Chapter 8
A Story of Chicks, Science Fairs and the Ethics of Students' Biomedical Research

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8.1 Learning Opportunities Through Science Fairs

Science fairs at the secondary level provide students opportunities to create projects that are driven by their own interests and questions. In the process of conceptualizing and carrying out a science fair project, students learn to manage long-term research, foster their own curiosity, work through challenges that arise from doing scientific inquiry, and collaborate with others (Cutraro 2011). The exploratory and investigatory aspect of science fair projects can represent science as inquiry. In this capacity, science fair projects help transform classroom science into process-driven, inquiry-based areas of study in which students can be personally and directly involved in scientific investigation (Balas 1998). Crystal Miller-Spiegel (2004) emphasize that science fairs demand strong communication and cognitive skills, and intellectual development. Thus, by participating in science fairs, students can be encouraged to develop interests and pursue careers in science, technology, engineering, or mathematics fields.

When students participate in a science fair, their involvement typically includes conducting an investigation, writing a report, creating a visual display of the project, giving an oral presentation to an audience, and receiving evaluation and assessment from the judges. Through this process, students learn important scientific concepts and experience first-hand what it is like to carry out a scientific investigation.

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However, the mere aspect of doing science is not necessarily the primary educational aim for science fairs. According to Carl Tant (1992), the primary goal of involving students in science fairs is to teach them how to *think*. In light of this aim, we must consider the educational value of science fairs, particularly for students who design experiments using animals (live vertebrates) and ask the question, "Why use animals in science fair projects?" To this end, our chapter provides a case narrative of a student who used chicken embryos to compete at a regional level science fair.

The purpose of this chapter is to invite students, teachers, science educators, scientists, and other voices to participate in discussing the implications rising from this narrative. Through the case narrative, we raise the following questions: (a) Must we use animals in science fair projects to meet the educational aim of teaching students to critically think about anatomy and physiology, and learn engaging in such scientific exploration as a process of inquiry? (b) What perceptions of science are we impressing upon students when we deemphasize the ethical issues of using animals in scientific experiments, such as respect for all life and interactions between humans and animals? (c) Can we re-construct the educational aim of engaging in scientific exploration as a way to critically examine and understand the harmonizing interactions between human lives, nature and other living animals? When we socially construct an alternate aim of teaching and learning science, the authors posit that the need to use live animals in science fair projects will become obsolete for educational purposes and that students can learn to appreciate science as a way of inquiring into and understanding more meaningful interactions with the natural world.

8.2 The Historical Context of Science Fairs

In 1921, Science Service, a nonprofit membership organization, was founded by Edward W. Scripps, a journalist, and William Emerson Ritter, a California zoologist. The goal of Science Service was to inform the public about scientific achievements. In 1942, Science Service and Westinghouse launched the first and most prestigious science competition for high school seniors – the Science Talent Search (STS). In 1950, the first National Science Fair for high school winners from local and regional science fairs was launched in Philadelphia. In 1958, the National Science Fair became the first international competition, with participants from Japan, Canada, Germany and the U.S. Intel Corporation took over the sponsorship of STS in 1998. This annual international fair has grown into what is known today as the Intel International Science and Engineering Fair (ISEF). In 2008, Science Service became Society for Science & the Public (SSP) and has been the governing body to continue overseeing its two major science competitions in the United States - STS and ISEF (Society for Science & the Public 2000–2015).

8.3 Use of Animals in STS and ISEF: Early Years

Students who participate in science fairs can compete on local, regional, state and national levels. Most science fairs and competitions at different levels are organized according to the rules and guidelines established by the Intel ISEF. In this section, we will examine the rules and regulations of STS and ISEF pertaining to the use of animals in science fairs.

Since its inception in 1942, the STS encouraged and incentivized students to seek careers in science with grand cash awards and opportunities to travel when declared the winner of the competition. Another competition, Intel ISEF, was founded in 1950. As such, the two competitions became a competitive platform to engage in scientific endeavors for the aspiring young scientists. However, these efforts and eagerness to become a great scientist (and to win that grand prize) was sometimes at the great expense of animal suffering (Rowan 1984). John Hillaby (1970) called this widespread use of animals in science fair projects "sanctified torture." To illustrate, students bathed goldfish in detergents, and carried out splenectomies and heart transplants (Rowan 1984). To add to the grand flare of these prizewinners, students, who wore surgical gowns and masks, performed these procedures in front of television cameras. In 1968, the Mississippi State science fair award winner used twenty-five squirrel monkeys to demonstrate electric stimulation to the brain, which caused the death of one squirrel monkey with holes in its head and of others due to a variety of illnesses resulting from the project (Rowan 1984). The award winners at these science fairs were consistently those who deliberately used animals in their experiments, such as skin grafts on 1,000 mice, or bisection of the brains of mice at home, which resulted in the death of most of the animals (Rowan 1984). In response, the *New York Times* published an editorial titled, "Prizes for Torture," which argued that the adult organizations were thoughtlessly encouraging students to perform these atrocious experiments ("Prizes for Torture," 1969).

The singular project that caught the attention of animal advocates took place in 1969 when a high school student from Virginia used five house sparrows (Rowan 1984). At the University of Texas, the student had learned a technique of removing the eyeballs to blind the sparrows to see if they could find their food source in one arm of the Y-shaped box and avoid the source of the electric shock in the other arm of the box. When the sparrows would not move, they were starved for six days to increase the incentive to seek food. The student's conclusion from the study was that the birds were likely to die when starved up to 70% of their bodyweight (Rowan 1984). The student received a $250 prize even though three of the sparrows died as a result of the student's actions (Miller-Spiegel 2004). The *Chicago Tribune* responded to this event and strongly rebuked Westinghouse for considering such an experiment worthy of an award in the STS competition (Animal Welfare Institute1969). In summary, when the science competitions first began, there was little to no regulations on what was allowed or not allowed in science fair projects with respect to the ethics of use of live animal**.**

8.4 Rules and Guidelines: STS, ISEF, and Federal

In 1969, under pressures from the general public, Westinghouse changed its rules and guidelines for the STS. According to the STS Rules and Entry Instructions (Society for Science & the Public 2015):

No projects involving live non-human vertebrate animal experimentation will be eligible…

Live vertebrates are defined as any live, non-human vertebrate, mammalian embryo or fetus, bird or reptile eggs within three days (72 hours) of hatching, and all other vertebrates at hatching or birth. (p. 5)

The exceptions to this rule are only when projects: (a) involve observing animals in their natural environment, or (b) are conducted in a registered research institution in which the student will only have physical contact with the animals such as handling and husbandry conditions that meet the Institutional Animal Care and Use Committee (IACUC) standards; **and** the student works with non-living materials supplied by the supervising scientist; **and** animals are not sacrificed solely for the student's project; **and** the student's project begins with non-living material where no invasive procedures were conducted on live vertebrate animals; **and** the student is not involved in the collection of data directly or indirectly where the research involves invasive or intrusive experimentation causing pain and distress to the vertebrate animals (Society for Science & the Public 2015)

The ISEF rules set the guidelines and standards for science fairs at different levels as well as throughout the world. In contrast to the changes made by STS in its policies, the ISEF remained firm in its position to allow the use of animals in the competition. According to the ISEF's International Rules and Guidelines:

