Evolving Minds: Helping Students with Cognitive Dissonance

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EVOLVING MINDS: HELPING STUDENTS WITH COGNITIVE DISSONANCE

A Dissertation
Presented to
the Morgridge College of Education
University of Denver

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
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Abstract

Even 150 years after Charles Darwin published *On the Origin of Species*, public school teachers still find themselves dealing with student resistance to learning about biological evolution. Some teachers deal with this pressure by undermining, deemphasizing, or even omitting the topic in their science curriculum. Others face the challenge and deliver solid scientific instruction of evolutionary theory despite the conflicts that may arise. The latter were the topic of this study.

I interviewed five teachers that had experience dealing with resistance to learning evolution in their school community. Through these in-depth interviews, I examined strategies these teachers use when facing resistance and how they help students deal with the cognitive dissonance that may be experienced when learning about evolution. I selected the qualitative method of educational criticism and connoisseurship to organize and categorize my data.

From the interviews, the following findings emerged. Experienced teachers increased their confidence in teaching evolution by pursuing outside professional development. They not only learned more about evolutionary theory, but about creationist arguments against evolution. These teachers front-load their curriculum to integrate the nature of science into their lessons to address misunderstandings about how science works. They also highlight the importance of learning evolutionary theory but
ensure students that they do not have an agenda to indoctrinate students. Finally these experienced teachers work hard to create an intellectually safe learning environment to build trusting and respectful relationships with their students.
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Chapter One: Introduction

In the fall of 2005, I was beginning my twelfth year of teaching secondary science. At this time in my career, I was teaching earth science, biology, and paleontology—an elective course I created which was born out of my childhood (and yes, adulthood) love of dinosaurs and other prehistoric creatures. All of these classes had a common thread—evolution.

From a young age I was fascinated by the biodiversity that existed on Earth over the past three-plus billion years, as well as the commonalities that all organisms share. Even more importantly, I was enthralled by the idea of strange and grotesque creatures that stomped through the undergrowth, terrorized the skies, and probed the murky seas for hapless victims. I learned “here be monsters,” a phrase typically reserved for legendary creatures in uncharted territories on medieval maps, was no longer limited to mythology. Animals like *Opabinia*, the five-eyed abomination with pliers at the end of its proboscis, and *Therizinosaurus*, a large theropod dinosaur described as a cross between Big Bird and Count Dracula, demonstrated that fact was truly stranger than fiction. These monsters not only lived here on planet Earth, but were related to me—and the theory of evolution showed me how. I was hooked, and was able to make a career out of my childhood interests. As a teacher, I organized my curriculum using the theory of evolution as a unifying theme.
The district in which I taught lies in a politically and religiously conservative area of a traditionally conservative county in Colorado. The United States Air Force Academy lies on the western border of the district, and one school is actually located on its property. The district encompasses Focus on the Family, the evangelical Christian non-profit organization founded by James Dobson, as well as New Life Church—a non-denominational megachurch founded by the former pastor Ted Haggard. The city is also home to a regional office of the Association of Christian Schools International and Compassion International. In 2005, National Public Radio deemed Colorado Springs a “Mecca for evangelical Christians” (Brady, 2005), and the city has been unofficially nicknamed the “Evangelical Vatican” (Crawford, 2010).

Antievolutionists, frequently evangelical Christians, in our district were prevalent and often vocal. Despite evolution being one of the state science standards, many parents and students objected to learning about it. Some candidates for school board used creationism and intelligent design as a platform, and teachers were contacted by outside institutions favoring their inclusion in the curriculum. Some teachers in my school allowed students to do projects of their choosing when it came to the unit on evolution—filling the hallways with displays of creationism and intelligent design. One teacher openly criticized the theory in class by reading from Johnson’s (1997) book *Defeating Darwinism by Opening Minds*. Others undermined evolution themselves or neglected the topic completely—even in biology classes.

Expectedly, antievolutionist students in the community frequently held the same beliefs as their parents. Challenges in class were not uncommon, and it became clear to
me that students needed help integrating evolutionary knowledge with their prior beliefs and values. They also needed to be provided with an environment conducive to intellectual risk-taking. I strived to do both. In terms of teaching evolution I wasn’t a maverick, but I also was not swayed by external pressure to stop teaching it or to deemphasize it. I understood that it was good science, and strongly believed in its importance to every student’s science education.

