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Through the Looking Glass: Examining the Practice of Science Classroom Dissection with a Multi-faceted Lens

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Through the Looking Glass:

Examining the Practice of Science Classroom Dissection with a Multi-faceted Lens

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Signature Sheet

This thesis, written under the direction of the candidate's thesis advisor and approved by the Chair of the Master's program, has been presented to and accepted by the Faculty of Education in partial fulfillment of the requirements for the degree of Master of Science. The content and research methodologies presented in this work represent the work of the candidate alone

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Abstract

Dissection of lab specimens is a common procedure in science classrooms, yet there are many unasked and unexamined questions relating to this practice. In addition to ethical considerations, there are personal and environmental health impacts of using conventional dissection, which has historically included animals and animal organs embalmed in preservative chemicals. The efficacy of using dissection as a learning tool is worth examining.

The purpose of this thesis is to ask, analyze, and examine the multi-faceted questions associated with the use of dissection in the general science classroom. In addition, it is an invitation to engage a discussion about the possible negative consequences of using dissection, and to encourage consideration of alternatives that might be more ethically, pedagogically, and environmentally sound than existing practices.

A review of the literature reveals that as many as 75% of classroom biology teachers use dissection and, generally, it is widely accepted and lauded as an important tool for learning about anatomy and physiology. Teachers express concern for a variety of issues associated with dissection, primarily student health and safety, and respect for lab specimens. As a response to these and other concerns, alternatives to physical dissection have been developed. These, however, are not widely used for a variety of reasons.

The field research completed in this study is a qualitative analysis of the intellectual and emotional attitudes and beliefs associated with using dissection in the general science classroom. Additional perspectives are represented, and incorporated into the literature review, by interviews with experts in the fields of solid waste management and conservation biology.

Chapter 1 Introduction

As I have grown as a person and educator, I have come to find myself questioning the process of using classroom dissection. It is a procedure that generates a spectrum of mixed emotions, while also sacrificing animal lives to create an unquantified volume of biological waste. In addition, it does not necessarily leave students with a lasting body of knowledge or an educational experience that they value.

Our society is faced with increasingly threatening environmental challenges, such as polluted air and water, exposure to industrial-era chemicals that can cause a range of human health problems, global climate change, diminishing resources, and excessive consumption. Considering this reality, it is important to ask what the true educational value of dissection is, and how it might be contributing to and exacerbating these concerns. In addition, there are moral, ethical, and psycho-emotional ramifications regarding the use of dissection in the classroom. Educators and students could question these as a means to understand the depth and breadth of effect elicited by using dissection.

Statement of Problem

Dissection is a widespread practice in the classroom but has many costs that are neither examined, nor discussed, among teaching professionals. It is important to question why physical dissection remains embedded in the practice of many general biology classrooms, considering the availability of alternatives and the range of sub-optimal results of its use. If dissection use is because of convention, convenience, or the belief that it is the best way for students to learn animal anatomy, these reasons can be challenged. In addition, it is argued that the failure to

scrutinize the environmental and ecological impacts of procuring and discarding animal specimens is symbolic of a greater challenge in the culture of schools, education, and our society, which is that the full cycle of consumptive practices are not being addressed.

Purpose Statement

The purpose of this study is to examine the practice of classroom dissection by reviewing its advantages and disadvantages. In simplest terms, what are the costs and benefits of using dissection in a general science classroom?

Research Question

If the practice of classroom dissection is examined through a critical lens, what is to be discovered about its efficacy, affect, and environmental impact? In the context of this research paper, efficacy refers to the ability of this tool to help students reach learning goals; how effective is dissection? Affect refers to the psychological, emotional, cognitive, and moral consequences using dissection might have on students. Environmental impact refers to the effect dissection has on natural cycles, wildlife populations, and ecological health.

Theoretical Rationale

The theoretical framework for this thesis is threefold, correlating to science literary, humane education, and the environmental movement. Science literacy refers to knowledge of science-related concepts as well as the ability to apply skills used in the scientific thinking process, such as observing, communicating, comparing, organizing, relating, inferring, and applying (Lowery, as cited in Hart, Wood, & Hart, 2008, p. 60). Science literacy is a goal of science education, and

the pedagogical practices used by teachers, such as direct instruction, project-based learning, experiments, and labs, are some of the tools through which science literacy is developed in students.

The American Heritage Dictionary defines *humane* as kind or compassionate (1994, p. 408); thus, a humane education is an education that embodies the values of kindness and compassion in its treatment of animal, and, presumably, human, subjects. The Encyclopedia of Animal Rights and Animal Welfare states that humane education can take two approaches, one being to develop guidelines about accepted and unaccepted activities that govern the use of animals in education, and the other which engages the "process of considering issues of acquisition, care and use, and disposition of nonhuman animals in educational activities" (Bekoff & Meaney, 1998, p. 142). Organizations such as Animalearn, Interniche, and The Humane Society of the United States (HSUS) advocate compassionate educational practices and provide resources for educators seeking alternatives to dissection. The Animalearn website states, "we work to foster an awareness of and a respect for animals used in education. We strive to eliminate the use of animals in education and we are dedicated to assisting educators and students to find the most effective non-animal methods to teach and study science" (Animalearn, 2013a). Interniche is an organization dedicated to providing "high quality, humane education" in the fields of biological and medical sciences. Its goal is to reduce the suffering and death of specimens bound for classrooms and to advocate for students seeking alternatives. Similarly, the HSUS advocates the elimination of dissection in the classroom on the grounds of morality, ethics, and animal welfare/rights.

Lastly, the environmental movement began in the 1960s as a result of Carson's, *Silent Spring*, (1962). This book drew attention to the unintended consequences of pesticide use and

illuminated the reality that human practices and behaviors are able to devastate the ecology of a place. Carson's work is a cornerstone of the environmental movement, which has grown over the past several decades to include international, national, and local organizations such as The Word Wildlife Fund, The Sierra Club, The Center for Biological Diversity, Turtle Island Restoration Network, and The Oceanic Society, to name only a few of many.

Synthesizing the three contexts, one can begin to create a framework through which questioning the practice and process of dissection becomes essential. Specifically, in the context of science literacy, what are the goals of using dissection and are they being met? From a humane education perspective, what are the psychological, moral, and ethical implications of using dissection in a conventional manner? From an environmental perspective, what could educators investigate about the whole cycle of accessing the animals to be dissected, then preserving, using, and disposing of them? In summary, educators are asked to align the imperative of science literacy within a framework of humane, compassionate, environmentally sound education.

Assumptions

This paper is in reference, specifically, to dissection performed by high school students in a required, two-year life science course. At the outset of the writing process, the researcher believes that dissection can be a valuable hands-on learning experience that fulfills students' curiosity, yet its costs may not outweigh its benefits. It is not necessary for general biology students to see the internal anatomy of lab specimens. If dissection is used, it must be used in a thoughtful context with adequate building of background knowledge and scaffolding on the part of the classroom teacher; this includes a discussion about the potential conflict and controversy

about using lab specimens. Dissection is contrary to humane education as it does not consider and respond to the ethics of procuring and euthanizing animals to use in the classroom. Reflecting upon these concerns, science education might better focus on holistic, ecosystems-based curricula that foster a broad ecological and environmental science perspective. Lastly, educators are dedicated practitioners who work intensively to educate and mentor their students. Many teachers would benefit from support and encouragement to address some of the questions raised within this paper, and create innovative classroom practices that address the environmental health and social challenges of our time.

Background and Need

In its fact sheet on classroom dissection, the Humane Society of the United States suggests that "killing animals for classroom dissection causes animal suffering, cheapens the value of life, and depletes wild animal populations" (Balcolmbe & HSUS, 1998, p. 2). It also outlines important background information about different species of animals used for dissection and how they are sourced, methods biological supply companies use to obtain animals, student feelings toward dissection, legislation about using dissection in the classroom, as well as alternatives to, and pros and cons of, using dissection.

Simultaneously, in its position statement on using animals in the classroom, the National Science Teachers Association (NSTA, 2008) suggests that, "student interaction with organisms is one of the most effective methods of achieving many of the goals outlined in the *National Science Education Standards (NSES)*" (p. 1). The paper then outlines the classroom use of live animals, and of dissection, as means to achieve the aforementioned "interaction with organisms", and suggests that if teachers choose to use dissection, it can help students "develop skills of

observation and comparison, discover the shared and unique structures and processes of specific organisms, and develop a greater appreciation of the complexity of life" (NSTA, 2008, p. 2).

Summary

There is a range of thought, feeling, and opinion about the utility and appropriateness of dissection in the classroom. This spectrum of outcome encourages educators to look more deeply into the costs and benefits of dissection in order to engage a discussion about its role in our classrooms and science curricula.

Chapter 2 Review of the Literature

Introduction

A review of the academic literature on the subject of dissection includes a full range of emotional responses, as documented by researchers, teachers, and students. In addition, its efficacy as a teaching and learning tool has been examined, and the research illustrates both positive and negative outcomes.

Some suggest that animal rights activists threaten the use of dissection in the classroom (Dharmapalan, 2012). Others suggest that dissection is "speciesist" because it requires a valuation of some life forms over others (Gilmore, 1991). One dissection advocate feels that "there are no similarly useful or popular activities to introduce students to the skills and concepts" that dissection is designed to teach (Bernstein, 2000, p. 374), yet acknowledges teachers are not using it in the most well developed context, thus reducing its effectiveness. In their book, *Why Dissection?*, Hart, Wood, and Hart (2008) state that dissection is commonplace in high schools, yet is being "phased out in professional medical and veterinary schools" (p. 17), and they question why this practice persists at the pre-college level.

Researchers have studied the outcome of using dissection versus using dissection alternatives to help students reach learning goals. Results show that alternatives work, yet some educators prefer physical dissection. Overall, the psycho-emotional and educational mindset toward dissection is as diverse and varied as the population of students and teachers who decide whether or not to use it.

Historical Context

For over two millennia, artists, scientists, and medical students, including historical figures such as Aristotle, Galen-a second century physician, Vesalius-a sixteenth century anatomist, Leonardo da Vinci, and Michelangelo, have used dissection as a tool for learning anatomy and physiology (Hart, et al., 2008).

During the 1500s Andreas Vesalius, founder of modern human anatomy, popularized dissection as a tool for teaching and research (Hart, et al., 2008, p. 22**)**. At that time, human cadavers were the preferred subjects of dissection, however, their use became challenging because of legal and ethical concerns, and, as a result, the use of animal specimens for dissection became increasingly common.