The use of vertebrate animals in science projects is allowable under the conditions and rules in the following sections. Vertebrate animals, as covered by these rules, are defined as:

(a) Live, nonhuman vertebrate mammalian embryos or fetuses
(b) Tadpoles
(c) Bird and reptile eggs within three days (72 hours) of hatching
(d) All other nonhuman vertebrates (including fish) at hatching or birth. (Intel International Science and Engineering Fair [Intel ISEF], 2015–2016, p. 9)

The Society for Science & the Public (SSP) encourages students to consider alternatives to using animals in their projects, and "if the use of vertebrate animals is necessary, students must consider additional alternatives to reduce and refine the use of animals" (Intel ISEF 2015–2016, p. 9). To this end, the ISEF provides guiding principles that include the "Four Rs":

(a) **Replace** vertebrate animals with invertebrates or lower life forms, tissue/cell cultures and/or computer simulations where possible.
(b) **Reduce** the number of animals without compromising statistical validity.
(c) **Refine** the experimental protocol to minimize pain or distress to the animals

(d) **Respect** animals and their contribution to research. (Intel ISEF 2015–2016, p. 9)

In addition to these guiding principles, the ISEF requires that projects involving vertebrate animals must be reviewed by and receive approval from the affiliated fair Scientific Review Committee (SRC). Certain experiments involving restrictions to the animal (i.e., food or fluid restriction) must be approved by the Institutional Animal Care and Use Committee (IACUC) and conducted at a Regulated Research Institution. All studies involving vertebrate animals, except for observational studies, must be supervised by a qualified scientist or designated supervisor. Studies involving vertebrate animals may be conducted at home, school, farm, ranch, or in the field when the project meets the four specific criteria: (a) studies of animals in their natural environment, (b) studies of animals in zoological parks, (c) studies of livestock that use standard agricultural practices, and (d) studies of fish that use standard aquaculture practices (Intel ISEF 2015–2016, p. 12). However, when a study does not meet the criteria delineated in this particular section, the research must be conducted at a Regulated Research Institution. To illustrate critical rules pertaining to the use of animals, the ISEF Rules state that students are prohibited from conducting induced toxicity studies that include known toxic substances such as alcohol, acid rain pesticides, or heavy metals (Intel ISEF 2015–2016, p. 12). Studies that anticipate causing the death of the animal are prohibited. If an illness or distress is caused by the study, the experiment must be terminated. If animal death results as part of the experimental procedure, the study must be terminated and will not qualify to compete (Intel ISEF 2015–2016, p. 11).

These ISEF rules were developed to guide student researchers to adhere to the federal regulations that guide the use of animals in scientific research by scientists themselves. These federal regulations are detailed, complex and continuously evolving. As such, a close examination of the historical development of these federal regulations would help us better understand the current status of what is and what is not acceptable in relation to the use of animals in scientific research. Originating from the Laboratory Animal Welfare Act (AWA) of 1966, the U.S. Animal Welfare Act is the only federal law in the United States that regulates the use and treatment of animals in research, exhibition, and transport settings and by dealers (Animal Welfare Act 2013a). Since the original law was passed in 1966, the AWA was amended in 1970, 1976, 1985, 1990, 2002, 2007 and 2008. Of the amendments, in 1985, the AWA improved standards for laboratory animals. To summarize key components of the amendment, "The Improved Standards for Laboratory Animals Act" delineates "humane care" to the animals, and specifies that pain and distress must be minimized during procedures and that alternatives to using such procedures be considered by the researcher (Food Security Act 1985). Operating under the AWA, the Animal Welfare Regulations (AWR) specify detailed standards and regulations that pertain to various aspects of animal care and use in research studies, including the registration and licensing of research facilities, meeting the standards of IACUCs, ensuring adequate veterinarian care, as well as delineating requirements for recordkeeping, reporting, procurement, handling, care, treatment, and transportation of animals (Animal Welfare Act 2013b, 9 CFR, Part 2). The U.S. Department of Agriculture (USDA) is the federal agency that implements and enforces the AWA and AWRs.

In 1973, the Public Health Service Policy on Human Care and Use of Laboratory Animals (PHS Policy) was introduced in order to "require institutions to establish and maintain proper measures to ensure the appropriate care and use of all animals involved in research, research training, and biological testing activities" (National Institutes of Health 2015, p. 7). Revised in 1979 and again in 1986, the Health Research Extension Act of 1985 provided the statutory mandate for the PHS policy (Health Research Extension Act of 1985). Similar to the AWA and AWRs, the PHS Policy mandates that research projects are reviewed by IACUC and recordkeeping and reporting requirements. Further, the PHS Policy requires institutions to comply with the National Research Council's (NRC) *Guide for the Care and Use of Laboratory Animals* known as The Guide (NRC 1996). The principles endorsed by The Guide support alternatives for reducing or replacing the use of animals; minimizing discomfort, distress, and pain; and, providing adequate veterinary care among others policies related to the appropriate handling and caring of the animals (NRC 1996).

When live animals are killed in a student's science project, it is important to consider the different contexts within which the local decisions are made. For instance, in our story, the student was from a rural school district. The factors (social, political, educational, values, and etc.) that may have gone into the decision making process to allow the project to advance to the regional level might not necessarily be the determinants in a different context (i.e., an urban school district). Nonetheless, the laws are explicit as to when and how the secondary students can use live animals in their science projects. As represented by these federal laws and regulations of the science fairs, the efforts to consider the interactions between humans and animals in the context of scientific research as well as in teaching are evident.

With these regulations in mind, let us explore the following case narrative.

8.5 An Impactful Encounter with a Student at a Science Fair

The case narrative that follows was developed by one of the authors who was reviewing displays of various research experiments at a regional-level science fair. The case narrative depicts the details of the student's experiment using 38 chicken embryos, the author's conversation with the student, and the author's subsequent reflections and thoughts. The case narrative is followed by a reaction from science educator Shaknoza Kayumova, whose response is grounded in feminist epistemologies.

> The story I'm telling – about what makes it possible for humans to use other animals as subjects in biomedical research projects – has been told many times before, and like all stories, it changes according to who is doing the telling. In some versions, the human

> scientists are the heroes and other-than-human animals are their experimental material or perhaps their silent partners, and the enemies are inhumans who protest on behalf of the animals. In other tellings, the animal advocates are the compassionate good guys, and the scientists are cruel tormentors of innocent, enslaved animals. These are always stories about good and evil, although what is good and what is evil depends on the particular telling (Weigand 2008, pp. 1–2).

Weigand eloquently articulates the controversial nature of using animals in research. Notwithstanding her considered opinion that human use of other animals for research and testing is wrong, Weigand's intention is "not to justify or logically demonstrate the truth of that position" (Weigand 2008, p. 2). Rather, her purpose is to tell a story that constructs the reality in which these controversial views exist. In our story, we also welcome constructive discussions about how we, as science teachers, should teach our students about animal research and ethics.

A poster whose title read, "The Effect of Alcohol on Chicks" soared above all the other posters in the room. Not only was the poster physically one of the tallest posters in the room, but also the project title, the underlying message of the title, as well as the photos of dead chicks personally caught my attention. There was a crowd of teachers who were whispering about the graphic nature of pictures of dead chicks on the poster and the methods by which ethyl alcohol was injected to assess its effect on the mortality rate of chicken embryos. I stood in front of the poster wondering how I could begin this conversation with the high school girl who seemed genuinely oblivious to the controversy that her poster had brought into the room.