Because of this, the autumn of 2005 had particular importance to my profession as a science teacher. A trial was in progress in Dover, Pennsylvania which had significant implications for me and my discipline. This trial would decide whether the idea of Intelligent Design had a place in the public school. Intelligent Design (ID) is the proposition that certain phenomena in the universe, especially living organisms, are best explained by an intelligent cause rather than by products of natural law and natural mechanisms (Davis & Kenyon, 1993; Eldredge, 2000; Johnson, 1991). Most scientists, philosophers of science, and science teachers saw the intelligent designer as a wolf in sheep’s clothing. The sheep, in this case, was creationism (Dembski & McDowell, 2008).

The trial ended in the same manner as every other court case involving the subject since 1925—on the side of evolution. Nevertheless, opponents of evolution were not swayed by the decision. As described in the next chapter, acceptance and understanding of evolutionary theory is still relatively low in America, and anti-evolutionist sentiments continue to run high.
Rationale for Study

Evolution, a time-tested theory (Eldredge, 2000), is a microcosm of the way science operates. It readily shows the true nature of science in its tentativeness, revisability, and openness to peer review. It has all of the benchmarks of a strong scientific theory (National Academy of Sciences, 1998)—it explains multiple data sets, it is a natural explanation, it explains anomalies, it is confirmed by independent lines of evidence, it uses the combination of inductive and deductive reasoning, it has the power of prediction and retro-diction, it is falsifiable, it has utility and fecundity (Hewlett & Peters, 2006) and it has yet to encounter a test which disproves its overall framework (Shermer, 2006).

Not only has the theory of evolution stood up to the test of time under contentious scientific (and non-scientific) scrutiny, it is renowned as the major unifying concept in biology. The theory is supported by the vast majority of scientists and scientific organizations—some of the most prominent being the National Science Teacher Association, the National Center for Science Education, the National Academy of Sciences, the American Association for the Advancement of Science, and the National Association of Biology Teachers (Alters & Alters, 2001). Therefore, it should be taught as such in the public schools. An attack on this theory is an attack on what scientists do, how they think, and the painstaking processes of how they have gathered evidence for evolution over the last 150 years since Darwin (1859) published *On the Origin of Species*. Simply stated, an attack on evolution is an attack on science itself.
That students understand the theory of evolution is not only essential to their understanding of biology, but how science itself works and is used (Eldredge, 2000). However, the problem is not merely solved by implementing science standards which require evolutionary theory to be taught. There are more facets to the problem than just asking teachers to teach the topic. Many students, especially in demographic areas where fundamental evangelicalism is prevalent, are taught from an early age to be unaccepting of evolution and be suspicious, if not condemning, of anyone who tries to teach it (Alters, 2006). Therefore, it is the teachers’ obligation to approach the topic of evolution with not only confidence in its strength as a scientific theory, but with the sensitivity to students’ beliefs that will not close their minds to the idea. Teachers’ attitudes, relationships with their students, background knowledge in evolutionary theory, understanding of students’ internal conflicts, and educational pedagogy may all be significant contributing factors to a student’s understanding of evolution.

There have been many studies done on teaching evolution. The majority of these are quantitative studies that measure students’ understanding of evolution or poll their personal beliefs about the topics of evolution and creationism (Berkman & Plutzer, 2010; Miller, Scott, & Okamoto, 2006; Moore, 2008; Newport, 2009). However, fewer studies regarding how teachers respond to antievolutionist pressures are found in the literature. For those studies that do provide qualitative data, information is typically provided in the optional comments at the end of a survey (Berkman & Plutzer, 2010). Few studies paint a portrait of the teachers who are fighting for good science education in the face of adversity. Similarly, although there are studies outlining how students learn through
cognitive dissonance (Barr & Tagg, 1995; Conrad & Haworth, 1995; Festinger & Carlsmith, 1959; Mills, 1999) and specific activities utilizing cognitive dissonance in the classroom (Carkenord & Bullington, 1993; Rauch & Schiering, 2010; Rosier, 2008), the literature is thin documenting qualitative studies on how teachers specifically help students with their dissonance regarding the conflict of their faith with evolution.