During the early 1900s, frog dissection became an established practice in the college classroom, and later it was introduced to the high school classrooms. Dead frogs became commercially available for educational use by 1920, and the practice of dissecting them in high school classrooms became commonplace. After the 1960 Biological Science Curriculum Study was completed to create science curricula for elementary and secondary students, there was an increase in the use of, and diversification of the different species of animals used in, high school classroom dissection (American Antivivisection Society, 2013).

In the late 1990s, the Humane Society estimated that about 6 million vertebrates - animals with backbones, such as frogs, fetal pigs, cats, rabbits, mice, turtles, dogfish sharks, pigeons, snakes, mink, foxes, and bats, and an equal number of invertebrates - animals without backbones, such as crayfish, grasshoppers, clams, squid, and cockroaches, were dissected each year (Balcombe & HSUS, 1998). In addition, organs such as cow eyes, hearts, and lungs, and

sheep brains are procured from slaughterhouses and used for dissection in the classroom. Today, with the click of a mouse and a budget, one can order a variety of preserved creatures, from the microscopic to the macroscopic, to use in the classroom.

Research on science teachers' perspectives reveals that as many as 75-79% of biology teachers use dissection in their classrooms, and, when asked, report both benefits and concerns associated with the practice (Oakley, 2012). While dissection continues to be a commonplace activity in many classrooms, some individuals, including teachers, students, and animal rights advocates, have begun to question its use, and some countries have banned it entirely (Oakley, 2012). To date in the United States, several states have enacted laws that protect the rights of students who choose not to dissect (Physicians Committee for Responsible Medicine (PCRM), 2013).

Dissection has been referred to in the academic literature as a "controversial pedagogical practice" (Oakley, 2012, p. 253). It elicits a range of feelings and emotions in individuals, perhaps because its use does include both positive and negative repercussions. This results in a conflict between ethics, morality, education, and practicality. To more fully understand the whole process of dissection as a classroom practice, and to inform the choices surrounding dissection, this thesis will investigate and illuminate the multi-faceted questions surrounding it. These considerations include the pros and cons of dissection and dissection alternatives, student perceptions of dissection, environmental and ethical/psychological concerns, the 'biological supply' industry, science standards, student choice, and questions to consider.

Review of Academic Research

Pros and Cons of Dissection and Dissection Alternatives

Pros and Cons of Dissection

In their review of the literature, Barr and Herzog (2000) report that the use of dissection in a classroom is beneficial because teachers feel that it provides a valuable hands-on learning experience and that it is a way for students to appreciate the "delicacy and fragility of animal tissues"; in addition, it can be an "exciting" educational experience (p. 54). Oakley (2012) found that teachers report the nature of the benefits of dissection as: *pedagogical* because it solidifies and reinforces classroom content, *realistic* because it illustrates the complexity and similarities/differences among organisms, *experiential* because it provides hands-on learning and allows students to develop skills with dexterity and lab procedures, and *ethical* because it is "an opportunity for students to develop respect and admiration for life" (p. 257). In some cases, completing a dissection enhanced student interest in pursuing a career in the sciences and medicine (Barr & Herzog, 2000).

Simultaneously, there are multiple concerns regarding use of dissection. Balcombe and HSUS (1998) outline the animal welfare concerns in a fact sheet about dissection. According to the document, most animals destined for dissection are removed from their natural habitat. Frogs are taken from wetlands, sharks are caught in the nets of fishing trawlers, and other animals are wild-caught. Cats might have been obtained from animal shelters and dealers. Some animals and animal parts are byproducts of the meat and fur industry, which supply fetal pigs, mink, foxes, and rabbits. Furthermore, the Animal Welfare Act does not provide protection for non-mammals and laboratory-bred rats and mice. The result of this is that there is no mandated reporting to, or by, the government of the capture, housing, transport, and euthanizing of animals

such as amphibians, birds, fish, and reptiles (Balcombe & HSUS, 1998); thus, these activities are unregulated. In some instances, the procurement of animals includes practices that many would find abhorrent, such as the drowning of thousands of cats, bound for U.S. classrooms, by a Mexican biological supply company, the live-embalming of rats, and the injection of deadly preservatives into live crabs (Balcombe & HSUS, 1998).

Teacher-reported concerns with dissection include health and safety issues such as exposure to formalin and disposal of specimens, pedagogical concerns such as student learning and classroom management during dissection labs, costs, and ethical considerations such as the removal of animals from the wild and whether or not it is morally justified to kill animals for the classroom (Oakley, 2012). In addition, some students become discouraged from pursuing careers in the fields of medicine and science as a result of doing dissections (Barr and Herzog, 2000). Gilmore (1991) suggests that the use of animals for dissection is a form of “speciesism”, which equates to racism and sexism in its inability to “take into account the interests of another being” (p. 211) and that it must be difficult for a student to “question the authority of a biology teacher who requires that students dissect an animal” (p. 212).

This variety of practical and emotional feelings and beliefs toward dissection compounds the questions that might arise as a result of its use in the classroom and invites deep inquiry into what individuals’ thoughts and responses are founded upon.

Pros and Cons of Dissection Alternatives

There are many alternatives to physical dissection that teachers might consider using in the classroom. These include computerized dissection programs, such as “V-Frog” and “E-Rat”, which are specifically designed to teach students about anatomy and physiology. There are other options, such as 3D anatomical models, plastinated specimens, videos, slides, charts, diagrams,

CD-ROMs, overheads, and online presentations (Oakley, 2012). Additional opportunities exist, and are a function of teacher creativity, classroom budget, time, and goals. For example, a life science teacher and an art teacher might design a cross-curricular unit to create an anatomy cut-out or pop-up book, flip-book, or other type of display that allows students to use a constructivist approach to learning anatomy and physiology.

Some of the benefits that teachers reported with respect to using dissection alternatives include the following: they are useful as a supplement to physical dissection because they help students prepare by providing representations of internal anatomy, they are an important as a learning tool for students who opt out of physical dissection, they are reusable and allow the learning experience to be repeated, which creates more potential for mastery of material, they are generally less costly than purchasing specimens for physical dissection, they have a smaller environmental footprint, and they lack the associated ethical questions that physical dissection includes (Oakley, 2012). Some of the concerns teachers share about using dissection alternatives include the belief that they are not comparable to physical dissection because they are not realistic and do not "showcase diversity within a species" (Oakley, 2012, p. 260).

In addition, school resources such as outdated computers can make the use of virtual dissection programs difficult and/or there might be a lack of professional development/support for teachers who would like to use alternatives. Other concerns cited include lack of student interest in alternatives and the belief that students already spend enough time on computers. Ironically, some teachers cite the belief that using alternatives might "densensitize" students to the value of life and "deprive them of an opportunity to develop an ethic of appreciation toward animal life" (Oakley, 2012, p. 260).

Efficacy of Computerized Alternatives to Dissection

In the context of this research paper, efficacy refers to the ability of dissection alternatives to help students reach desired learning outcomes or goals. These are myriad, and dependent upon what a teacher aspires his or her students to learn, and/or what the curriculum and science standards require. Virtual dissection yields varying results, and has been shown to be as, or more, effective to facilitate student learning than conventional physical dissection. In several different research studies, computerized dissection programs that teach students about anatomy, or prepare them for the study of anatomy, were found to be useful and generative of successful learning outcomes.

In 2010, Lally, Piotrowski, Battaglia, Brophy, and Chugh, studied 102 secondary students enrolled in a one-year life science course. The students were divided into two groups; members of one group were asked to do a physical dissection, and members of the other group were asked to do a virtual dissection using a program called "V-Frog". The dissection occurred during one learning session and concluded with a test and survey to measure affect at three different time intervals: before, immediately after, and once again at an undisclosed amount of time later. The researchers found that students who performed the virtual dissection had higher scores on the immediate post-test, but this effect diminished over time because, they speculate, students forgot some of what they had learned between testing sessions. The researchers suggest, that students need to repeat learning experiences so that they "overlearn" to the point of "automaticity" (Schneider & Schiffrin, as cited in Lally et al., 2010, p. 196). Virtual dissection allows this possibility because students can use the computer programs multiple times, whereas physical dissection does not because specimens can only be used once, or disintegrate over time. The researchers concluded, "the implication for teaching is that virtual dissection is a viable

alternative to physical dissection" (p. 197), and that using *both* virtual and physical dissection would likely produce "better learning outcomes than either would individually" (p. 197).

Similarly, Predevac (2001) focused a study on determining how effectively students can learn rat anatomy using a program called "E-Rat". It was found that students who used the computer-based instruction scored 7.4% points better than those who did the physical dissection (Predevac, 2001). In an opinion survey of Bachelor of Medicine and Bachelor of Surgery students in India, Rehman, Khan and Yunus (2012) report that the majority of students who used computers to help themselves learn human anatomy felt that it was beneficial, however they did not *prefer* the use of computers over the use of cadavers, nor did they support the idea of replacing a human body with a computerized simulation. This suggests that computer use can be a supplement to learning anatomy and acknowledges the importance for medical students of having human cadavers to learn from. However, it might encourage educators to question why general science, non-specialized students at the high school level are being asked to perform dissection tasks when the efficacy of alternatives has been demonstrated and only a fraction of these students will become surgeons, doctors, or veterinarians.

Student Perceptions of Dissection

Just as the use of dissection has its pros and cons, the perceptions students develop as a result of its use generate a spectrum of response. Barr and Herzog (2000) studied student reactions to the dissection of a fetal pig and found that a majority, twelve out of seventeen, of the students enjoyed the process. Students cited several reasons for this, including the "similarities between the pig's internal structures and their own" (p. 58). In addition, some students were able to make connections between human diseases that they, or a family member, had experienced while examining the various organs. One student remarked, "The clams and the frogs and everything

are just not like us. It's kinda neat to see how I work…Actually, it sort of came together, the two things. I mean, the fetal pigs really are a lot like humans. I could see the parallel between humans and animals" (p. 58).

During the fetal pig dissection, some students expressed delight and curiosity as they examined the specimen and its viscera. One concluded that the authenticity of the "liquid and blood and stuff" of a real creature provides an experience that dissection models would not. Eleven out of seventeen students agreed with the statement on the questionnaire, "I have no ethical problems with dissection" (Barr & Herzog, 2000, p. 60).