After reviewing her methods and finding sections, I began with a comment, "your data are quite striking, Jenna. Out of 35 chicks, 33 died upon being injected with alcohol. Can you tell me a little bit more about how you designed your study?" Jenna, with much confidence, began describing the method she had used to conduct her experiment. Jenna described, "yes, ma'am. I followed the scientific method. First, I got chicken embryos and brought them home. Then, I cracked open each shell one-by-one just a little bit so that I could inject the alcohol. I injected different percentages of ethyl alcohol to a group of five chicks at a time. I made some observations and recorded how long it took for the chicks to respond to the alcohol. My graph and table here show you that all but two chicks died instantaneously. The remaining two chicks died after a while."

Then, I posed additional questions related to Jenna's methods. "Are the chicks fully developed at 18 days and alive in the shells? Where and how did you procure your chicks?" Jenna replied, "yes, ma'am. They are alive in the shells. I cracked open the eggs to take them out and injected them with rubbing alcohol. They can't live for very long once their shells are broken. So, they die off pretty quickly. I have a neighbor who has a chicken farm. I went over to him and asked if I could have some chicks for my project. He gave them to me." I replied, "oh that is very interesting, Jenna. You mentioned that the chicks died off pretty quickly after their shells were broken. Wouldn't the death rate be due to being taken out of their environment since they were most likely not ready to hatch? I guess what I am really curious is if breaking their shells before they were ready to hatch had something to do with their dying, and not solely due to the effects of the alcohol. What do you think?"

Jenna looked over to her board for a few seconds and explained, "Well, yes, that is possible. But, it is the alcohol that killed the chicks based on my science experiment, I think, because my result and my numbers are *significant*." One of my male colleagues, Dakota, who was observing my interaction with Jenna in silence, spoke up, "Yeah, yes… You are technically right that your numbers are *significant* - yes, that is true. I mean, your data are striking – 33 of 35 are dead. Actually, all of them eventually died. But, you are breaking them out of their natural environment before they can survive on their own, right?" At this particular moment, in the unspoken agreement between the male teacher and I, we wanted to pose thought provoking questions that would guide Jenna to realize the confounding factors that were present in her study, notwithstanding that there was still the unspoken ethical controversy that somehow needed to be addressed. To his question, Jenna replied, "I made careful observations after I injected the alcohol. The chicks were alive when I took them out of their shells. After I injected the alcohol, I recorded how long it took them to respond to it. They died off minutes later, and I think that is due to the alcohol." At this point, I decided to move forward from this conversation about the science behind her project. I wanted to address the ethical issues that no teachers quite knew how to address with this student.

I asked Jenna about how her project was approved, and she described the Institutional Review Board (IRB) process. "My teacher and the panel approved this study. I have a folder here with the completed forms." I carefully flipped through several sheets of paper enclosed in the manila envelope and commented, "Oh wow, yes, I see that all these forms have been signed off and your panel approved the study. You must've been really excited to do this project! Whose idea was the project?" Jenna's answer to this question was a lukewarm shrugging of her shoulders and a brief response, "my teacher suggested it." I took her reaction as implying that this experiment was just a science fair project.

"So, Jenna, you don't think you are hurting animals when you crack their shells and inject them with alcohol?" Jenna replied, "No, ma'am. I do not consider them as animals because I eat chickens. I don't think I am hurting any animals. Oh, but I do have pet chickens that I take very good care of." As a teacher and science educator, Jenna's statement was extremely interesting. She did not consider the conducting of experiments on chick embryos as harmful because she viewed them primarily as a food source rather than living animal. Because she considered chicken as food, she was completely detached from realizing that she was injecting a toxic chemical into an animal that was breathing and living.

I wanted to continue this conversation after hearing Jenna's response. Then, I asked, "Would you say you have a pretty convincing argument about the detrimental effect of alcohol on women?" Jenna confidently replied, "Yes, ma'am, I do. Based on my data, pregnant women should not be drinking alcohol." I continued, "Jenna, let's pretend for a moment that I am about two or three weeks pregnant with a baby inside of me. If I drink alcohol, would that *harm* my baby who is about 18 days old?" Jenna answered me with a strong conviction, "Oh, yes, ma'am. My research findings show that it will definitely harm your baby. When you are pregnant, you should not drink any alcohol." I took this opportunity to bring our conversation back to her research and asked her, "Then, would you reconsider injecting rubbing alcohol into an 18-day old chick, who is about the same age as the baby inside of me? Could injecting alcohol into a chick embryo be also harming a life – an animal?" Jenna was genuinely shocked at my question, as her eyes widened and she was speechless for a moment. She was clearly a bright student who thought over these questions as I was posing them to her. After a moment of shock, she slowly answered, "Um, yes, … ma'am, I think so."

I determined that at this point our conversation had gone on long enough and I wanted to give Jenna some space and time to think about the response she just gave me. I did, however, ask where her teacher was, since the advising teachers were supposed to attend the competition. Jenna once again shrugged and said, "Oh, I am not sure. I think he is here somewhere." I lingered around the secondary level competitions for about an hour to see if I would see her teacher return; however, he never returned.

As I walked towards other posters, Dakota caught up with me. He mentioned, "You know, I could have never brought up that analogy as you have done with that student – about pregnancy. That would have been inappropriate if I did that. I am glad you brought it up with her. I really think she needed to understand what we were trying to get her to think about – that she was hurting and killing live animals simply to carry out scientific research. We can address and provide feedback on her scientific design, but what use is that when she is completely removed from understanding what she was *really doing* in her experiment? I can't believe her study was approved and got through. At my school, this would have never been approved. No, never. Oh, there – do you see someone going up to her poster? I think they are telling her to cover up the photos of the dead embryos. Finally!" I nodded and agreed with him without much word because I, too, was deep in my thoughts about Jenna and our conversation. I thought Dakota made a strong point – what use does providing a student feedback on his/her "scientific method," or on "science" behind the experiment, when the student has not been taught to consider the ethical issues and the view that doing science is not simply a matter of conducting "scientific experiment," but that it is a process of inquiry towards understanding our world better? Indeed, what use would there be in teaching science and, better yet, what are we teaching our students in our science classrooms? It seems that far too often these kinds of student projects begin with the science with the ethical issues only as an afterthought. Perhaps, I thought, a better approach to encouraging students' interest in the natural world would be to begin with the ethics.

I left the competition that day wondering what kind of learning experience this science fair project has been for Jenna – learning the science behind the experiment, but to what end and what educational goal and whose interest? As technology and scientific knowledge advance, what should we be emphasizing in our science classrooms and what kind of "science" should we teach our students? I could only hope that she would reflect on our conversation and evaluate for herself (not by anyone else, her teacher, or any other authority) whether doing this experiment truly benefitted her science education.

