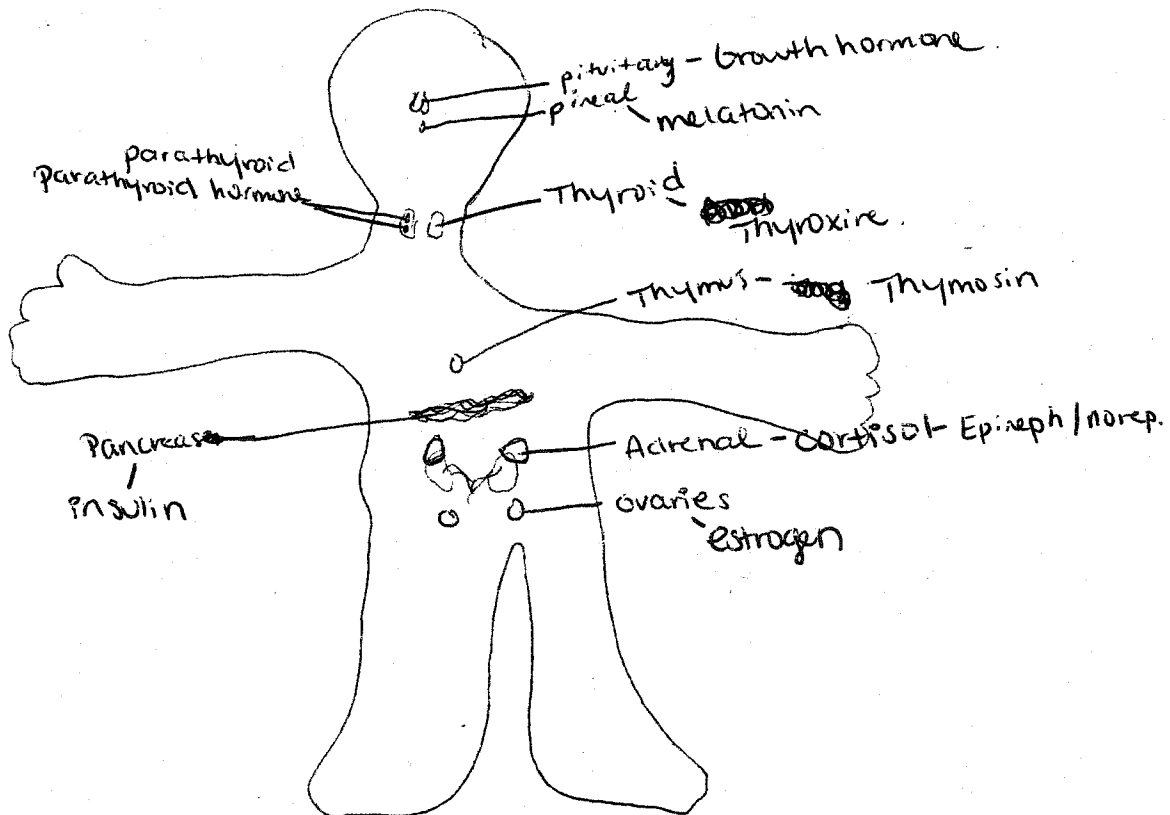
1. respiratory, lungs
2. possibly excretory, urination
3. Cardiac, heart
4. Skin organs - sweat glands.

15. WHAT'S UNIQUE ABOUT THE THYMUS GLAND AS YOU AGE?

It decreases in size as you age. It's large in children but shrinks considerably in adults.
 WHY IS THIS NOT A PROBLEM?

As children, we cannot fight off diseases and are not immune to many things. This gland ↑ production of WBCs. As we age, we are better equipped to deal w/ diseases and no longer need the thymus to help.

16. SKETCH AN OUTLINE OF A FEMALE AND LABEL WHERE 8 GLANDS ARE LOCATED. NEXT TO EACH GLAND, IDENTIFY THE NAME OF ONE HORMONE SECRETED.