For some students, however, the dissection was a negative experience. The students "seemed uninvolved", "rarely touched the animals", and were visibly disgusted (Barr & Herzog, 2000, p. 58). Three students either disagreed or strongly disagreed with the statement, "I have no ethical problems with dissection" (p. 60). One student reported welling up with tears as she cut into the fetal pig, and two others covered up their specimen's faces. Some students believed that non-science track classmates did not have a need to learn dissection. One said, "I don't really think it's right to raise animals for high school dissection because you don't learn all that much about it", and suggested that only half of her classmates were paying attention and "doing it the right way" (p. 60). Another student expressed the belief that the pigs were put on Earth for a purpose, which was not high school dissection, and stated her concern that, "God is going to punish me for cutting up a little pig. I think it is awful" (p. 60). This particular response indicates a critical need for teachers to discuss not only the ethics of dissection, but also the practical realities of how the specimens are sourced. For example, fetal pigs are a byproduct of the pork industry, which provides food that many people eat, and are not bred, specifically, for

the purpose of dissection. Making critical connections about the supply chain that provides these specimens will more fully inform a student's willingness and ability to participate in the activity.

All students in the study acknowledged the "unpleasant" odor associated with the dissection (Barr & Herzog, 2000, p. 64), and agreed that dissection should be "an option rather than a requirement" for Biology II students (p. 54).

In another study, Holsterman, Ainley, Grube, Roick, and Bögeholz (2011) studied the relationship between disgust and interest during biology class dissections. They state, "The role of predispositions in the development of on-task affective experience is important for science education, especially biology education, where curriculum content involves experiences that may prompt strong negative and positive feelings, for example, touching dead animal parts in a dissection" (p. 185). In other words, knowing how students integrate potentially negative emotions as they experience these activities is important for science educators because of the prevalence of such activities in science curricula.

The researchers found that students were generally highly interested in the dissection activity, and that student levels of disgust were relatively low. Girls consistently reported higher levels of disgust. The study also found that there is a "consistent negative relation between disgust and interest" (Holsterman et al, 2012, p. 191); high levels of disgust correlate with low levels of interest, which could potentially diminish student willingness to actively participate, and learning potential. Simultaneously, high interest levels might generate a fuller degree of participation, despite the feelings of disgust a student might feel. This research suggests that it is imperative for educators to determine how students will respond to activities that generate strong emotions and to consider the effect these emotions will have on student willingness to participate as well as the efficacy of the activity as a learning tool.

These studies remind educators that student response to dissection as a classroom task can be both positive and negative, and students' feelings before, during, and after dissection have a notable effect on the utility of the task as a tool to learn and retain content, as well as to achieve understanding of science standards.

Environmental, Ethical, and Psychological Concerns

Environmental Concerns

There are at several environmental concerns to consider when educators contemplate using animal specimens for dissection in the classroom. Teachers who use dissection sometimes allude to some of these problems, however it is not apparent that these worries preclude their use of dissection as an educational practice. The environmental concerns include 1) the ecological effect of procurement of specimens from the wild, 2) the health effects of chemicals traditionally used in the preservative process, and 3) the solid waste management of disposed biological specimens.

Ecological Effects of Procuring Specimens from the Wild

The ecological effects of procuring specimens from the wild can be difficult to quantify, because trade of non-mammalian species is not regulated. According to a representative from the Carolina Biological Supply Company (CBSC), animals such as skates, rays, and dogfish shark are a byproduct of the fishing industry (anonymous, personal communication, January 23, 2014). These animals are "incidental catch", or "bycatch", unintended fatalities of industrial fishing methods. Rattlesnakes can be purchased by the biological supply company after a traditional "rattlesnake roundup", however they are not available in abundance because they are costly. According to the representative, leopard frogs, also known as grass frogs, are in abundance in Mexico because of the creation of irrigation canals, which have led to an increased population of

the frogs. Permits are sold for individuals to collect the frogs, which are then sold to biological supply companies (anonymous, personal communication, January 23, 2014). Although the means by which these specimens are collected might seem innocuous or justified, there are biological consequences to be considered. According the Center for Biological Diversity (2013b), "In North American marine waters, at least 82 fish species are imperiled. Across the globe, 1,851 species of fish — 21 percent of all fish species evaluated — were deemed at risk of extinction by the IUCN in 2010, including more than a third of sharks and rays" (para. 11).

In addition, rattlesnake roundups, from which rattlesnakes bound for dissection are purchased, are having a devastating impact on rattlesnake populations in some parts of their native range.

> "Rattlesnake roundups" are contests calling for hunters to bring in as many snakes as they can catch in a year, at which point the snakes are slaughtered and sold for skin and meat. Six states still host these killing contests: Alabama, Georgia, Kansas, New Mexico, Oklahoma and Texas.
>
> Roundups are driving some species of rattlesnakes toward extinction. A recent study analyzing 50 years of roundup data found eastern diamondback rattlesnakes in sharp decline due to roundup pressure and habitat loss. Rattlesnakes play a key role in the food web, especially in terms of rodent control". (Center for Biological Diversity, 2013a, para. 1-2)

Finally, removing amphibians, such as frogs, from their natural habitat can lead to an ecological imbalance because frogs play a vital role in the ecosystem; they are secondary consumers, tadpoles contribute to nutrient cycling, and adults are important "biological pest controllers". In addition, they are prey items for other species (Center for Ecological Sciences, 2014).

Dr. Kerry Kriger, a conservation biologist and founder of Save the Frogs, suggests that the biological supply companies' purchases of specimens, such as skates and rays, "endorses, funds, and enables" the practice of taking these animals out of the wild (personal communication, February 5, 2014). It allows fishermen to continue harvesting unwanted species from the ocean and then discarding them, in some cases overboard, and in others, to sell. As the ecological effects of using such practices are beginning to be understood, humans, especially mentors and educators, must consider how the practices are contributing to more serious trends and challenges, such as the loss of global biodiversity. Experts report that our planet is experiencing an anthropogenic mass extinction event similar to that which happened sixty-five million years ago (Center for Biological Diversity, 2013b). Currently, scientists estimate that species are going extinct at a rate 1,000-10,000 times the background extinction rate of one to five species per year as a result of human activities such as habitat destruction and introduction of non-native species, and human causes such as global warming (Center for Biological Diversity, 2013b).

It is argued that the collective societal cognitive and emotional disconnection from the realities of material consumption enables, and perhaps invites, educators to avoid considering the effects of using specimen dissection in the classroom. This very consumption has notable, yet in many cases unstudied, environmental impacts, and could be addressed in order to support a more ecologically informed and, thus, ecologically sound, set of educational practices, and human relationship with the planet. Dr. Kriger suggests that the biological problems we face today "have nothing to do with" lack of knowledge about anatomy and physiology, and that we could evolve the ways we teach to reflect current needs (personal communication, February 5, 2014). These needs include learning about and tending to the numerous ecological challenges animals such as amphibians face, using virtual dissection instead of actual physical dissection, and doing

hands on habitat restoration to protect the species under threat (personal communication, February 5, 2014). Doing so could negate the need for wild-caught specimens and the associated harmful ecological impacts.

Health Effects of Preservative Chemicals

The health effects chemicals are reported in a format known as a Material Safety Data Sheet, MSDS, also known as the SDS, Safety Data Sheet (anonymous, personal communication, April 17, 2014). Formalin is a chemical solution commonly used to preserve laboratory specimens; it is created by the dissolution of formaldehyde into an alcohol solution (anonymous, personal communication, January 23, 2014). Formalin has a variety of potential health effects. The MSDS for formalin states that it can cause "irritation, redness, and pain" to the eyes and skin. Prolonged skin contact can cause "hypersensitivity" and "contact dermatitis". In addition, inhaling the fumes from formalin can cause irritation to the respiratory tract resulting in sore throat, coughing, and shortness of breath (United States Department of Agriculture, 2014). Formaldehyde is a suspected human carcinogen (National Cancer Institute, 2014). The California Department of Public Health has recommended exposure limits for workplace chemicals that might be found in the air. In an eight hour period, it recommends an *average* exposure to formaldehyde of no more than 0.75 parts per million, and a short-term exposure of two parts per million—in other words, during any 15 minute period, an individual's exposure "must not" exceed two parts per million (California Department of Public Health, 2014, p. 3). In addition, it is recommended that individuals exposed to formaldehyde use gloves made of "nitrile, neoprene, butyl rubber, or polyethylene laminate to protect against incidental skin contact with formaldehyde" because latex may not provide sufficient protection (California Department of Public Health, 2014, p. 4). Formalin is typically 3.7% formaldehyde, and "presents some health

and safety concerns when handled incorrectly, and presents environmental and legal concerns when disposed incorrectly" (Department of Environmental Conservation, 2011, p. 1). The health concerns and safe-use guidelines associated with use of specimens are delineated on warning labels containing specimens bound for dissection. See appendix for examples of such warning labels.

To quantify the presence of industrial toxins in the human body, Environmental Working Group (EWG) studied umbilical cord blood samples from ten infants and found 287 different chemicals overall, with an average of 200 chemicals in each person. These chemicals include waste byproducts, consumer product ingredients, and industrial chemicals and pesticides banned 30 years ago (EWG, 2012). These results and their implications are elucidated in the video entitled *10 Americans*. The webcast suggests that there are numerous human health problems associated with the presence of industrial era chemicals that people are exposed to from development, in-utero, to childhood and through adulthood. These include neurodevelopmental disorders, as well as increases in childhood acute lymphocytic leukemia, hypospadias, childhood brain cancers, autism, infertility, inability to carry a baby to term, and breast cancer, as well as decreasing sperm counts (EWG, 2012). One in three women, and one in two men, will develop cancer (EWG, 2012). The narrator suggests that presence of these chemicals are present in the blood does not mean that there will be biological damage, however, it suggests, "there is a reason to be concerned", that "we ought to do all we can to minimize exposures", that "industrial pollution begins in the womb", and that small doses of certain bioactive chemicals can have physiological effects (EWG, 2012).

With respect to the chemicals used to preserve dissection specimens, it is not clear what the effects of short-term exposure to these chemicals are, and this is not to suggest that students

who participate in classroom dissection will become ill, as a result. However, it is an invitation to consider unintended health consequences of accepted practice, especially because there is little research on the combined effects of all the chemicals to which humans are exposed throughout their lives (EWG, 2012). In addition, the precautionary principle invites individuals to limit their contact with carcinogenic substances. Teachers who work in the same classroom for several class periods are being exposed to these chemicals for a longer time period than their students, whose lab periods are only portions of the school day. Ward's Science has addressed these concerns, and its specimens' formaldehyde off-gassing standards meet OSHA's recommended levels of less than 0.75 ppm per eight hours (Ward's Science, 2014, p. 133). Simultaneously, the Alaska Department of Environmental Conservation states of formalin and formaldehyde, "if you can smell them, you are over the recommended exposure levels" (2011, p. 1). What are teachers and students to do with such seemingly disparate information?