8.6 Animal Rights, Education, Present and Future of Science

As this story unfolds, it appears as if we are trying to wrap our heads around Jenna's decision to use and even kill chicks for the purposes of her scientific endeavor. The story reads as an example of an "insensible" and oppressive act by a student performed in the name of inquiry and science. However, the story also exemplifies how Jenna's understanding of the nature of science and science projects permitted her to make justifications on a very important socioscientific and ethical issue implicated through her decision to use chicks as objects of her science inquiry (Zeidler et al. 2002). Jenna, as an individual, shares the norms and practices of an anthropocentric society. An anthropocentric society privileges humans, and "regards humans as separate from and superior to nature and holds that human life has intrinsic value while other entities (including animals, plants, mineral resources, and so on) are resources that may justifiably be exploited for the benefit of humankind" (Boslaugh 2016, para. 1). Jenna positioned the chick as a source of food – a "thing" that is chopped, cooked, and eaten everyday (animal skin is also used as a commodity in a garment industry). If we take Jenna out of this story, then her decision about using the chicks for her scientific experiment does not seem so different than the ways in which other animals are used in research. Jenna's intentions may genuinely be tied to a scientific inquiry; our intentions for killing, chopping, and cooking chicks, fish, cows, pigs, dogs, and horses are instrumentally tied to our appetite and need to satiate our hunger. Chicks are raised mainly for their meat and eggs! Moreover, in context, the state of Georgia is known as a poultry capital of the world. To attest to this, one of the state's largest and flagship university systems includes a nationally renowned department dedicated to poultry science. If we take for example some of the research and educational efforts in the department the list includes the following topics:

Physiology: Regulation of Myogenesis in Avian Embryos; Sperm-egg Interaction in Birds; Role of Surface Carbohydrates.

Genetics/molecular: Genetic Relationships of Growth and Reproduction in Diverse Poultry Populations; Programmed Cell Death; Characterization of the Apoptosis Endonuclease.

Microbiology: Methods for Identifying Temperature Abused Broiler Chicken Carcasses.

Processing Technology: Development of New Processes and Technologies for the Processing of Poultry Products and Slaughter Technology.

To keep up with this kind of science research in poultry science, at least dozens of chicks are used daily. This also speaks to another complexity about the purposes of science and science education. Using animals for science is a complex socioscientific and ethical issue. Zeidler and Nicols (2009) argue that:

> Socioscientific issues involve the deliberate use of scientific topics that require students to engage in dialogue, discussion and debate. They are usually controversial in nature but have the added element of requiring a degree of moralreasoning or the evaluation of ethical

> concerns in the process of arriving at decisions regarding possible resolution of those issues. (p. 49)

Jenna, as a student, is developing reasoning skills in science education, and she took a position on the issue and instrumentalized the chick as an object in her science project. Now questions that beg answers include: a) How on earth do we allow for chicks and chickens for the purposes of science every single day, and no one questions the intention and/or integrity of this field? b) Why and under what conditions is it acceptable to use animals as objects of science? c) We find it acceptable for animals to be raised and slaughtered for food, yet when an adolescent somehow replicates what we as adults and society do, why and how do we suddenly begin to recognize the dehumanized and oppressive nature of this act? d) What would be our own reaction to this project if it was performed by a renowned scientist, with important implications for human health, inventions, and scientific findings of the future (i.e., for saving lives of human fetuses)? e) Would we still be appalled by this project? Ecofeminism, a field which has emerged "from various fields of feminist inquiry and activism: peace movements, labor movements, women's health care, and the anti-nuclear, environmental, and animal liberation movements," has been raising these questions for the longest time (Gaard 1993, p. 1). According to ecofeminists, issues about animals and their rights is the question of living bodies. Looking at animals as living bodies is an ethical position, not necessarily lodged in individuals, but in a society and institutions that structure individuals' subjectivities about norms, ethics, responsibilities and so on. In this example, it is important to recognize that Jenna's subjectivities and her understanding of the world, science, and ethics are structured through social, cultural, economic, geographic, and political contexts, which also influence the assumptions and conventions of scientific practices. So there is a question of the *subject* (be it a student, teacher, scientist, and so on) and his/her relation to the world. The dilemma of the subject and ethics in this ever evolving techno-scientific era reminds us of what Rosi Bradiotti (2006), a feminist philosopher, says of how "the new global … requires a robust new theory of the subject as a multi-layered entity that is not unitary and still capable of ethical and political accountability" (p. 144). Although the subject is structured through dimensions of social, cultural, and institutional conventions, according to Bradiotti the shift in the frontiers of subjectivity is possible on the grounds of *affectivity*. We have argued elsewhere (Kayumova and Tippins 2016) that it is time to reconsider science practices as bodily and affective. Affect is understood not in a psychological term as emotions, but as a capacity to feel that emerges when the subject intra-acts (Barad 2003) with other physical, social, and cultural entities (bodies) in the world. Affectivity becomes the strength that targets the subject's power to make a decision that is not confounded to the rational. Jenna's rational thinking allowed her to treat the chicks without the involvement of any senses. The chick was considered to be a source of food, and object, compared to a value of human that science serves. According to Braidotti "what is mobilized is one's capacity to feel, sense, process and sustain the impact with the complex materiality of the outside" (p. 145). What we may need in science education is a shift that allows students the capacity to feel the relation to other entities (bodies). "This shift entails an ethical dimension … imposes a vision of the subject [the teacher and the student] as fully immersed in relations of power, but ethically compelled to strive after freedom" of thought and ethical decision making (Bradiotti 2006, pp. 148–151).

8.7 Understanding a Continuum of Positions

The movement in advocacy of animal welfare, which began receiving attention in the 1900s, has challenged us to reconsider the way we interact with other animals, connect to the environment, and recognize the symbiotic relationships between us and other organisms (Tsuzuki et al. 1998). While searching various databases for publications related to use of animals in science fairs, we found that the majority of the papers were published in the late 60s through the 90s. Using the key words, science fairs, vertebrate, and animals, the search resulted in about forty-nine articles published since 1996. Of these articles, about five articles were related to the use of animals in school science classes. Only one article by Michael Fox and Andrea Ward (1977) was directly related to the use of animals and the ethical issues surrounding them in the context of science fairs. *Alternatives to Laboratory Animals* (ATLA) is an international, peer-reviewed scientific journal that publishes articles on the latest research related to the development, validation, and use of alternatives to laboratory animals (ATLA 2014). In 2004, ATLA dedicated an entire supplemental volume of articles on the replacement, refinement and reduction alternatives in scientific research, and on ethical issues in using non-human primates in research as well as their use in education settings. However, only three of these articles were related to secondary school science education settings in the U.S., and of these, only one was related to the use of animals in the context of science fair projects (written by C. Miller-Spiegel 2004). As such, the authors of this chapter believe that the discussion surrounding the use of animals in science fairs needs to be revitalized, because participating in science fairs can significantly influence how students perceive the way science is done.

Our review of the literature suggests a continuum of positions on the use of vertebrate animals in secondary school science education settings (i.e., dissections, science classes, curriculum, and science fairs/competitions). The continuum begins with those who advocate for alternatives to animal experiments in high school science classes (Strauss and Kinzie 1991). According to Miller-Spiegel (2004), students often cannot extrapolate their results from animal experiments to humans, or make meaningful connections to humans and other animals. Barbara Orlans (1993) analyzed science fairs and supported the prohibition of animal use on the basis of the following arguments:

1. *Morally:* it is indefensible to hurt or kill animals unless original contributions that will advance human health and welfare can be expected. Elementary and secondary school studies do not meet this test.