The area to be researched in this study concerns how science teachers, primarily in religiously conservative areas, successfully deal with the evolution/creationism controversy. I am interested in teachers who meet the controversy head on, remain respectful of student beliefs, but still deliver solid education in science and evolutionary theory. This dissertation will examine how teachers in this situation relate to their students, how they communicate ideas in a meaningful way, how they organize their curriculum, how they make their learning environments intellectually safe for students who may disagree, and how they help students work through intellectual conflict. It is important to note, however, that I am not interested in teachers who give time to creationism or intelligent design just to appease students. Regardless of the personal beliefs of the participants, I want to research teachers who teach that evolution is the only known scientific theory that explains the body of evidence that we observe in the natural world.

**Significance of This Study**

This study is aimed at teachers who want to do well by their students, but struggle with the stress and emotional exhaustion of the contentious nature of teaching evolution. Stress in teaching that leads to teacher burnout has been attributed to a number of things.
Three of these include poor student-teacher relationships (Howard & Johnson, 2004; Split, Koomen, & Thijs, 2011), feelings of personal inadequacy (Howard & Johnson, 2004; Pas, Bradshaw, & Hershfeldt, 2012; Schonfeld, 2001), and extra-organizational stressors (Grayson & Alvarez, 2008; Howard & Johnson, 2004). All three of these may be experienced when teachers are presenting evolutionary theory.

Teachers who do not learn ways to deal with conflict or potential challenges by students in a constructive way may strain the student-teacher relationship. If not handled properly, students may lack motivation for learning the subject, display a lack of respect for the teacher, or manifest their frustration with classroom disruptions. This study may provide teachers with strategies to build trust with their students while they learn about a topic that might challenge their worldview.

Feelings of personal inadequacy can arise when teachers feel incompetent or poorly trained when they teach topics outside of their areas of expertise. Often, students who find evolutionary theory to be at odds with their religious beliefs are often more versed in the debate than their teachers. It is my hope that this study will provide not only useful strategies on how to deal with potential controversy, but to encourage teachers to seek appropriate training in this area of knowledge in order to provide confident, solid science education.

Extra-organizational stressors can arise when there are negative community attitudes toward teachers. The strategies that are uncovered in this study, combined with the background information in the literature review, may help teachers communicate to
their students and community that teaching evolutionary theory is not only legal, but scientifically the right thing to do.

In the larger scheme of things, learning about evolution may help students to deal with their own cognitive dissonance and apply useful tactics to other areas of learning. Teachers who can use cognitive dissonance effectively in their classes can affect student learning, motivation, and retention (Burns & Gentry, 1998; McFalls & Cobb-Roberts, 2001; Rosier, 2008). Perhaps the strategies uncovered in this study can help teachers create expert learners who approach uncomfortable learning situations by actively analyzing and evaluating information using effective metacognitive strategies (National Research Council, 1999).

Definitions

For the purposes of this study, creationism will be defined as the belief that God (typically from the Judeo-Christian tradition) created the universe, Earth, and its living inhabitants in their present form through divine intervention rather than through natural law. Although there is a wide spectrum of creationist beliefs (Scott, 2000), most biblical creationists believe that the story of creation is outlined more or less factually in the first book of the Bible (Genesis 1:1-31 New Revised Standard Version). According to this creation story, the process took only several days. The concept of intelligent design alludes to a designer of living things who resides beyond the laws of nature. Believers are very careful not to call this designer “God” and refrain from naming him, her, it, or them (Scott, 2006). Since both beliefs stem from the idea that a supernatural being rather than natural law is responsible for creating life, both creationism and intelligent design
will be implied when the term “creationism” phrasing is used. Finally, evolution can be defined as the theory that describes how living organisms change over the history of the Earth. The theory encapsulates not only the small changes observed within species over a few generations, but that all organisms share a common ancestry (Eldredge, 2000; National Academy of the Sciences, 1998). Evolutionary theory does not support nor deny the existence of a creator, but does state that the evolutionary process is bound by the rules of nature as we know them (Hewlett & Peters, 2006).

**Research Questions**

Five research questions guide this study.

1. *How are teachers prepared to deal with the issues that accompany the teaching of evolutionary theory?* Since teachers of evolution may encounter resistance from students and the community, they should be trained to deal with it in a professional manner. I am interested in how schools and districts prepare teachers to deal with the evolution/creationism controversy when it occurs to help reduce friction and ensure student learning. Additionally, I am interested in the professional development in this area that teachers seek beyond that which their own school or district may offer.