Solid Waste Management of Disposed Specimens

Once used, the animal remains from dissection practices must be disposed of. Industrial societies, developing, and societies, worldwide, have been posed with the task of discarding the remains of everyday practices. According to Rathje and Murphy (1992), "dumping" has been the favored means of disposal of unwanted items "from prehistory through the present day" (p. 34). In their book *Rubbish*, (1992) they assert, "In the United States, a garbage problem is in some respects the price we pay for having learned to do some important things very well" (p. 40), citing the use of sterile gloves during a surgery. They state, "Taken as a whole the garbage of the United States, from its 93 million households and 1.5 million retail outlets and from all of its schools, hospitals, government offices, and other public facilities, is a mirror of American society" (p. 11). The question is, what does this waste mirror? To a large degree, it mirrors the

"throwaway" quality of our society, "heralded" by *Life* magazine in 1955 (p. 41). According to the Environmental Protection Agency (EPA), in 2012, 164 million tons of municipal solid waste were discarded into landfills (2014, p. 4), for an average per capita disposal rate of 2.36 pounds per day (p.9). Additionally, "99% of the stuff we harvest, mine, process, transport—99% of the stuff we run through this system is trashed within 6 months" (Leonard, 2013, p. 9); in other words, only 1% of the total material that is part of the production and consumption system is either in use, or embedded in a commercial product, after 6 months; the rest has been disposed of, in some way.

The one-time use of lab specimens in a science classroom illustrates both the "dumping" solution and the "throwaway" notion when animal carcasses are thrown into the trash. According to representatives from one of Marin County's waste management agencies, *local* regulations state that animals less than ten pounds can be put into the municipal trash if they are wrapped in plastic (personal communication, March 20, 2014). Simultaneously, animal control agents are required to follow special procedures when they dispose of animals such as roadkill; further investigation reveals that specimens preserved in formalin may NOT be able to be disposed of in the "regular" trash, because, due to waste disposal regulations specific to California, they might be considered hazardous (anonymous, personal communication, April 9, 2014). Thus there is somewhat of a question about proper disposal of these preserved carcasses that need to be discarded. Since the number of animals being disposed of annually is unquantified, the volume of this waste is, thus, unquantified.

Whether or not the disposal of school dissection specimens is a "problem" depends upon a few factors, primarily this very question of how many animals are being thrown away on a daily basis. One could estimate the number of animals used each year by calculating how many

students, per year, are participating in dissection. For example, in California, during the school year 2011-2012, there were 1, 400, 937 students in grades six through eight, and 1, 979, 678 students in grades nine through twelve (California Department of Education (CDE), 2013a.). In many classrooms, students are divided into groups when they do laboratory work, so that there might be two to four people working on one animal; as noted, some teachers do not use dissection. If one were to calculate the usage of frogs based on an estimate of 75% of teachers using dissection at the high school level, one could assume that 75% of students in grades nine *or* ten, general biology students, are using dissection at least once during their high school career. Following is an example of such a calculation:

1. 1, 979, 678 students/4 grade levels = 494, 920 students per grade level
2. 494, 920 students (i.e. freshman) * 75 % (students whose teachers use dissection) =

   371,190 students who use/participate in dissection
3. 371, 190 students/ 4 students per group = 92,798 groups
4. 92,798 groups * 1 frogs dissected/group = 92,798 frogs dissected annually

Although the number 92, 798 is not an exact figure, because the exact number of students in each grade level is not being used, nor is the actual number of students per group known or "conscientious objectors" accounted for, calculations such as this could provide a general index of the numbers of frogs or other animals being removed from the wild or salvaged from slaughterhouses, and then disposed of every year. Alternatively, teachers could provide data about how many animals they purchase and use during the year; this would quantify the volume of biological waste generated by dissection.

In addition to the number of specimens being disposed of, there are other factors that need to be identified in order to determine if the disposal of dissection specimens is detrimental to the environment; these factors include what solutions they have been preserved in, and the concentration of those solutions (anonymous, personal communication, March 20, 2014). Two resultant concerns associated with disposal of these preserved animal carcasses include leachate potentially contaminated with chemical preservatives, and methane generated from the biodegradation of the specimens, which occurs even if they have been preserved (anonymous, personal communication, April 9, 2014).

Leachate is the effluent created by the combination of materials breaking down in a landfill, can be difficult to measure, and can contain heavy metals (anonymous, personal communication, March 20, 2014). Whether or not leachate is environmentally damaging is determined by the characteristics of the landfill, itself, which include the soil upon which the landfill is constructed, how wet the landfill is, and how the landfill is managed. Landfill leachate can cause contamination of the groundwater. Rathje & Murphy (1992) cite an example of a dump in Oklahoma that is built on "highly permeable ground" in an area with a high water table. It was found that a number of industrial organic chemicals, ingredients in "common commercial and household products", such as pesticides, fumigants, cosmetics, lacquer remover, and polyvinyl chloride, had begun to leach into the local groundwater (p. 123). The authors warn, "A landfill teeming with roisterous activity, and spilling its insides into the outside world, is the situation one wants to avoid. That way lies Fresh Kills, which pours at least a million gallons of leachate into New York Harbor every day" (p. 122). The authors also state, "America's small businesses and almost every one of its households consume and discard countless items that contribute a steady flow of poisonous, carcinogenic, or otherwise hazardous substances into the

municipal waste stream" (Rathje & Murphy, 1992, p. 122). Rathje & Murphy cite nail polish as an example of a substance that is usually discarded in small quantities. However, if it were to be discarded in "fifty five gallon drums instead of in a half-ounce bottle", one would be legally required to dispose of it in a "state licensed Subtitle C hazardous waste disposal site" (p. 122). Similarly, formaldehyde, a component of formalin, would be considered federal hazardous waste and would have to be discarded similarly if it were being disposed of in large quantities. However, once it is incorporated into a consumer product, it is considered "processed", and can then be disposed of as household, non-hazardous waste in some states. In the state of California, household hazardous waste is *not* exempt from the laws that regulate industrial hazardous waste; it is illegal to dispose of hazardous waste in the "regular" trash, and the toxicity and hazardous characteristics of household- and business-generated, used products need to be determined before their disposal. The responsibility for this determination lies not with the manufacturer, but with the "generator"; the generator is the consumer who uses the product and is then *generating* it as waste. Thus, in the state of California, the person discarding the waste, in this case, the educator, is required by state and federal law to determine if the waste is hazardous. One way this can be achieved by having the specimens tested (anonymous, personal communication, April 4, 2014).

It is beyond the scope of this thesis to further delineate these requirements, however, in practice, it is unlikely that teachers who use chemically preserved specimens and/or their science departments have initiated this testing, just as it is unlikely that a consumer will have their leftover paint tested before discarding it. Therefore, the recommended practice is that educators- in California and other states with similar hazardous waste regulations- dispose of the specimens as hazardous waste, as a precaution (anonymous, personal communication, April 17, 2014), unless or until the actual specimens have been tested. In addition, it is suggested that educators

consider the general effect of discarding preserved animal carcasses on the local landfill, and on the ecosystem, itself. A representative from the local municipal waste agency states, “Groundwater that has been tainted with formaldehyde is not a desired outcome” (anonymous, personal communication, March 20, 2014). For more information on disposal recommendations for formalin-tainted waste, see the California Department of Toxic Substances Control (2014) fact sheet on managing hazardous waste for medical, dental, and veterinary offices.

An additional landfill-related concern is the generation of methane, which is a greenhouse gas 20 times more potent than carbon dioxide (anonymous, personal communication, March 20, 2014). The breakdown of organic material in an anaerobic environment, such as a landfill, creates methane, and thus contributes to the greenhouse effect and global climate change. Biological specimens that are disposed of in the garbage will eventually biodegrade, because the bacteria can “easily digest” diluted formalin once the carcass has been landfilled and compacted, however, this process occurs in an anaerobic environment, thus is methanogenic (anonymous, personal communication, April 10, 2014). Considering the growing number of quantifiable environmental challenges both human and non-human life face, it is essential to consider the negative impacts of throwing away millions of animal specimens annually, and then to minimize or eliminate these detrimental effects. Until this is more fully studied and quantified, it is suggested that educators consider focusing their classroom practices on using materials that are non-toxic, compostable, reusable, and/or recyclable, as much as possible.

A related challenge associated with the disposal of lab materials, including specimens and chemicals, is that “a lot of teachers don’t know how to get rid of” materials they use in the lab, nor do they know what kinds of safety equipment to use (anonymous, personal communication, March 20, 2014). In the teacher interviews conducted for this thesis, this was

found to be true. None of the teachers interviewed indicated that they had followed the manufacturers' recommended disposal guidelines, which are to check with local waste management authorities to ensure that disposing of the specimens in the municipal trash/landfill is acceptable practice. The educators thought, or assumed, that because the company sells them as "non-toxic" they could be disposed of in their classroom trashcans. Some companies, such as Ward's, sell specimens preserved by various means, including fixation in formalin and shipment in a "formaldehyde scavenger" solution that binds free-formaldehyde that "may seep from specimens" (Ward's Science, 2014, p. 132). Other specimens are available in Ward's Select solution, which uses no formaldehyde in the fixing and preserving processes, and some specimens are available freeze-dried (Ward's Science, 2014, p. 132). Thus, there are varying levels of specimen toxicity. Teachers must take the time to determine what proper disposal protocols are for the specimens they are using, in order to comply with the laws and guidelines designed to protect the environment, and to model and utilize best practice as recommended by regulatory agencies. One waste management professional implores, "Part of the responsibility of a school is to teach students how to do things properly" (anonymous, personal communication, March 20, 2014). As indicated in the following chart, this includes contacting local waste management authorities to determine what local regulations require. Below are disposal recommendations from four biological supply houses:

Company	Disposal Guidelines
Carolina Biological Supply Company	Specimens: "Specimens preserved in *Carosafe* or *Carolina's Perfect Solution* can often be discharged into a sanitary sewer system. The specimens are not classifiable as federal hazardous waste and do not represent a biohazard. However, you should check with your local solid waste authority (e.g. the local governmental authority in charge of solid waste, your local landfill, or your waste disposal company, if applicable) to ensure that this is an acceptable practice. If it is, we recommend that you double bag your specimens before placing them in your school's

Company	Disposal Guidelines
Carolina Biological Supply Company, continued.	regular waste." Preserving fluids: "If you preserved specimens are in pails of *Carosafe* or *Carolina's Perfect Solution,* the fluids can often be disposed of into a sanitary sewer system because neither fluid is classified as a federal hazardous waste and the quantities are generally small. However, you should check with the local wastewater authority (e.g. the local government authority that handles wastewater treatment or the local wastewater treatment plant) to make sure this is an acceptable practice. If it is, you can pour the fluids into a sink and flush them down the drain with running water." "Caution: *If your school is equipped with a septic tank system, seek advice from a supervisor or administrator before discharging* Carosafe or Carolina's Perfect Solution *into it. Even these safe chemicals can upset the microbiological balance that is so important to the system's proper functioning."* (Carolina Biological Supply Company, 2014)
Delta Biologicals	"Biological preserved specimens are not considered hazardous waste and normally may be disposed of in the usual solid waste manner, however, as restrictions and regulations vary you may (try) contacting your local waste management department to determine appropriate disposal methods." "After completing the dissection, wrap the specimen and its parts in newspaper and deposit in an outdoor trash container. Make sure these items are placed in a securely covered trash container that will not allow children and animals to access the contents." "Absorbent waste materials should also be safely discarded in outdoor trash containers." "Delta Biologicals will assist you in the disposal of specimens. You can purchase a "Salvage Pail with Lid and Box" and you pay the postage; we'll take care of the disposal." "FREE SPECIMEN DISPOSAL is available if requested." (Holscience, 2014)
Flinn Scientific, Inc.	"Be sure to read the Flinn Scientific "Biological Waste Disposal" instructions in the *Flinn Scientific Catalog/Reference Manual* and note especially the section on the disposal of Type III Biological Materials." "Local conditions" and "local regulations" may "influence the proper disposal procedures of your biological materials. It is critical to know your local regulations and guidelines for such materials." (Flinn Scientific, Inc., 2014)
Ward's Science	"While our fixatives and holding solutions are completely degradable, you should check with your local regulations before discharging them.