2. *Psychologically:* it can be emotionally upsetting for youngsters to participate in harming or killing animals; even worse, it may be emotionally desensitising or hardening to immature minds.
3. *Socially:* in these days of widespread violence, fostering personal acquaintance with inflicting pain should be avoided.
4. *Educationally:* teaching about abnormal states before the student has a sound grasp of normal physiology is against common sense and does not advance scientific education.
5. *Scientifically:* promoting teenage animal surgery or induction of painful pathological conditions fosters an improper regard for animal life and an unbalanced view of biology that will rebound adversely when the next generation of scientists comes of age. (Orlans 1993, p. 206)

For instance, dissection activities can be observed in the science classroom, especially in the anatomy and physiology subject area. However, studies have shown that students at every educational level (i.e., secondary, undergraduate, medical) feel uncomfortable to a varying degree with the dissection or experimentation on live animals (Solot and Arluke 1997; Stanisstreet et al. 1993; Arluke and Hafferty 1996). In Solot and Arluke (1997), some students experienced feeling of "squeamishness" such that they chose to opt out of the dissection activity and/or leave the room, because they felt physically sick. One student reported, "I would, like, throw up" (p. 41). Other studies have shown that dissection even became the "turn-off" factor for students about science (Balcombe 2000; Bishop and Nolen 2001; Hug 2008; Oakley 2009, among others). As the discussion surrounding the ethics of killing live animals in a school setting continues, medical schools have responded to these concerns and began phasing out animal labs across the U.S. The medical schools have chosen alternate ways to study human anatomy such as using computer simulations and other technology. Today, only seven to eight schools still include live-animal experiments as part of the curriculum; however, the trend is being phased out around the world (Wadman 2008).

On the other end of the continuum, some educators defend the use of animals for teaching biology on the basis of arguments that experience with live animals is essential for biology education (Morrison 1993). For instance, Orlans (1993) found that these educators favored the use of animals in high school classrooms emphasizing that dissection of animals enabled students to learn the anatomical structures and interrelationships among tissues and organs, as well as develop manipulative skills and increase hands-on experience. Thurman Grafton (1980) cited other reasons for advocating the inclusion of animals in science fair projects, noting how they provide "challenging motivation to students to explore the excitement of research in the biological sciences" (p. 104). Grafton went onto explain how students could gain hands-on experience in detailed projects, which could encourage and motivate them to pursue scientific careers. As such, further restrictions on the use of animals in these competitions "would not be in the best interest of the public in terms of educational motivation, career development, and ultimate public service" (Grafton 1980, p. 104).

We do not intend to establish a dichotomy between these two positions. Reviewing how educators position themselves on this continuum calls us to consider one of the aforementioned questions, "Must we use animals in science fair projects to meet the educational aim of teaching students to critically think about anatomy and physiology, and learn engaging in such scientific exploration as a process of inquiry?" To answer this question, we first consider the seminal work of Joseph Schwab. In the 1960s, Schwab was one of the key figures who argued that a different approach to science teaching was needed and that such an approach would change the conception of science itself (Schwab and Brandwein 1962). Further, Schwab argued that school science curriculum should mirror the notion of science as "principles of enquiry" (Schwab and Brandwein 1962, p. 11). Joseph Schwab and Paul Brandwein (1962) stated:

> Scientific research has its origin, not in objectives facts alone, but in a conception, a construction of the mind. … Thus, the knowledge won through inquiry is not knowledge merely of the facts but of the facts interpreted. (pp. 12–14)

Taking his argument further, Schwab distinguished between "stable" and "fluid" *enquiry*. The stable *enquiry* was to fill a gap in a growing body of knowledge, while fluid *enquiry* entailed the development of new ideas and principles (Schwab and Brandwein 1962, p. 15). This changing notion of science as principles of *enquiry* had important implications in education, for it brought about a new aim – teaching science as a process of *inquiry* in order to improve students' abilities to reason scientifically. Thus, the authors of this chapter invite our readers to examine the position of advocating for the use of alternatives to animal experiments in the context of science fairs and consider the supporting arguments based on the moral, psychological, social, educational, and scientific grounds.

8.8 Assumptions Related to the Case Narrative

We use this platform to invite students, teachers, science educators, scientists, and other voices to participate in discussing the implications rising from this case narrative related to the use of animals in science fair projects. To do so, we conclude by delineating some theories and related assumptions that help us further our position.

First, our advocacy for alternatives to animal use in the context of science fairs is based on the concept that causing pain and suffering is problematic (Singer 1976). Peter Singer (1976) argued that stimuli that cause pain to humans can also cause pain to animals. Thus, higher animals share the right in not being subjected to pain and suffering. One of his most influential arguments was that equal harms should be counted equally and not downgraded for animals (Singer 1976). To illustrate, he provided an example:

> If I give a horse a hard slap across its rump with my open hand, the horse may start, but presumably feels little pain. Its skin is thick enough to protect it against a mere slap. If I slap

> a baby in the same way, however, the baby will cry and presumably does feel pain, for its skin is more sensitive. So it is worse to slap a baby than a horse, if both slaps are administered with equal force. But there must be some kind of blow - I don't know exactly what it would be, but perhaps a blow with a heavy stick - that would cause the horse as much pain as we cause a baby by slapping it with our hand. That is what I mean by the same amount of pain; and if we consider it wrong to inflict that much pain on a baby for no good reason then we must, unless we are speciesists, consider it equally wrong to inflict the same amount of pain on a horse for no good reason. (Singer 2004, p. 3)

In summary, Singer (1976)'s argument was not the question of whether animals can reason or talk, but whether animals can suffer and feel pain and whether it was ethical for humans to inflict such pain on other non-human animals. Not all scholars would agree with Singer's questioning and perspective on pain and suffering. Nonetheless, our thinking is informed by the tenets of ecojustice theory in that we do not position humans above other animals: therefore, animals share the right not to be subjected to pain and suffering.

Second, we view our relationships with animals and nature from the perspective of ecojustice. According to Teresa Shume (2015), an ecojustice perspective elucidates the root causes of unsustainable ecological practices (such as ideological, political, and cultural structures) that marginalize and oppress people. It "aims to unveil cultural metaphors carried by language that shape relationships with nature and impact the interdependence of social justice and environmental sustainability; it is a theory that poses thorny questions about *modernist thinking,* the *unsustainability of many current cultural assumptions and practice,* and *what it means to be educated*" (Shume 2015 p. 20). To this end, Shume (2015) calls for reevaluating cultural assumptions, which form the basis for human relationship with nature and with each other. Rebecca Martusewicz, Jeff Edmundson, and John Lupinacci (2011) provide six elements to define ecojustice. Of the six, the following two elements are relevant to our discussion of the ethical issues related to the use of animals in science fairs: (a) The recognition and analysis of deeply entrenched patterns of domination that unjustly define people of color, women, the poor, and other groups of humans as well as the natural world as inferior and thus less worthy of life, and (b) the recognition and protection of diverse cultural and environmental commons – the necessary interdependent relationship of humans with the land, air, water, and other species with whom we share this planet (p. 9–10). Ecojustice philosophy, thus, gives equal importance to both social and environmental concerns; in other words, it does not focus exclusively on social justice over environmental justice, or vice versa. Instead, ecojustice closely examines the common cultural roots of these issues (Shume 2015). Further, ecojustice focuses on issues of culture and community, rather than promoting individualism. As such, Princess Lucaj, Michael Mueller, and Deborah Tippins (2015) posit that this perspective, which moves away from solely focusing on the needs and concerns of humans, encourages us to more deeply consider injustices for all forms of life.