17. WHAT ARE THE NAMES OF THE CELLS WITHIN AND THE 2 HORMONES SECRETED BY THE ISLETS OF LANGERHANS:

- | | |
|-----------------------|--------------------------|
| 1. Cell: <u>Alpha</u> | Hormone: <u>glucagon</u> |
| 2. Cell: <u>Beta</u> | Hormone: <u>insulin</u> |

Match the hormone with an action (some may be used twice!; #1-19/H-V) and a gland with a location (#20-25/A-G)

- | | |
|---|-------------------------|
| 1. <u>N</u> increases metabolism; use of oxygen | A. THYROID |
| 2. <u>H</u> increases mitosis; cell reproduction | B. PARATHYROID |
| 3. <u>O</u> decreases Ca in blood | C. PANCREAS |
| 4. <u>I</u> increases milk production expecting mothers | D. PINEAL |
| 5. <u>M</u> increases uterine contractions for birth | E. THYMUS |
| 6. <u>J</u> increases sex cell development | F. ADRENAL |
| 7. <u>L</u> water conservation hormone | G. PITUITARY |
| 8. <u>K</u> eggs released females; male testosterone levels | H. GH |
| 9. <u>V</u> increases w.b.c's in infancy | X PRL |
| 10. <u>P</u> increases Ca levels in blood | X FSH |
| 11. <u>U</u> controls circadian rhythms | X LH |
| 12. <u>Q</u> fight/flight hormone | X ADH |
| 13. <u>S</u> changes glycogen to glucose | M OT |
| 14. <u>R</u> maintain glucose concentrations btw. meals | N. Thyroxine |
| 15. <u>T</u> helps diffusion of glucose into cell | Ø Calcitonin |
| 16. <u>P</u> increase osteodasts; decrease -blasts | P. PTH |
| 17. <u>T</u> excess glucose to liver to make glycogen | Q. Epineph/ Norepineph |
| 18. <u>O</u> decrease osteoclasts; increase-blasts | R. Cortisol |
| 19. <u>J</u> sperm/egg cell development | S. Glucagon |
| 20. <u>G</u> base of brain | T. Insulin |
| 21. <u>A</u> anterior trachea | U. Melatonin |
| 22. <u>E</u> heart/sternum | V. Thymosin |
| 23. <u>F</u> atop kidney | |
| 24. <u>C</u> posterior to stomach | |
| 25. <u>B</u> posterior to thyroid gland | |

Match the disease with a description

1. E. DWARFISM
2. ~~P~~ P. DIABETES INSIPIDOUS
3. N. CRETINISM
4. O. GOITERS
5. C. HYPERTHYROIDISM
6. M^H. ACROMEGALY
7. K. ADDISON'S
8. J. CUSHING'S
9. F. GIGANTISM
10. G. H.R.T.
11. L. HYPOTHYROIDISM
12. D. PROSTATE CANCER
13. I. OLIGOMENORRHEA/
AMENORRHEA
14. B. MENOPAUSE
15. A. S.A.D.

- ~~X~~ a. depression during winter months; increased melatonin levels; get outside; fluorescent lights
- ~~X~~ b. women btw. 45-55; hot flashes mood swings, estrogen therapy
- ~~X~~ c. increased thyroxine produced; rapid heart and breathing rates when at rest
- ~~X~~ d. enlargement of male's semen gland; size of a walnut, pain during urination/ejaculation
- ~~X~~ e. genetic condition; short stature, decreased GH
- ~~X~~ f. increased GH secretion; excessive growth caused by pit. tumor
- ~~X~~ g. estrogen replacement for post-menopausal women, linked to cancers
- ~~X~~ h. tumor on Pit. gl causes brow and mandible to protrude
- ~~X~~ i. absence or suppression of menstruation; due to extreme exercise, stress
- ~~X~~ j. increased cortisol produced; due to taking corticosteroids for a long time, fat stored in thorax and shoulders
- ~~X~~ k. autoimmune disorder against adrenal gland; decreased cortisol...fatigue, weight loss
- ~~X~~ l. decreased thyroxine production; slower metabolism, fatigue, weakness
- ~~X~~ m. too much growth hormone causes enlargement of bones in face, hands, feet;
- ~~X~~ n. a form of hypothyroidism; poorly developed skeletal system
- ~~X~~ o. enlargement of thyroid gland; swollen neck; need to get iodine into diet

~~P~~

4-90

Name Victoria
CHP. 12' F. Q. #1

1. DEFINE RESPIRATION-

2. GIVE THE FOUR (4) PARTS OF RESPIRATION:

1. breathing in-out
2. diffusion in aveoli
3. transportation to tissues
4. cellular respiration

3. HOW IS INHALED AIR WARMED BEFORE IT ENTERS THE LUNGS?

By running over blood vessels and warm passageways

4. GIVE TWO FUNCTIONS OF THE MUCOUS MEMBRANES IN YOUR NASAL CAVITY:

1. collect dust + debris
2. lubricate

5. WHAT ROLE DO THE PARANASAL SINUSES PLAY?

Give sand quality, reduce weight of skull

6. WHAT'S THE SIGNIFICANT DIFFERENCE BETWEEN TRUE AND FALSE VOCAL CORDS IN THE LARYNX?

True vocal cords actually change sand in voice false moves the epiglottis to shut air way

6b WHAT'S THE FUNCTION OF THE FALSE VOCAL CORD?

to shut epiglottis or pull on it

7. WHAT'S THE DIFFERENCE BETWEEN THE EPIGLOTTIS AND GLOTTIS?

Epiglottis is the flap that closes over the trachea to prevent food from entering, glottis is the opening of the trachea

8. HOW ARE NODULES AND LARYNGITIS RELATED?

Both are inflammations, disease associated of the vocal cords. Nodules are growths, laryngitis is inflammation.