Company	Disposal Guidelines
Ward's Science, continued.	Specimens may be easily disposed of in a landfill as inert organic waste or incinerated as required by your local codes." (Ward's Science, 2014, p. 133)

The cultural context that encompasses these concerns is also a subject that could be addressed. As previously mentioned, American citizens live in a consumer culture characterized by a "throwaway" paradigm. Goods are manufactured and used, and landfill-bound material is being generated minute by minute. In many cases, consumers are not fully educated about the proper use and disposal of the product they are using, especially if it contains toxic chemicals. Rathje & Murphy (1992) surveyed residents of Marin County, California and found, "homeowners, when interviewed, had little idea of what kinds and what quantities of hazardous waste they were throwing away" (p. 76). Many of the preservative solutions in which biological specimens are preserved and shipped are not considered to be *federal* hazardous waste; the catalogs selling these products state that they may "often" be discarded of in the trash, yet the manufacturers also state that local regulations might differ. The marketing strategies these manufacturers use have created a belief that their products are non-hazardous, and some educators are purchasing, using, and discarding of these products without further investigation. In this case, it seems that the companies could demonstrate more corporate responsibility by explaining or defining the terms used to describe their products, considering that the advertisements used to sell these specimens lead to misinformation and misunderstanding among consumers. In addition, it is imperative that consumers "do their homework", and become educated about the materials they are purchasing. Teachers could consider whether or not they need to use products that contain carcinogenic or otherwise harmful chemicals, as well the

ultimate fate of these products, and discern and use proper disposal techniques for all classroom supplies purchased.

Educators could ask how much they can minimize their classroom's contribution to the municipal waste stream, especially of chemical-laden materials whose effects are not fully known. Citizens, including educators, could ask how they can reshape their contribution to, and participation in, the "throwaway society" by embracing some of the following tenets:

- Purchasing high quality materials that are made to last or can be reused indefinitely
- Buying and using materials that generate less, or zero, waste
- Buying goods that support a "cradle to cradle" model, in which used goods are able to be remanufactured, rather than disposed of, at the end of their functional life

To some degree, this can become a question about how humans would like to care for and cohabitate on the Earth. Use of potentially toxic chemicals in households, schools, and industrial settings is one aspect of human behavior that can pose environmental challenges because these chemicals are distributed into the environment while they are being used, and then must be disposed of. One waste management expert suggests that our job is to "improve" the outcomes of human activities that have an impact on the planet, and that we have forgotten that "we live in an ecosystem" (anonymous, personal communication, March 20, 2014). Embracing the "improvement" paradigms, and considering our role as one of many species that live on the Earth, within both classrooms and homes, are possibilities with unlimited potential. In addition, legislation that prioritizes "people and public health", rather than protects "polluters, companies, and profits", is of paramount importance, and will help "fix the real world" that humans live in (EWG, 2012).

Ethical and Psychological Concerns

A review of the literature indicates that the ethical and psycho-emotional ramifications of using dissection in the classroom trouble some educators and philosophers. The concerns tend to be illuminated by those who question the practice of dissection and other uses of animals in educational fields such as psychology, and human and veterinary medicine. In general, the literature on human feelings and beliefs toward these practices focuses more on college students rather than high school students, although some studies have attempted to quantify pre-college students' feelings toward and beliefs about dissection.

A meta-analysis of student and professor attitudes toward the use of live animals in psychology education elucidates some of the apprehensions that may arise. Although it is an indirect comparison, one might interpret some of these concerns to also apply to high school age students who are asked to perform dissection in their classrooms. According to Cunningham (2000), "the ethical principal of reverence for life and respect for the sanctity of being, which may serve as an ultimate concern in a student's life, can conflict with the pedagogy of an instructor who believes that such animal laboratories are the cornerstone of the psychology course" (p. 194). Dissection is a "tradition" in the pre-college biology classroom (Hart, Wood, & Hart, 2008). Students who are asked to experiment upon and dissect animals against their will might experience diminished learning, as well as "dulling of observation and critical thinking skills" (Kelly as cited in Cunningham, 2000, p. 199). In addition, requiring students to repeatedly witness distasteful practices can cause them to experience desensitization, as well as "emotional numbing and cognitive acceptance" of the experiences (Thomas, Horton, Lippencott, & Drabman as cited in Cunningham, 2000, p. 200). Outcomes of such experiences can cause students to distance themselves emotionally from animals, create "hardened attitudes" toward

animal suffering (Heim as cited in Cunningham, 2000, p. 200), "teach students to regard animal as expendable tools", and "foster a disrespect for life, human life included" (Bowd as cited in Cunningham, 2000, p. 200). Some suggest "harming and killing" sentient creatures might be contrary to our attempts to reduce violence in society (Orlans as cited in Cunningham, 2000, p. 200). It is proposed that students whose personal morals and ethics are disregarded in favor of scientific pursuits are given the message that their values cannot stand up to the rigors and needs of academia, that "knowledge is more important than morals", and "the detached and unrestricted desire to know and understand is a value higher than conscience" (Cunningham, p. 200). In a separate article, Jackson (1991) opines, "The animals, usually dead, are presented to the class as objects; their bodies are pinned to boards; their skin is cut and pulled apart; their innards are probed; and the remainder is tossed in the trash. Dissection leaves no room for reverence" (p. 2). Despite these possibilities, others suggest that building a background of respect and gratitude for the dissection process and the animals it consumes can generate a positive outcome for students. One teacher articulates:

> As medical schools now provide guidance in the way human cadaver materials are handled with a degree of reverence, schools entrusted with the sensibilities of even more impressionable children provide no such training for their teachers as they set about exploiting animals that for many children represent beloved pets and companions….Many (teachers) are aggressively dismissive of a need for ethical and reverent handling of animals materials, believing that children should be expected to be as casual with the materials as they, and that any concession to these ideas opens the door to the elimination of dissection as a practice….I have always found that ethical and sensitive student preparation in approaching any dissection, be it a clam or chicken wing,

> and an atmosphere of gratitude, has always promoted a healthier and richer learning environment (respect for the materials and focus on the task, for instance), thus a better outcome for students. (Storm as cited in Hart, et al., 2008, p. 144)

Educators must ask themselves how educational practices might influence a student's emotional and moral development, and question the ultimate effects this might have on their beliefs and behavior outside the classroom. Almost certainly, it is not the goal of schools to numb students to their intuitive feelings. How can the curiosity that some students have toward practices such as dissection be fostered while other students' disdain for such procedures is respected? Is it possible that dissection be reserved for students, either in high school or college, who have become specialized in their interests and career paths? What are educators modeling for youth when they purchase specimens, some of which are animals that these students might have as pets at home, for example, cats, use them for a brief period of time, and then discard them? What does this teach students about the sanctity of life and reverence for other species? Could this be contributing to a general disconnection from the natural world and what is termed by Louv (2005) as "nature deficit disorder"? In his book, *Last Child in the Woods*, Louv (2005) coins this phrase as a term to describe the "human costs of alienation from nature, among them: diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses" (p. 36). He states, "Parents, educators, other adults, institutions-the culture itself- may say one thing to children about nature's gifts, but so many of our actions and messages-especially the ones we cannot hear ourselves deliver-are different" (p. 14). Additionally, Bekoff (2007) proposes, "When many people sit back and look around at the world, they realize that they are too far removed from the other animals-and even too far removed from plants, rocks, and streams-with whom they share planet Earth. This distance has made the world a mess-with

lethal pollution, too many cars, too much disease, too much stress, too many people, and too many abused animals whose lives have been ruined. Many people are coming to realize that they are *a part* of the rest of nature and not *apart* from it" (p. 7). Using these thought processes, ideas, and values as a framework for the discussion about dissection will yield a different and compelling conversation.

Teachers who choose to use dissection could create an imperative to take time to initiate a thoughtful, incisive discussion, prior to dissections, to inform students about the sources of specimens, as well as to offer them an opportunity to share their moral and ethical concerns about participating in the activity. This would be a precursor to allowing student choice regarding whether or not they feel it is justified for them to participate in dissection, or whether they might prefer to achieve the learning goals by alternative means. Ultimately, a student's objection to participating in dissection, based on moral grounds, should be respected in an attempt to achieve a more humane educational system and society. As issues such as bullying come to the fore, and educators embark on incorporating the values of social and emotional learning, the whole spectrum of student response to classroom policies and practices can be discussed and considered. In addition, it is essential that citizens, including students, teachers, and administrators, begin to ask the greater question about how humans cohabitate with other species on Earth. What societal models and paradigms do educators intend to create with their choices and actions?

The 'Biological Supply' Industry and the Culture of Consumption

There are several companies dedicated to providing animals specimens for dissection, including the Carolina Biological Supply Company, which sells both live and preserved animals and animal parts. The website of Carolina Biological Supply Company illustrates the retail nature of

the biological supply industry. The home page of the website includes options for the consumer, such as, convenient shipping and specialized delivery options for live specimens, as well as tabs entitled “browse top categories”, “top sellers”, and “new products”. In addition, a promotion invites the purchaser to “sign up to receive useful teacher tips and exclusive discounts, with $25 off your next order”, and to “teach anatomy from real life” (CBSC, 2013a.). The site is contains pictures of specimens available, as well as students clad in goggles and lab coats, employing the use of scalpels. Selling tools and supplies to support the practice of dissection is modeled, justified, and encouraged.