Operating under an ecojustice perspective, we align ourselves with environmental ideologies, namely, ethics and values-driven ideologies and transformative ideologies. Ethics and values-driven ideologies provide perspectives that "nonhuman entities have value that goes beyond utilitarian, scientific, aesthetic, or religious worth to possessing intrinsic value." According to Julie Corbett (2006), humans have moral and ethical duties to (some) nonhuman entities, which have a "right" to exist. (p. 28). Within this subset of ethics and values-driven ideologies, animal rights ideology maintains that animals are being subjected to unjustifiable discrimination by humans who can discriminate (Corbett 2006). Transformative ideologies "seek to transform anthropocentric relations and extensionism of 'right' into more eco-centric relationships" (Corbett 2006, p. 28). Within this subset of transformative ideologies, deep ecology echoes the importance of acknowledging, "all life on earth possesses equal intrinsic value, value that exists independently of human needs and desires" (Corbett 2006, p. 43).

Third, we operate under the two key propositions of social constructionism. Social constructionism is not a theory, but a set of ideas. It does not belong to a single person: rather, it is a confluence of ideas that emerge from conversations. It is not a fixed dialogue, for it continues to transform into new conversations. Kenneth J. Gergen (among others such as Vivien Burr) has been writing about social constructionism since the early 1980s (Gergen 1982; Gergen 1999, 2009, 2015) and, in his writing, he invites readers to think about social constructionism as a way of understanding the world. Once we accept this invitation, we begin to understand how social constructionism deconstructs traditional ideas and dialogues about objectivity, value neutrality, one's identity (self), relationships, power, knowledge, the truth and more.

First proposition of social constructionism is that scientific knowledge is socially constructed in ways that take into account good observations and defensible evidence**.** In his work *Ideology and Utopia*, Karl Mannheim (1985) proposed constructionist views of scientific knowledge in that: (a) "scientific theories do not spring from observation but from the scientist's social group," and (b) "scientific groups are often organized around certain theories," thereby, leading to the view of science as a social process (cited in Gergen 2015, p. 23). This proposition implies that anything we do or a construct that we characterize grows out of the traditions with which we are involved. Solot and Arluke (1997) eloquently demonstrate this point. In their study, consider the students who felt squeamish about dissecting, or, at first, felt ambivalent about the experimentation on live animal began to rationalize why the dissection was not as bad as they initially thought. Then, students began using humor as a way to get through the dissection activity by calling their specimen "Miss Piggy," or "Pudgy" (Solot and Arluke 1997, p.45). In other words, students became desensitized and detached, so that the dissection activity became acceptable as a way of knowing and learning science without the consideration of ethics in the process. In the later sections, we discuss science as a socially constructed. When we consider the enculturation and socialization of our youth into the scientific communities, we may be projecting the notion that the objectivity and detachment is the only model for understanding the physical world (Solot and Arluke 1997).

We perceive and understand the world within our knowledge system of which our previous experiences (as well as the experiences of others) have been a part. Therefore, these rules, structures and models that prescribe what we should do in a situation give us a sense of "social reality" that becomes reliable and can be also comprehended by others who experience this reality as we do (Jacobsen 2008, p. 106). As such, intersubjectivity is a critical component in how we create our social reality where exemplified assumptions, expectations, and prescriptions (such as rules and traditions) are socially constructed and socially accepted (Jacobsen 2008). This notion of what is accepted as normal (in other words, the notion of conventionality) pertains to not just one single individual, but it speaks to our relationships with others in society. As Jacobsen (2008) puts, "my background knowledge, implicit assumptions, expectations and so on, are hence not primarily *mine,* understood as my own personal and unique constructions. On the contrary, they are *social* constructions" (italic emphasis in original, p.106).

Second proposition of social constructionism is that any socially constructed description caries value, because values are created and sustained within forms of life. As we relate with one another, develop languages, and follow the traditions of the society in which we participate, we develop values. These values are often implicit and simply presented in the way we do things. Thus, there are no value-free or neutral accounts of things; everything we say or do in this world carries values. We may like to think that science is an objective and accurate accounting method for describing this world. However, scientists bring in their background assumptions when they report their findings and when they design and conduct experiments. When scientists write about their studies, even their use of language carries values and reflects their background assumptions.

In the context of science, scientific descriptions are anything but neutral: rather, they are value-laden (Gergen 2015). To illustrate this point, Emily Martin analyzed the way medical textbooks characterized the female reproductive system, especially the eggs (Martin 1987). She concluded that a woman's body was portrayed as having passive characterization and as a "factory" with the primary purpose of reproducing by way of being "conquered" by the male sperms. Through this example, the language that describes the scientific account of how human reproductive organs work is not so value free or neutral – it carries sexist views of scientists who operate within the traditions of Western science, which is heavily dominated by males. The data from the National Science Foundation (NSF) supports the gender disparities in the Science, Technology, Engineering and Mathematics (STEM) workforce, while we see the greatest gender disparities in engineering, computer science, and the physical sciences (NSF, Science & Engineering Indicators 2014). Further, when we accept a scientific account of one thing over another, we are making a choice, which carries certain social values. As such, descriptions that we construct carry certain ways of life and certain objectives that we would like to do with them as opposed to others.

Helen Longino (1990) is one of the seminal scholars who support the idea that science is both value-laden and a social process. As part of the social and cultural context with which we are involved, we bring value-laden assumptions that constrain scientific practice in certain ways (Longino 1990). For example, a potential conflict may arise between moral values of a researcher and specific ways of carrying out research, particularly research with human subjects, or in the instance of our case narrative, with vertebrate animals. To alleviate this tension, restrictions and regulations on experimentation have been developed, but are not always enacted or enforced, because the enclave of traditions in which we participate determines the directions of research and boundaries (Longino 1990). Similarly, the twenty-first century scientists share her view. To name a few, Anderson (2004)'s study explores how one's political values may guide scientific inquiry by using feminist science guided by feminist values as an example. Gaskell, Einsiedel, Hallman, and Priest (2005) discuss the tensions between science and society, as the increasingly number of scientific research pioneers into value-laden areas (i.e., socio-scientific issues) and engages society on the ethical, legal, and social implications.

To summarize the two discussed propositions of social constructionism: What we teach our students in the science classroom is often dominated by the traditions of western science – but we can deconstruct the traditions of science. Rather than viewing science as checking off steps in the scientific method, we can help students re-conceptualize science as a social process of inquiry. Our students have been enculturated and made to feel comfortable with the notion of scientism. Perhaps students and teachers have come to accept the way that things are, without the ethical consideration of doing scientific experiments by using animals, because we feel natural in our environment and are familiar with this very notion of scientism, as it has been the accepted and dominant practice in western science. Schutz (1967) describes this attunement with nature as taking things for granted without questioning or scrutinizing their validity. Schutz (1967) further explains that we take on this unsuspecting attitude, because we are naturally attuned to the system of knowledge to which we belong and that constitutes our background assumptions. This knowledge system is what we know and employ in our life to navigate the world. René Descartes urges us:

> to doubt things which we may continue to believe, and with good reason, such as the propositions that two and two equal four, or that there is an external world. We can be justified in acting upon these beliefs, we may even be unable to conceive of what it would be like for those beliefs to be false (this is particularly the case with mathematical beliefs), but our not being able to conceive how something could be false does not mean it cannot be false. (cited in Gaukroger 2002, p. 71).