2. *How do teachers handle external resistance to the teaching of evolutionary theory?* Resistance to teach evolution can come from many sources—the community (especially places of worship), parents, school boards, and even principals and colleagues. I seek to learn how teachers deal with external pressures to omit or undermine evolutionary theory in the curriculum, and still provide solid instruction of evolutionary theory in the face of adversity.
3. What strategies do teachers use when teaching evolutionary theory to classes where resistance may occur? Students who hear anti-evolution messages outside of school will frequently bring that resistance into the classroom. Whether the resistance is passive or vocal, it may result in poor engagement and effort by students during the period of time that evolution is being taught. I want to learn how teachers prepare students for potentially controversial material, how they deal with adversity in the classroom when students bring it to the surface, and what curricular and pedagogical techniques are used to keep students engaged in potentially unpalatable subject matter.

4. How do teachers create an intellectually safe learning environment for students who may disagree with evolutionary theory? Creating a safe learning environment is essential for a student to take risks. Students who are criticized or ridiculed for their beliefs may refrain from asking questions or stretching their understanding, and may simply disengage or shut down as a result. I am interested in how teachers create a safe environment for their students to promote intellectual risk-taking in a subject which they may perceive as taboo.

5. How do teachers help students with the cognitive dissonance that they may experience when learning about evolution? “Cognitive dissonance” is an internal conflict that people experience when they are presented with evidence that disputes their prior beliefs. Similar to a child who may learn for the first time that Santa Claus does not physically exist, students who are exposed to the evidence of evolutionary theory for the first time, who see evidence with new clarity, or who begin to make connections between bodies of supporting data may experience such mental strife if the information conflicts
with their preconceived world view. I am interested in how teachers help these students understand and deal with perceived conflicts in order to reduce anxiety or unpleasantness—yet still maintain the importance and credence of evolution to understanding the natural world.
Chapter Two: Review of the Literature

The review that follows is divided into several sections. First is an overview of the history of the evolution/creationism debate in the United States. In order gain a context of how teachers respond to the controversy, a history of the conflict itself must be understood. As creationists have changed strategies, science teachers needed to become aware of them as well as their motivation behind them.

The second section deals with the state of evolution in public schools today. It considers the influence that creationists have had on teachers as well as students. Strategies outlining the ways that teachers have responded are also discussed.

The last section discusses cognitive dissonance theory. When a person holds two conflicting ideas simultaneously, they can attempt to regain consonance in a variety of ways. This research may be important to teachers whose students regard the theory of evolution as being in opposition to their religious beliefs.

History of Creationism and Evolution in the United States Courts

When geneticist Theodosius Dobzhansky (1964) made the statement, “Nothing in biology makes sense except in the light of evolution” (p.449), he was criticizing the anti-evolution creationist movement becoming prevalent in the mid 1960’s. Little did he know that fifty years later, the battle over the public school science curriculum would still be raging. With an analog that would please any biologist, creationists themselves would
display the phenomena of adaptation and evolution in response to a changing environment.

**Biblical creationists and evolution.** The topic of evolution first entered the United States courtrooms in the 1920’s. In January of 1925 the Tennessee House of Representatives passed the Butler Act—making it against the law for public schools to teach any theory that denies the story of the biblical creation of humans, and to teach instead that man has descended from a lower order of animals. Soon after, the Tennessee senate and governor signed the bill into law. Oklahoma at this time had already prohibited the adoption of textbooks that promoted evolution and Florida lawmakers had condemned the teaching of Darwinism as “improper and subversive” (Numbers, 1998, p. 78). The South saw Tennessee as being frontrunners in the movement since it was the only state which made teaching human evolution a punishable crime.

What came out of the law was the famous “Scopes Monkey Trial” in which John Scopes, a biology teacher and coach, was arrested for teaching evolution. After many famous debates, speeches, and monologues by several famous people, the end result was that John Scopes was found guilty and fined $100. Although history has glamorized the trial, it was actually a planned test case designed to bring fame and money to the small town of Dayton, Tennessee. Contrary to popular belief about the trial, lawyers actually wanted a conviction in order to test the constitutionality of the law, believing that it violated not only the constitution of Tennessee but the Fourteenth Amendment of the
United States Constitution, barring states from making or enforcing “any law which shall abridge the privileges or immunities of citizens of the United States” (Numbers, 1998, p. 78).