A variety of preserved zoological specimens is available for purchase, including the following mammals and mammal parts: pregnant and non-pregnant cats, cow organs, dogs, mink, pig organs, pigs, rabbits, rats, mice, and sheep organs (CBSC, 2013b.). Cats are marketed as having been preserved in a safe, non-toxic solution and are available as follows, “dry packed in vacuum-sealed plastic bags, one per bag. Plastic bags and waterproof student name tags are furnished one free with each cat”; prices range from $41.95 to $94 each (CBSC, 2013c). The following non-mammals are available: crayfish and crustaceans, dogfish, earthworms and annelids, frogs, bullfrogs, grasshoppers, spiders and scorpions, perch, reptiles, squid, starfish and sea urchins (CBSC, 2013d), and skates, stingrays, clams, and quahogs (CBSC, 2013e).

From the researcher’s perspective, the commodification of both living and non-living specimens, and the means by which the website markets good deals to consumers with a budget, is concerning. This website, and others which sell similar products, normalizes the purchase of once-living creatures, some of whom were removed from their natural habitat, for a one-time learning experience for students. The selling of animal parts that are a by-product of the slaughterhouse industry might be more acceptable to those who are concerned with the

ecological impacts of purchasing wild-caught specimens, however animal rights advocates remind consumers that animals raised for meat often experience cruel and inhumane lives and deaths.

> Animals are also obtained as 'byproducts' of extremely cruel industries. For instance, slaughterhouses provide fetal pigs, and fur farms sell skinned mink, foxes, and rabbits. Most of these animals led deprived or otherwise miserable lives and die in agony. Common methods of killing include: suffocation, anal electrocution, drowning, gas chambers, or euthanasia.
>
> Because these animals are considered mere objects or products, the lack of quality care, handling, and treatment often leads to trauma, injury, or premature death. For example, live animals are often shipped in overcrowded packaging, which leads to injury, food deprivation, dehydration, and/or suffocation. These animals also can be exposed to extreme temperatures and rough handling. (Animalearn, 2013b, para. 4-5)

The industrial era has generated a culture of consumption, in which material goods are bought and sold on a daily basis, and economic growth is emphasized to the detriment of the planet, itself. It is possible for any person to buy a product, use it, and then discard it without considering where it came from, how it was made, whether or not humans or animals were subjugated in the process, or where it is going when its useful life is over. Landfills across the country are filling up with the discards of our daily lives, and some places, such as Marin County, California, have begun to educate consumers and advocate for a zero-waste paradigm as a means to address this critical issue. In addition, the EPA has introduced a "beyond waste" paradigm, based on sustainable materials management, which emphasizes using less, and "reducing toxic chemicals and environmental impacts throughout the material's life cycle" (2014, p. 13).

A review of the literature reveals that the educational benefits and moral implications of using animals to teach students about anatomy and physiology are questionable. What is not questionable is that these used, preserved carcasses must be procured and discarded. It is argued that the one-time use of specimens and their subsequent disposal perpetuates the material culture and contributes chemical-laden biological waste to our landfills. Educators are invited to begin considering this ecological impact and to make efforts to mitigate it by creating or utilizing classroom practices that are more environmentally sustainable and sound than those that already exist.

There are industries that supply specimens for dissection, either as products initially intended for dissection, or as byproducts of food-production. The existence of these industries, and their practices, creates pause for thought and reflection, and could be investigated and reconfigured from an ecological perspective. For example, fishing practices could be altered to minimize bycatch so that the ultimate fate of these animals is not the dissection table, then the landfill. Or, perhaps slaughterhouse remains could be preserved in a different way so that the exposure to formalin for students investigating them later is eliminated, and they can be disposed of in the municipal compost. Although these solutions are theoretical, they symbolize the potential to incorporate placing value on ecological and ecosystem health, rather than accepting the imperfect systems, such as industrial fisheries and conventional disposal techniques, as they are.

The Letter of the Law: Science Standards and Student Choice

Science standards are the guiding framework that determine what students at a given grade level should know and understand. In the state of California, Biology/Life Science standards for

grades nine through twelve are divided into the following categories: cell biology, genetics, ecology, evolution, and physiology (CDE, 2013b.). The physiology framework reads as follows:

Physiology

9. As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment. As a basis for understanding this concept:

   a. *Students know* how the complementary activity of major body systems provides cells with oxygen and nutrients and removes toxic waste products such as carbon dioxide.

   b. *Students know* how the nervous system mediates communication between different parts of the body and the body's interactions with the environment.

   c. *Students know* how feedback loops in the nervous and endocrine systems regulate conditions in the body.

   d. *Students know* the functions of the nervous system and the role of neurons in transmitting electrochemical impulses.

   e. *Students know* the roles of sensory neurons, interneurons, and motor neurons in sensation, thought, and response.

   f.* *Students know* the individual functions and sites of secretion of digestive enzymes (amylases, proteases, nucleases, lipases), stomach acids, and bile salts.

> g.* *Students know* the homeostatic role of the kidneys in the removal of nitrogenous wastes and the role of the liver in blood detoxification and glucose balance.
>
> h.* *Students know* the cellular and molecular basis of muscle contraction, including the roles of actin, myosin, Ca^{+2}, and ATP.
>
> i.* *Students know* how hormones, (including digestive, reproductive, osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms. (CDE, 2013b, p. 55-56)

Notably absent from this framework is any content that would necessitate dissection of animal specimens.

Hart et al., (2008), remind us that the guidelines and frameworks for achieving mastery of standards do not specify "teaching methods, lesson plans, or science laboratories to be used" (p. 71). Thus, it is not a *requirement* for teachers to use dissection to teach anatomy and physiology, similarities and differences among organisms, or any other science standards. A teacher's choice to do so is informed by his or her pedagogical goals, background, and experience. Surprisingly, there is little discussion about the potential disagreement surrounding dissection, Hart et al. (2008) state:

> One might expect that a somewhat controversial topic such as dissection, which has even been the focus of some legislation, would be a topic for lively discussion in educational materials and philosophy of education texts directed to precollege. Major dialogs concerning science curricula do not consider dissection, nor does the topic arise in course outlines. We were unable to find an ongoing prominent platform where teachers and

> educational professors are discussing teaching methods for biology laboratories, and whether they involve dissection or alternatives. (p. 7)

The authors indicate that human and animal anatomy is the “mainstay” of biology (Hart, et al, 2008, p. 34); dissection has become a convention in the classroom by which to teach this, yet the authors suggest, “perhaps there should be a line drawn between appropriate educational and research interest, and the use of dissection simply because this has been done as the standard practice in the past” (p. 34). It is important to note that some states have passed legislation that requires that teachers inform students of upcoming dissection activities and provide alternatives, and requires that teachers do not penalize students who conscientiously object to performing dissection. These states include Florida, California, Pennsylvania, New York, Rhode Island, Illinois, Virginia, Oregon, New Jersey, and Vermont (Physicians Committee for Responsible Medicine). In some countries, such as The Netherlands, Switzerland, Argentina, and Israel, dissection is no longer practiced in the pre-college classroom, and in others, such as Sweden, Germany, and England, it is rare (Oakley, 2012).

Considering this reality, perhaps it is possible for educators in the general biology classroom to minimize the use of preserved specimens, or to innovate and use equally compelling, and less controversial, alternatives to dissection. In addition, educators must question the overarching goals of teaching biology and life sciences to students. Is the goal to teach students about anatomy and physiology so that they can make wise health care choices for themselves? Is the goal for students to be able to identify the similarities and differences among the internal structures and organs of a worm, a frog, a fetal pig, and a human? Is the goal for students to be able to identify the parts of a cell, an organ system, or an ecosystem? Is the goal for students to memorize information and structures, or to understand and synthesize themes,

ideas, and concepts? Perhaps educators' goals include all of the above. In a tome on the purpose of education, Ravitch (2010), articulates:

> Certainly we want them (students) to be able to read and write and be numerate. Those are the basic skills on which all other learning builds. But that is not enough. We want to prepare them for a useful life. We want them to be able to think for themselves when they are out in the world on their own. We want them to have good character and to make sound decisions about their life, their work, and their health. We hope that they will be kind and compassionate in their dealings with others. We want them to have a sense of justice and fairness. We want them to understand our nation and our world and the challenges we face. We want them to be active, responsible citizens, prepared to think issues through carefully, to listen to differing views, and to reach decisions rationally. We want them to learn science and mathematics so they understand the problems of modern life and participate in finding solutions. We want them to enjoy the rich artistic and cultural heritage of our society and other societies. (p. 230)

The question becomes, how do practices, including dissection, which educators use and model in the classroom, achieve culturally agreed upon goals of education?

Questions to Consider

- Whose role is it to determine acceptable levels of chemical exposure for minors who may not be aware of the chemicals' potential health effects, or proper safety protocols? What are the health implications for students if, or when, they are not being provided with proper protective equipment, such as adequate ventilation, during classroom laboratory exercises? Are these potential health effects trivial, or troubling? How could this be

investigated in the context of multiple chemical exposures from the air, water, food, and daily products individuals ingest or use?

- What are the lasting educational benefits of using dissection? What anatomy/physiology/science content does an adult, who did a dissection in high school, remember about the experience? Is this necessary in the body of knowledge a student takes with himself or herself into adulthood?
- What are the implications of discarding a once-living creature into the trash? Does this send an implicit, albeit unintended, message about the value of life, or the value of some species over others?
- Is it possible that educational practices, such as specimen dissection, enable or facilitate practices, such as factory farming of livestock, that allow, or even require, consumers to dissociate from their emotional bond with living creatures?
- Is it possible that specimen dissection sends an implicit, albeit unintended, message of human dominion over other species?
- How important is it for the general biology student to be able to do comparative anatomy? Is dissection of animal specimens, as a tool to learn about human anatomy, anthropocentric? Is anthropocentrism a characteristic to be cultivated?
- Is dissection relevant for the general biology student? Is it pedagogically necessary in the contemporary classroom? Is it an essential learning experience that students gain a lasting body of knowledge from, or a convention illustrative of educational values from a previous era?

- How can dominant cultural paradigms modeled in the educational system be shifted toward an Earth and eco-centric model that prioritizes regenerative and restorative classroom practices that address the environmental challenges of our era?
- If educators were to consider and contemplate these questions, what might the resulting benefit to human relationship with animals and, even the planet, be?