50 years later, Schutz's position is still relevant today as evidenced by the prominent feminist science scholars such as Sandra Harding, Donna Haraway, and Evelyn Fox Keller, among others, who challenge the dominant practice in western science. The feminist science scholars encourage us to rethink and view science knowledges from a different point of view or perspective (i..e, standpoint epistemology, etc). In other words, we must be critical of how we accept the dominant discourse in science and understand our daily life by its traditions, which we take for granted. We must acknowledge that all our attempts at constructing knowledge are *socially situated*, and that cultural beliefs play a role at every step of scientific inquiry. This includes "the selection of problems, the formation of hypotheses, the design of research, the collection of data, the interpretation and sorting of data, decisions about when to stop research, the way results of research are reported" (Harding 1996, p. 244).

Further, science educators should aim to instill values of science that deemphasizes individualism, which is "a belief that humans are independent autonomous units, that pursuit of self-interest leads to the greatest good, and that competition is natural" (Martusewicz et al. 2011, p. 25). In this way, students may understand that the purpose of participating in science fairs is not to promote an individual student's pursuit of a grand prize or to "compete" against other individuals, but to learn the process of inquiry and critical problem solving skills. Only then, perhaps, can we start to convince students, teachers as well as other stakeholders in science education that the use of animals in science fairs does not meet these educational goals and is no longer necessary in the teaching and learning of science.

As we move towards these ideas, the authors believe that science can truly become a way of knowing and understanding the world enriched with new possibilities, new ideas and new ways of life for everyone.

8.9 Reflections and Implications for Science Educators

The advancement of scientific endeavors and progress is meaningless if we begin to consider scientific investigations ultimately superior to ethics and moral values. Another perspective could point to how the advances in sciences and technology have, in turn, influenced and shaped our ethical and moral values. Notwithstanding which perspective with which one may position, it is critical to engage students in constructive discussions about human use of animals in research and the controversial nature of ethics pertaining to such practice. As seen from Jenna's case, teachers and educators can, and should, create space for these types of discussions. The aim of guiding students to independently design a research study should be about teaching students how to critically think and inquire about the world around us. On this note, there are several important points to highlight from this case narrative. First, Jenna was confident in making a claim that drinking alcohol during one's pregnancy would be harmful to a living baby. She emphasized that she had used the "scientific method" to observe, gather data, and make key assertions based on findings. In this point, we begin to see the nature of science from the student's perspective. In her response, she made it clear that she viewed science as making a singular claim by employing a defined set of steps (i.e., the scientific method) and proving a point. Additionally, there was a major flaw in her study design, which was removing the embryos from their shells, significantly reducing their survival. Not realizing this critical flaw in the science behind the study, she was making "study-generated claims" and putting forth its significance onto humans. This was simply an example of bad science being taught to students, if we examine the science aspect alone.

Second, Jenna extrapolated the findings from her study and made assertions about issues related to the health of humans. However, this is not the optimal way of teaching the aim of doing science, as we inevitably portray that we produce scientific discoveries to better the lives of humans at the expense of other animals. Jenna's perspective on chickens as a food source allowed herself to be detached from seeing her experiment as harming live animals. The end result of her study justified the means of her study. Because she believed that her findings were significant and that this study gave a clear warning to females about the harmful effects of alcohol, and potentially deterring women from drinking during pregnancy, Jenna gave no consideration to realizing that she was killing the chicken embryos through a painful death. Any teachers or science educators would agree that the drastic number of embryos dying due to the injection of alcohol has no real implications or value to the health-related issues of humans – it is simply irrelevant, and the findings from this study did not apply to humans drinking alcohol during pregnancy. Even if the significance was carried over, the harmful effect of alcohol during pregnancy is widely known already, which Jenna simply repeated to confirm – but we must ask ourselves, to what end. Thus, science teachers must guide students to reflect and evaluate society's over-emphasis on the primacy of humans over other animals, and how such a notion has an impact on the negotiation of what is ethical, humane, and moral.

Lastly, science teachers and educators must be mindful of this question: what did the student learn, and to what end are we teaching science to our students? Our aim should always be that we are teaching students to critically think, inquire, and examine the world around us through science. In this process, we must engage in a concerted effort to share the message that individuals alone do not discover the Truth by way of empiricism, but that science is a process of inquiry and a social process that is richly laden with our values, ethics, morals, and background assumptions of society.

As teachers, we should be mindful about what science we teach. Science should not be taught as being positioned in society where humans inflicting pain and suffering on other animals is justified for the sake of scientific advancement. In science classrooms, we should aim to emphasize the symbiotic relationship between humans, environment and other animals and how science makes it possible for us to understand these interactions and provide a way of thinking to improve such relationships. If science teachers begin to deconstruct the notion that science is devoid of values, then students' science learning would be far more enriching and meaningful, and it could more likely result in positive long-term impacts on how they view science for the rest of their lives.

References

Anderson, E. (2004). Uses of value judgments in science: A general argument, with lessons from a case study of feminist research on divorce. *Hypatia, 19*(1), 1–24.

Animal Welfare Act. (2013a). 7 U.S.C. §§ 2131–2159 (U.S. Government Printing Office).

Animal Welfare Act. (2013b). 9 C.F.R., Part 2. § 2131 *et seq* (U.S. Government Printing Office).

Animal Welfare Institute. (1969). More cruelty among teenaged science students. *Information Report*, *18*, 2–3.

Arluke, A., & Hafferty, F. (1996). From apprehension to fascination with 'dog lab': The use of absolutions by medical students. *Journal of Contemporary Ethnography, 25*(2), 201–225. doi:10.1177/089124196025002002.

ATLA Alternatives to Laboratory Animals. (2014). *Welcome to ATLA*. Retrieved from http://www.atla.org.uk/about-us/

Balas, A. K. (1998). *Science fairs in elementary school*. Columbus: ERIC Clearinghouse for Science, Mathematics, and Environmental Education (ERIC Document No. ED432444). http://files.eric.ed.gov/fulltext/ED432444.pdf

Balcombe, J. (2000). *The use of animals in higher education: Problems, alternatives, and recommendations*. Washington, DC: The Humane Society Press.

Barad, K. (2003). Posthumanist performativity: Towards an understanding of how matter comes to matter. *Signs, 28*(3), 801–831.

Bishop, L. J., & Nolen, A. L. (2001). Animals in research and education: Ethical issues. *Kennedy Institute of Ethics Journal, 11*(1), 91–112.

Boslaugh, S. (2016). Anthropocentrism. In *Encyclopedia Britannica*. Retrieved from http://www.britannica.com/topic/anthropocentrism

Braidotti, R. (2006). *Transpositions: On nomadic ethics*. Polity.

Corbett, J. B. (2006). *Communicating nature: How we create and understand environmental messages* (p. c2006). Washington, DC: Island Press.