In 1926, Mississippi sided with Tennessee and outlawed the teaching of evolution. In 1927, at the height of the antievolution movement, more than a dozen states considered legislation which banned or restricted the teaching of evolution (Numbers, 1998, p. 88). In 1928, Arkansas became the third and last state to ban the teaching of human origins by means of evolution. Interest in the topic then began to fade. Texas and Oklahoma were the only states still considering antievolution legislation by 1929.

A push for science education in the late 1950’s may have led to the overturning of antievolution laws. Many historians attribute this to the Russian success of putting the Sputnik satellite into orbit. This is believed to have embarrassed the American scientific establishment. The event served as a wake-up call for politicians and science-policy experts who viewed America’s slip in the space race as the result of inferior science education. Almost at once the federal government began to fund programs which improved science textbooks for high school students—books which included the biological theory of evolution. The Biological Sciences Curriculum Study was formed and produced textbooks with evolution being a central theme. However, the old antievolution statutes were still in place, so those teachers who used newer textbooks were still in violation of the law.

The next few decades produced several significant court decisions regarding evolution and creationism issues. In 1968, in *Epperson v. Arkansas*, the U.S. Supreme
Court ruled that a state could not require that teaching and learning must be tailored to the principles of any particular religion. The Arkansas statute was ruled to be in conflict of the First Amendment of the U.S. Constitution. Finally it was legal to teach evolution everywhere in America. However, legality and morality were not viewed as synonymous, and many still fought against it.

In 1981, Kelly Segraves filed a suit stating that the teaching of evolution prohibited his and his children’s free exercise of religion. In Segraves v. California, the Court found that the California State Board of Education’s Science Framework gave sufficient accommodation to the views of Segraves. The decision established that, regardless of the perceived incompatibility of one’s religious views and evolution, merely teaching about it cannot be construed either as an establishment of a religion or as an infringement upon the free exercise of students' and parents' religions.

In the early 1980's, state legislatures across the nation debated a creationist-inspired model bill that called for the balanced treatment of “evolution-science” and “creation-science” in public schools. Arkansas and Louisiana enacted this proposal into law. In 1982, a federal court overturned a 1981 Arkansas statute which required balanced treatment to “creation science” and “evolution science.” By wittily placing the word “science” after each term, lawmakers tried to give the appearance that both ideas had equal scientific merit. This decision, in McLean v. Arkansas Board of Education, also gave a detailed definition of the term “science” and declared that “creation science” was not in fact a true science. It was also determined that the theory of evolution does not presuppose either the absence or the presence of a creator.
The Supreme Court, in the case of *Edwards v. Aguillard* in 1987, showed that Louisiana’s “Creationism Act” was in fact unconstitutional. At that time, Louisiana was prohibiting the teaching of evolution unless it was accompanied by “creation science.” The Creationism Act was found to be one that was unlawfully endorsing religion. The Court also found that a comprehensive science education is “undermined when it is forbidden to teach evolution except when creation science is also taught.”

In *Webster v. New Lennox School District*, in 1990, the Seventh Circuit Court of Appeals found that a school district may prohibit a teacher from teaching creation science in fulfilling its responsibility to ensure that the First Amendment’s establishment clause is not violated, and religious beliefs are not injected into the public school curriculum. The district court found that the school district had not violated Webster’s free speech rights when it prohibited him from teaching “creation science” since it is composed of religious tenets.

In 1994, a teacher named John Peloza claimed that his First Amendment rights to free exercise of religion was violated by a school district’s requirement that evolution be taught in biology classes. In *Peloza v. Capistrano Unified School District*, the Ninth Circuit Court of Appeals found that the district was not in violation of the First Amendment and also rejected Peloza’s definition of a “religion” of “evolutionism.” At this point, the issue was laid to rest for several years as antievolutionists revised their strategy. This strategy came in the form of “intelligent design.”