Summary

In an effort to create a more holistically complete educational system, educators are invited to integrate three principles and ask if educational practices meet them. Specifically, are the policies and practices utilized in the classroom pedagogically sound, ethically sound, and environmentally sound? As a classroom practice, dissection can be an effective tool by which students learn anatomy and physiology, yet the literature shows that it is not the best way, nor the only way to achieve this goal, as some educators believe. Examining dissection from an ethical perspective reveals a wide range of beliefs that indicate that it is not morally acceptable to all students or teachers. In addition, the ecological effects of gathering some specimens bound for dissection invites deliberation because each species has its niche, and unregulated extraction of species from their native habitat affects the balance of the ecosystem. The environmental and human health implications of using preservative chemicals are unknown. Finally, disposing of these specimens requires their bodies to become landfill material rather than allowing them to return to the nutrient cycle, as would happen during the natural course of their life and death. When examined from these various perspectives, it becomes clear that dissection is not an irrefutably harmless practice. These considerations give educators several reasons to more fully question the convention of its use in their classrooms.

Biology, by definition, is the *study of life*. Perhaps it is time to more fully engage a conversation about enlivening a different paradigm in which students actively interface with living creatures, habitats, and ecosystems, and become knowledgeable stewards of local flora, fauna, and natural areas through restoration projects and citizen science. In this new paradigm, dissection as a means for general biology students to learn anatomy and physiology might become the exception, rather than the rule. Students can be given the opportunity engage in a

new, awakened, interactive relationship with the diversity and fragility of the world around them. They can “get to know their neighbors”, and begin to understand how the Earth’s ecosystem, itself, is a functioning body that supports all life on this planet. In the end, this is not a question about whether or not dissection can be an interesting academic experience that some students reap benefits from. The question becomes, at what cost, and how can the many facets of this essential question be addressed in a meaningful, solution-oriented way?

Chapter 3 Method

Research Approach

This study explores use of dissection and teacher experience with, and knowledge of, various facets of this practice, including, but not limited to, use of dissection and alternatives to dissection, types of specimens dissected, concerns about health effects of preservative chemicals, student attitudes toward dissection, and effectiveness of this practice to achieve learning outcomes. The research relies on interviews conducted with secondary science teachers who use, have used, or actively choose not to use dissection in their classrooms.

Ethical Standards

This paper adheres to ethical standards in the treatment of human subjects in research as articulated by the American Psychological Association (2010). Additionally, the research proposal was reviewed by the Dominican University of California Institutional Review Board for the Protection of Human Subjects (IRBPHS), approved, and assigned number 10177.

Sample and Site

Target subjects for this study were secondary science teachers at a public high school in northern San Francisco Bay Area.

Access and Permissions

The researcher was given permission to interview teachers by the school principal. Teachers and other professionals involved in the interviews received written and verbal explanations of their

content and purpose prior to participation.

Data Gathering Strategies

The researcher created a two-page questionnaire with which to interview secondary science teachers. Teachers were asked to participate with the researcher in person to answer questions and create an active dialogue about the subject of dissection.

Data Analysis Approach

Information was gathered using the data from the questionnaires/interviews and responses were assessed based on their similarity to each other and to the existing literature.

Chapter 4 Findings

Description of Site, Individuals, Data

Teachers interviewed for this thesis are six members of the science department at a high school in northern California. Individuals are four male and two female teachers with nine to twenty-one years of teaching experience, and are all in the thirty to sixty age range. Four out of six teachers have master's degrees, and one has a Ph.D. Classes taught, currently and historically, by these teachers, include: Integrated Science I, II, III, & IV, Environmental Science, Advanced Placement Environmental Science, Biology, Advanced Placement Biology, Anatomy & Physiology, Chemistry, and Physics. Efforts were made to include all members of the science team, however one teacher remained unavailable for an interview.

Themes

The teacher interviewees were asked a series of questions about dissection and were asked to answer them from their experiences in the classroom. Among teachers who choose to use, or have used, dissection, the most commonly cited benefit is the "hands-on", contextual, experiential nature of the practice. Teachers state, the students "see it firsthand", they "see actual structures", they "see realistic atria, ventricles, that the left side is bigger". Students "see how it (the heart) pumps blood to the whole body", and how organs are "packaged & suspended in the body". In addition, two teachers, one who currently uses dissection, and one who has quit using dissection, state that it is important for meat-eating students to "know what they are eating". For them, doing dissection in the classroom was a means by which they could make visceral

connections for the students about dietary choices. One teacher uses this discussion as a precursor to a unit on farming.

Among teachers who choose to use, or have used, dissection there are several common challenges cited. Although not all teachers shared all of the following concerns, they collectively listed the following as impediments or negative factors influencing the dissection choice: some students philosophically reject the practice, some students do not approach the subject with seriousness, buying specimens is expensive and can use up a significant portion of the budget, and there are potential safety hazards with students using scalpels. All teachers who use or have used dissection in their Integrated Science classes have had students who refuse to perform the dissection.

Chapter 5 Discussion /Analysis

Summary of Major Findings

This research found that the reasons some teachers in this department use or have used dissection include:

- Dissection augments the study of anatomy & physiology
- Dissection enhances and enlivens anatomy
- Dissection allows students to compare the evolutionary advantages of animal structures to those found in humans
- Dissection creates a sensory, tactile learning experience for the students
- Dissection provides what might be the students' only opportunity to do a dissection in an academic setting, considering most students will not become science majors

The reasons some teachers in this department do not use, or have quit using dissection, include:

- Dissection is not within the course content for the sequence of classes they are teaching
- The teacher's area of expertise is a subject other than biology
- The teacher became more experienced as an educator and it became no longer imperative to stay aligned with other teachers who were doing dissection
- "Memorizing" parts of structures became unimportant to the teacher
- The teacher believes that dissection is not an essential academic experience

When asked what learning outcomes are being achieved by doing dissections in the classroom, the responses are varied, however, they tend to align with the teacher's perceived benefits of doing dissection, such as "it helps compare and contrast structure and function across vertebrates and invertebrates", and it helps "create understanding". One teacher uses dissection "more for the experience", citing that "we're too removed, too sanitized", and "we shouldn't be afraid of dead things". For this educator, dissection is an essential, explorative practice provided to encourage the students' curiosity, and there are "many more outcomes" than the students would be tested on; in other words, it is not about what is on the test.

In response to the question "how does doing dissection help meet the California state science standards, the teachers who use or have used dissection responded, "It doesn't", "I don't know, I haven't checked the standards in years", and "Students learn anatomy and how it applies to physiology". One teacher indicates that the department uses district-mandated programmatic goals with respect to anatomy and physiology, and these, presumably, are prioritized over the state content standards. Based on these responses, dissection is generally not used as a tool to support *state* science standards, however, it helps some teachers reach their educational or experiential goals in the classroom.

The teachers in this department who have used dissection in their science classrooms have all had students refuse to do the dissection. The exception to this is one teacher who had used the dissection of a cow eye in physics class to look at its components and compare them to the optical instruments the class was studying and using. 4 out of 5 of the teachers who used dissection in their biology or integrated science classroom, and had students refuse to participate, were able to provide alternatives for those students to use. These alternatives include sitting and observing, doing a virtual dissection, going to the library and working on the lab on a computer,

and doing an alternative research project. In all cases, the students were held responsible for the content presented in the lab.

When asked, "In general, how would you describe the students' response to dissection, emotionally and academically?", the teachers indicate that students exhibit a variety of reactions, which are often different "from class to class", and "within each class". One anatomy and physiology teacher states, "at first it is usually an either/or response, which usually becomes interesting and fascinating to students", who later exclaim, "I can't believe…", or this is "so cool" or "so amazing". The students in this class have chosen anatomy and physiology as an elective, and are informed of the use of dissection in a course workshop prior to enrolling in the class. According to a teacher who has used dissection historically, but no longer uses it, "There is a range of response, from distraught emotion to silly play to 'that's really cool'!" She says that the student response can be emotional, for example, some kids "get really disgusted or upset", and some get sick or make themselves sick. One teacher who currently uses dissection said that it is a powerful experience and has a strong impact academically. The pig pluck "blows students away". Another teacher has a different methodology to the dissection experience and, rather than assigning all students the same specimen and outline, he lays out a variety of organisms for the students to choose from. Students are then asked to choose three specimens, to "open them up", and to identify the structure that is interesting to them and to explain why. In this approach, "nearly all kids found the activity incredibly exciting" and remarked how "cool" it was, and how fun it was. They "loved everything about it". This teacher states, "There's a joy in seeing what *they* can learn" versus what we tell them to learn: "it creates an opportunity for us to learn something together", "we found structures in a starfish I'd never seen before". Students who dissected the cow eye in their physics class were "curious, enthusiastic, and appreciated the

hands-on" activity. Based on these responses, it seems that a small minority students are upset by the dissection experience and will avoid it, however, a majority appreciate and enjoy the practice as an explorative process of discovery.

Within this science department, a variety of animal specimens have been used for dissection. These include sandworms, earthworms, leeches, giant grasshoppers, clams, "starfish", chicken, squid, African clawed frogs, bullfrogs, cow hearts, cow eyes, cow kidneys, sheep brains, cats, and fetal pigs. In addition, teachers have been able to obtain "plucks" from a local slaughterhouse. A pluck is the connected heart, lung, and trachea from an animal. These are used for demonstration purposes, rather than dissection.

Teachers were asked if they had any concerns about the chemical solutions used to preserve the specimens obtained from biological supply houses. Their responses suggest that they have considered to this question, and that they believe the specimens are safe to use in the classroom and to be disposed of in the trash. One teacher mentioned using Wards' formaldehyde-free specimens. Another teacher indicates that, "it is not a major concern" because "formalin is less toxic than formaldehyde". In addition, he states, "The kids are protected with gloves, goggles, and aprons". A third teacher says he is "mildly concerned" about the chemicals, and that today's specimens are "less toxic". A fourth teacher expressed concern about formaldehyde, because it is toxic to both herself and her students; note, however, that formaldehyde is no longer used in the concentrated form it once was. This teacher chose not to purchase animals "pickled" in formaldehyde, and used fresh animals, when available, for dissection. The teachers who currently use dissection indicate that their specimens all go into the trash. One notes, "The packaging says it's non-toxic". One teacher said that, historically, the "preservative stuff" was taken away as "biohazard". It is not clear that any of these teachers had

consulted with the local waste management agency about whether or not it is permissible to dispose of their specimens in the trash. Many biological supply companies suggest doing so as a practice because local municipalities sometimes have different, or more stringent, guidelines than federal agencies require. These responses indicate that although the teachers feel some concern about the potential toxicity of the specimens, both in terms of human exposure and landfill disposal, these are accepted as part of the practice of using dissection, and there was no further investigation into the issue. This researcher's experience attempting to uncover the answers to some of these questions have not yet led to conclusive evidence about the health effects of occasional exposure to lab specimens, or to decisive disposal recommendations. Consultation with local waste management and environmental health authorities is pending.