Cutraro, J. (2011). Science fair as a family affair. *Science News For Kids*, p. 3.

Food Security Act of 1985, 17 U.S.C. § 1751 *et seq* (1985).

Fox, M. W., & Ward, M. A. (1977). Are science fairs fair to animals? *Science Teacher, 44*(6), 31–33.

Gaard, G. (1993). Living interconnections with animals and nature. *Ecofeminism: Women, Animals, Nature*, pp 1–12.

Gaskell, G., Einsiedel, E., Hallman, W., Priest, S. H., Jackson, J., & Olsthoorn, J. (2005). Social values and the governance of science. *Science, 310*(5756), 1908–1909. http://science.sciencemag.org/content/310/5756/1908

Gaukroger, S. (2002). *Descartes' system of natural philosophy*. Cambridge: Cambridge University Press. http://dx.doi.org/10.1017/cbo9780511606229.

Gergen, K. J. (1982). *Toward transformation in social knowledge* (p. c1982). New York: Springer. http://dx.doi.org/10.1007/978-1-4612-5706-6.

Gergen, K. J. (1999). *An invitation to social construction*. Thousand Oaks: Sage.

Gergen, K. J. (2009). *An invitation to social construction* (2nd ed.). Thousand Oaks: Sage.

Gergen, K. J. (2015). *An invitation to social construction* (3rd ed.). Thousand Oaks: Sage.

Grafton, T. S. (1980). The challenge and motivation of students through live animal projects. In H. McGiffin & N. Brownley (Eds.), *Animals in education: Use of animals in high school biology classes and science fairs* (pp. 99–105). Washington, DC: The Institute for the Study of Animal Problems.

Harding, S. (1996). Rethinking standpoint epistemology: What is 'strong objectivity'? In E. F. Keller & H. E. Longino (Eds.), *Feminism and science* (pp. 235–248). New York: Oxford University Press.

Health Research Extension Act of 1985, Pub. L. 99—158, "Animals in Research" § 495 *et seq* (Office of Laboratory Animal Welfare, 2015).

Hillaby, J. (1970, January 9). Sanctified torture. *New Scientist*, p. 69.

Hug, B. (2008). Re-examining the practice of dissection: What does it teach? *Journal of Curriculum Studies, 40*(1), 91–105.

Intel International Science and Engineering Fair. (2015–2016). *International rules and guidelines 2016*. Retrieved from https://member.societyforscience.org/document.doc?id=632

Jacobsen, M. H. (2008). *Encountering the everyday: An introduction to the sociologies of the unnoticed*. Palgrave Macmillan.

Kayumova, S., & Tippins, D. (2016). Toward re-thinking science education in terms of affective practices: reflections from the field. In *Cultural Studies of Science Education*. doi:10.1007/s11422-015-9695-3.

Longino, H. (1990). *Science as social knowledge*. Princeton: Princeton University Press.

Lucaj, P., Mueller, M. P., & Tippins, D. J. (2015). A life in relation to the broader stroke of education. In M. P. Mueller & D. J. Tippins (Eds.), *Ecojustice, citizen science and youth activism: Situated tensions for science education* (Vol. 1, pp. 1–7). Dordrecht: Springer. doi:10.1007/978-3-319-11608-2_1.

Mannheim, K. (1936/1985). *Ideology and utopia: Introduction to the sociology of knowledge*. New York: Harcourt.

Martin, E. (1987). *The woman in the body: A cultural analysis of reproduction*. Boston: Beacon.

Martusewicz, R. A., Edmundson, J., & Lupinacci, J. (2011). *Ecojustice education: Toward diverse, democratic, and sustainable communities*. New York: Rutledge. doi:10.4324/9781315779492.

Miller-Spiegel, C. (2004). The use of animals in national high school student science fair projects in the United States. *ATLA, Alternatives To Laboratory Animals, 32*(Suppl 1B), 495–500.

Morrison, A. R. (1993). Biomedical research & the animal rights movement: A contrast in values. *American Biology Teacher, 55*, 204–208. doi:10.2307/4449633.

National Institutes of Health. (2015). *Public health service policy on humane care and use of laboratory animals*. [NIH Publication No. 15-8013]. Bethesda: Office of Laboratory Animal Welfare.

National Research Council. (1996). *Guide for the care and use of laboratory animals*. Washington, DC: National Academy Press.

NSF, Science & Engineering Indicators. (2014). https://www.nsf.gov/statistics/seind14/index.cfm/chapter-3/c3s5.htm

Oakley, J. (2009). Under the knife: Animal dissection as a contested school science activity. *Journal for Activist Science and Technology Education, 1*(2), *59–67*.

Orlans, F. B. (1993). *In the name of science: Issues in responsible animal experimentation*. New York: Oxford University Press.

Prizes for Torture. (1969, May 10). *The New York Times*.

Rowan, A. N. (1984). *Of mice, models, and men: A critical evaluation of animal research*. Albany: State University of New York Press, c1984.

Schutz, A. (1967). *The phenomenology of the social world*. Northwestern University Press.

Schwab, J. J., & Brandwein, P. F. (1962). *The teaching of science: The teaching of science as enquiry*. Cambridge: Harvard University Press.

Shume, T. (2015). Put away your No. 2 pencils – Reconceptualizing school accountability through EcoJustice. In M. P. Mueller & D. J. Tippins (Eds.), *EcoJustice, citizen science and youth activism: Situated tensions for science education* (pp. 19–32). Switzerland: Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-11608-2_3.

Singer, P. (1976). *Animal liberation: Toward an end to man's inhumanity to animals*. London: Cape.

Singer, P. (2004). *The animal liberation movement* (p. c1985). Nottingham: Russell Press.

Society for Science & the Public. (2000–2015). *Mission and history*. Retrieved from https://www.societyforscience.org/mission-and-history

Society for Science & the Public. (2015). *Intel Science Talent Search 2016 rules and entry instruction*. Retrieved from https://member.societyforscience.org/document.doc?id=403

Solot, D., & Arluke, A. (1997). Learning the scientist's role: Animal dissection in middle school. *Journal Of Contemporary Ethnography, 26*(1), 28–54. doi:10.1177/089124197026001002.

Stanisstreet, M., Spofforth, N., & Williams, T. (1993). Attitudes of undergraduate students to the uses of animals. *Studies In Higher Education, 18*(2), 177.

Strauss, R. T., & Kinzie, M. B. (1991). Hi-tech alternatives to dissection. *American Biology Teacher, 55*, 154–157. doi:10.2307/4449249.

Tant, C. (1992). *Projects: Making hands-on science easy. A guide to science project management with stress prevention for teachers & parents*. Angleton: Biotech Publishing.

Tsuzuki, M., Asada, Y., Akiyama, S., Macer, N., & Macer, D. (1998). Animal experiments and bioethics in high schools in Australia, Japan, and New Zealand. *Journal of Biological Education, 32*(2), 119–126. doi:10.1080/00219266.1998.9655607.

Wadman, M. (2008). Medical schools swap pigs for plastic. *Nature, 453*(7192), 140–141. doi:10.1038/453140a.
Weigand, A. (2008). *Becoming human: Stories of animals and ethics in biomedicine* Temple University.
Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: Theory and practice. *Journal of Elementary Science Education, 21*(2), 49–58.
Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education, 86*(3), 343–367.

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