9. WHERE ARE THEY AND WHAT ARE 2 FUNCTIONS/PURPOSES OF THE C-SHAPED CARTILAGINOUS RINGS?

around the trachea to prevent it from collapsing during breathing and to allow the esophagus room to expand for bowls.

10. HOW ARE BRONCHIOLES AND BRONCHI RELATED?

Bronchioles are the smaller structures connected to the Bronchi, flow air to aveoli

APPENDIX D:
Examples of Dissection Worksheets

CAT OBSERVATION-SKELETAL SYSTEM

AXIAL SK. APPENDICULAR SK.

DORSAL SURFACE VENTRAL SURFACE

CRANIUM

MANDIBLE MAXILLA FRONTAL TEMPORAL NASAL PARIETAL
ZYGOMATIC OCCIPITAL PALATINE SPHENOID LACRIMAL

VERTEBRAE

CERVICAL THORACIC LUMBAR

THORACIC REGION

PECTORAL GIRDLE CLAVICLE
HUMERUS STERNUM-BODY, XYPHOID PROCESS, MANUBRIUM
SCAPULA TRUE RIBS FALSE RIBS FLOATING RIBS
COSTAL CARTILAGE

PELVIC GIRDLE

COXAL ILLIUM ISCHIUM PUBIS SACRUM COCCYX

APPENDAGES

RADIUS ULNACARPALS METACARPALS
PHALANGES TARSALS METATARSALS CALCANEUS BONE
ACHILLES TENDON FEMUR PATELLA TIBIA FIBULA

JOINTS

HINGE (2 AREAS) BALL&SOCKET (2 AREAS)

IMMOVABLE SLIGHTLY MOVABLE (2) PIVOT

CHP. 10 RESEARCH TOPICS

1

TONOMETRY
CONJUNCTIVITIS

2

GRAVE'S DISEASE
MENIERE'S DISEASE

3

ASTIGMATISM
TINNITIS

4

VERTIGO
STYES

5

SNELLEN TEST
BLEPHARITIS

6

PTOSIS
DIPLOPIA

7

MYOPIA
MACULAR DEGENERATION

8

NIGHT BLINDNESS
STRABISMUS

9

BAROTRAUMA
LASIK SURGERY-LASER KERATOTOMY

10

HYPEROPIA
LABYRINTHITIS

11

SWIMMER'S EAR
OTOSCLEROSIS

12

RUPTURED EARDRUM
ALLERGIC RHINITIS

13

DEVIATED SEPTUM
NASAL POLYPS

14

SINUSITIS
MOTION SICKNESS

LAB: ENDOCRINE SYSTEM/ ORGANS

SKELETAL SYSTEM IDENTIFICATION

STERNUM	COSTAL CARTILAGE	THORACIC RIBS
FLOATING RIBS	XYPHOID PROCESS	CLAVICLES

MUSCULAR SYSTEM IDENTIFICATION

RECTUS ABDOMINUS	OBLIQUES	PECTORALIS MAJOR
LATISSIMUS DORSI	TRAPEZIUS	SERRATUS ANTERIOR

ORGAN IDENTIFICATION

LUNGS	HEART	DIAPHRAGM
TRACHEA	LIVER	STOMACH
PANCREAS	SMALL INTESTINE	LG. INTESTINE
ESOPHAGUS	KIDNEYS	URETER
BLADDER	SPLEEN	

ENDOCRINE SYSTEM IDENTIFICATION ***GLAND & HORMONE

PITUITARY	THYROID	PARATHYROID	PANCREAS
ADRENAL	OVARIES/TESTES?	PINEAL	THYMUS
OVARIES or TESTES			

DIGESTIVE SYSTEM CAT EXPLORATION

Be sure to open the sternal cavity (muscle and bone) and abdominal cavity (muscle) to explore the organs listed below. DON'T cut too deep or remove any organs as we want to preserve them for later use. Be prepared for an oral quiz on today's dissected anatomy!