Although the educators in this study were not directly asked about their moral and ethical beliefs regarding dissection, several of the teachers made statements or comments that provided insight about their varying value systems. One of the six teachers eliminated dissection from her curriculum "as soon as" she could, and states, "I had problems with dissection way back when I was in college myself". She shared anecdotes about having to pith live frogs and add chemicals to the frog's legs to get them to contract." She expresses that she felt concern about the number of students in the university, and the nation, doing similar experiments, and wondered, "How many frogs does this add up to?" She asks, "If we know something is already true and how it operates, why do we still sacrifice all these animals, just to pass a class?" Another teacher expresses that she does not do cat dissections in her Anatomy & Physiology class because of the questionability of the sources and the fact that they are "too close to home." One teacher says he prefaces dissections in his classroom with a talk about "respect for life" and includes a list of behaviors forbidden during the dissection. Finally, one teacher, who enthusiastically supports

dissection, states, “it forces kids, in a positive way”, to understand that “an animal has to die for us”. He believes that this lays the groundwork for another conversation. He states, “The fact that they were killed for science-I don’t have a problem with it.” Simultaneously, he is opposed to vivisection and wonders, “What kind of life did this animal have while it was alive?” If he knew that the specimens suffered while they were alive, “I would have a problem with that”, he says. In addition, for this teacher, the objective of dissection is to inspire kids to pursue careers in science, or as surgeons, by looking inside animals such as frogs, fish, and cats. He says that, “Planting the seed of interest in cutting things open” is part of his mission, and acknowledges, “we can wrestle with the question of morals.”

Comparison of Findings to the Literature

Department wide, 3 out of 5 teachers currently teaching biological/life sciences, use dissection; this equates to 60% of interviewed teachers. If the un-interviewed teacher, who does use dissection, is included, the percentage becomes 66%. This is below the value of 75% cited in the literature; the majority of teachers in the department choose to use dissection, however the number is lower than average.

The responses to questions about the costs and benefits of, and student response to, dissection obtained from this interview process are in alignment with findings from the literature. Within this department, there is a range of thought regarding the use of dissection, and the teachers interviewed expressed both positive and negative outcomes from using dissection. In addition, the beneficial and detrimental outcomes these teachers cited were similar to those mentioned by other teachers studied in the literature. In general, the teachers in this department who use dissection do so because of a strong belief about its efficacy as an educational tool

and/or experiential process that benefits students academically or cognitively. Those who do use dissection in their classrooms use it without obvious reservation. These educators are cognizant of the varying challenges and questions of using dissection specimens, including exposure to chemical preservatives and potential student refusal to participate. These challenges and questions are accepted as part of the practice. The teacher who chose to eliminate dissection because of moral values is in the minority, as are students who refuse to participate on these same grounds.

Limitations/Gaps in the Research

The sample size for this research is small, and the teachers are all from the same school. The school culture represents the values of the progressive community the school serves; responses from schools in different, more conservative communities might differ. Students were not observed or questioned as part of this research project. Monitoring student interaction with, attitudes toward, and reaction to, dissection could be a valuable addition to the body of knowledge gained from this research.

Implications for Future Research

There is much potential, and an invitation, for educators and researchers to investigate the short and long term educational benefits of dissection. A longitudinal study that assesses students before, during, after, and at several intervals after dissection could provide valuable evidence about what students learn and remember from the dissection activity. In the long term, what anatomy and physiology content do adults remember, for example? This information might inform a teacher about whether or not to do dissection, or how to scaffold the activity to ensure

that students are achieving the desired learning goals. There exists a broad and somewhat esoteric question about how the classroom practices teachers model affect and inform student morals, ethics, and values. A long-term psychological study could be designed to identify the answer to the question, “Does using dissection in the classrooms behaviorally condition students to have less reverent attitudes toward certain classes of animals, for example insects or amphibians? If so, how, and what are the implications of this possibility?”

There was some speculation on the part of teachers, both those interviewed and those cited in the literature, that performing dissection in the high school classroom influences a student’s career choice. For example, one teacher felt that allowing his students to experience dissection in high school might encourage them to become surgeons. This question could be answered by interviewing or providing questionnaires for adults in a spectrum of careers and asking them how much, if at all, performing dissection as a high school student inspired or discouraged their career choice.

In addition, there remains an open question about how teachers and students are disposing of their used specimens and shipping fluids. This could be studied and addressed in an effort to ensure that proper techniques are being utilized. Additionally, the health effects of short-term exposure to these specimens and the fumes they off-gas are not known. More study on the synergistic effects of multiple-chemical exposure will, hopefully, generate an answer to this question, and embolden a departure from using carcinogens in the classroom.

Overall Significance of the Study

This study indicates illustrates that the choice to use dissection, in this science department, is a personal one, and is informed by the educators’ belief systems about whether or not dissection is

a pedagogically useful process. Although the educators cited similar reasons for using dissection, it is not clear that there is a department-wide consensus about its usage, or that the negative impacts, either real or potential, of dissection are being addressed. It seems that a platform could be developed, at school, local, state, and national levels, through which educators can discuss some of these challenges to arrive at a common understanding of what these negative impacts might be. Within the context of a changing world, in which stewarding the planet with a more eco-centric approach becomes increasingly important, this conversation is one that seems essential. In addition, classrooms that dispose of their formalin-preserved specimens in the trash may not be in compliance with the state laws designed to regulate landfill waste and protect the shared environment; this becomes a legal issue and must be addressed so that schools can model correct environmental and civic leadership and citizenship.

Despite the reality that the costs of dissection do not seem to be the subject of an overt discussion at the study site, it is clear that the teachers in this department are dedicated professionals who strive to provide meaningful educational experiences for their students, and those who use dissection do so in service of this goal.

About the Author

Melissa Witte is an avid birder, backpacker, wildlife enthusiast, and adventurer who has a deep concern for current environmental issues and how to ameliorate them through connection to nature and natural processes. She loves creatures of all shapes and sizes, including rattlesnakes and venomous spiders, and has a special affinity for birds and sea turtles. She feels most deeply inspired, motivated, and alive in the backcountry, and recently fell in love with the feisty Black-backed Woodpeckers and vanilla-scented Jeffrey Pines of Plumas National Forest.

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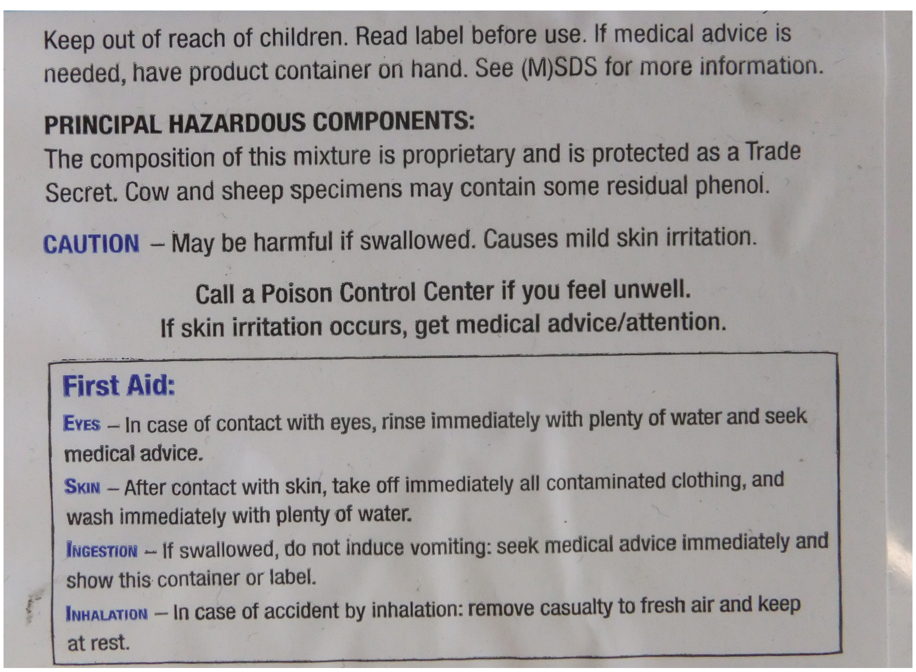
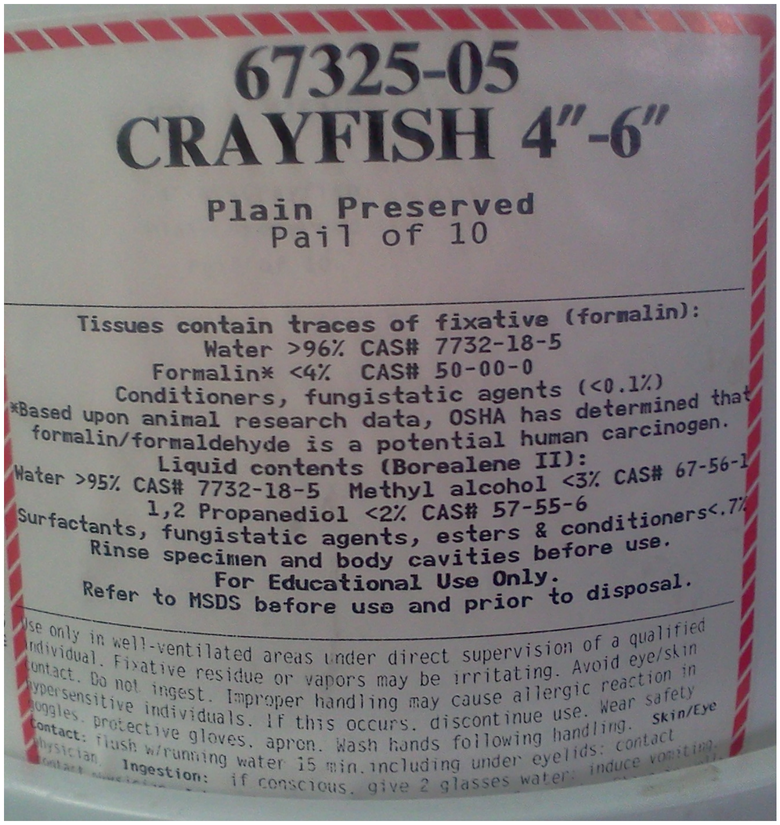
Appendix

Witte, Melissa. April 1, 2014.



Witte, Melissa. April 1, 2014.



Witte, Melissa. April 22, 2014.