NON-DIGESTIVE SYSTEM ORGAN EXPLORATION

1. HEART
2. L/R LUNGS
3. TRACHEA (WINDPIPE);
4. DIAPHRAGM
5. SPLEEN (left side of cat)
6. LIVER/GALL BLADDER
7. L/R KIDNEYS
8. PANCREAS

GLANDS

1. ADRENALS
2. THYROID
3. PARATHYROID
4. OVARY/TESTES
5. PANCREAS
6. THYMUS

DIGESTIVE SYSTEM EXPLORATION

1. TEETH *molars, cuspids, incisors
2. PAPILLAE
3. SUBLINGUAL GLAND? SUBMAXILLARY GLAND?
4. HARD AND SOFT PALATE
5. ESOPHAGUS *Locate area where esophagus passes through Diaphragm
6. STOMACH *Locate both Sphincters *I.D. Rugae by doing a cross sectional cut
7. DUODENUM OF SMALL INTESTINE *Any Bile or Pancreatic Ducts in the vicinity?
8. Cross section of JEJUNUM and ILEUM *Any Chyme?
9. MESENTERY GREATER OMENTUM? Drape-like tissue over intestines
10. APPENDIX?
11. LG. INTESTINE: ASCENDING , TRANSVERSE , DESCENDING , SIGMOID
*Do a cross section in each area to evaluate feces consistency
12. RECTUM AND ANAL SPHINCTER

RESPIRATORY SYSTEM
CAT DISSECTION

DIGESTIVE SYSTEM ANATOMY REVIEW

1. ESOPHAGUS
2. DIAPHRAGM

3. STOMACH *2 SPHINCTERS?
4. DUODENUM, JEJUNEM, ILEUM

5. APPENDIX
6. ASCENDING, TRANSVERSE, DESCENDING, SIGMOID COLON

7. RECTUM
8. PANCREAS

9. LIVER
10. GALL BLADDER

11. MESENTERY/OMENTUM
12. L/R KIDNEY 13. SPLEEN

RESPIRATORY SYSTEM ANATOMY

- | | |
|--|-------------------------|
| 1. BILOBED LEFT AND RIGHT LUNGS | 15. INTERCOSTAL MUSCLES |
| 2. DIAPHRAGM | 16. SERRATUS ANT MUSC. |
| 3. LARYNX | 17. RECTUS ABDOM. MUSC. |
| 4. EPIGLOTTIS | 18. STERNOCLEIDO. MUSC. |
| 5. GLOTTIS | 19. PULMONARY ARTERY |
| 6. TRACHEA | 20. PULMONARY VEIN |
| 7. C-RINGS | 21. AORTA |
| 8. LEFT/RIGHT BRONCHI | 22. CAROTID ARTERY |
| 9. BRONCHIOLES | |
| 10. ALVEOLI? | |
| 11. PLEURAL CAVITY | |
| 12. PARIETAL PLEURA | |
| 13. VISCERAL PLEURA | |
| 14. CROSS SECTION OF A LOBE-Look for holes indicating bronchioles, alveoli ducts or blood vessels. | |

APPENDIX E:
IRB Approval Form



UNIVERSITY of NEW HAMPSHIRE

September 19, 2003

York, Katharine
Natural Resources - James Hall

IRB #: 2862

Study: Connections in Dissection: How student conceptions of dissection change over the course of a school year

Approval Expiration Date: 01/10/2004 **Modification Approval Date:** 09/16/2003

Modification: Change in Title

The Institutional Review Board for the Protection of Human Subjects in Research (IRB) has reviewed and approved your modification to this study, as indicated above. Further changes in your study must be submitted to the IRB for review and approval prior to implementation.

Approval for this protocol expires on the date indicated above. At the end of the approval period you will be asked to submit a report with regard to the involvement of human subjects in this study. If your study is still active, you may request an extension of IRB approval.

Researchers who conduct studies involving human subjects have responsibilities as outlined in the document, *Responsibilities of Directors of Research Studies Involving Human Subjects*. This document is available at <http://www.unh.edu/osr/compliance/IRB.html> or from me.

If you have questions or concerns about your study or this approval, please feel free to contact me at 603-862-2003 or Julie.simpson@unh.edu. Please refer to the IRB # above in all correspondence related to this study. The IRB wishes you success with your research.

For the IRB,

Julie F. Simpson
Regulatory Compliance Manager

cc: File
John E. Carroll

**Regulatory Compliance Office, Office of Sponsored Research, Service Building,
51 College Road, Durham, NH 03824-3585 * Fax: 603-862-3564**