**The intelligent design movement.** Intelligent design is the idea that living things are so complex, that they could not be the product of mere natural law. Therefore, it is
argued, an “intelligent designer” must have created these complicated organisms (Davis & Kenyon, 1993; Discovery Institute, n.d.; Johnson, 1991). To avoid the separation of church and state issue that repeatedly thwarted their efforts, proponents of intelligent design are very careful not to mention God as the designer and state that the theory is not based on the Bible (Discovery Institute, n.d.)—though most notable proponents have strong Christian backgrounds (Scott, 2006). The party line answer to the question of the identity of the designer is that it is unknowable. The term “master intellect” is also frequently used (Davis & Kenyon, 1993). Although the ID movement avoids the biblical reference to a creator, it is believed by the scientific community to be a clever attempt to sneak religion (under the guise of science) into the public schools (Matzke & Gross, 2006). In essence, ID is regarded as old wine in new bottles.

Microbiologist Michael Behe (1996), in his book Darwin’s Black Box, describes several complicated biological systems and claims that they could not have formed by natural selection alone. Behe claims that some organs are so complex, such as the human eye and bacterial flagellum, that they could not have been the product of gradual selection since the entire system would break down if all parts were not functioning all together. He calls this idea “irreducible complexity.” Other biologists contend that genetic mutations could produce such organs in small steps as long as each addition provided an advantage of survival (Eldredge, 2000; Miller, 1999; National Academy of Sciences, 1998; Shermer, 2006). They argue that the fact that we have not found a lot of fossil evidence of the transitional steps of every organ cannot be accepted as proof that a designer intentionally neglected them.
Rick Santorum, a former senator and 2012 Republican primary presidential candidate, proposed incorporating pro-intelligent design language into President Bush’s No Child Left Behind Act when he was a senator in 2001. Much of this amendment was crafted by the Center for Science and Culture (CSC) which is part of the Discovery Institute, a conservative Christian think tank based in Seattle. The CSC lobbies for the inclusion of intelligent design in public school science curricula as an explanation for the origins of life and the universe while attempting to cast doubt on the theory of biological evolution by portraying it as a theory in crisis (Scott, 2006).

The ambitious plan to replace the current naturalistic methodology of science with the theistic alternative of intelligent design is outlined in a CSC document entitled the “Wedge Strategy.” Although it was not meant to be read by the public, it was published online by an anonymous person in 1999. The goals cited in the document include the governing goals;

- To defeat scientific materialism and its destructive moral, cultural and political legacies.
- To replace materialistic explanations with the theistic understanding that nature and human beings are created by God.

five year goals;

- To see intelligent design theory as an accepted alternative in the sciences and scientific research being done from the perspective of design theory.
- To see the beginning of the influence of design theory in spheres other than natural science.
• To see major new debates in education, life issues, legal and personal responsibility pushed to the front of the national agenda.

and twenty year goals:
• To see intelligent design theory as the dominant perspective in science.

• To see design theory application in specific fields, including molecular biology, biochemistry, paleontology, physics and cosmology in the natural sciences, psychology, ethics, politics, theology and philosophy in the humanities; to see its influence in the fine arts.

• To see design theory permeate our religious, cultural, moral and political life (Center for the Renewal of Science and Culture, n.d.).

Activities to accomplish the goals of the project are to be done in three phases. Phase I includes scientific research and the writing and publishing in this area. Phase II is primarily concerned with publicity and opinion-making. In this phase, books about intelligent design are published, teacher training programs are developed, and apologetics seminars and opinion-maker conferences are established. The final phase deals with cultural confrontation and renewal. In this phase, academic and scientific challenges are to be promoted in conferences. Legal action for teacher training is outlined, and a research fellowship program to promote a shift to social sciences and humanities is created.

The debate about whether to teach evolution or ID in the public school became even more high-profile when President Bush said that “both sides ought to be properly taught…so that people can understand what the debate is about” (Wilgoren, 2005). This
became a rallying cry for ID supporters as they encouraged schools to “teach the controversy” (Scott, 2006). The vast majority of scientists and most science teachers declare, as well as many clergy (Hewlett & Peters, 2006; Zimmerman, 2004), that there is no controversy. Intelligent design isn’t science, they claim, but merely another creationist political movement aimed to get God back into the public schools. Just like “creation science,” it would get its day in court. Several years ago, a small school district set the stage for intelligent design proponents as they attempted to implement their ideas into the public schools.

In the summer of 2004, school board members in the Dover Area School District in Dover, Pennsylvania openly expressed concern about the teaching of evolution. On the advice of the CSC and the Discovery Institute, they hired the Thomas More Law Center, a conservative Christian, not-for-profit law center, to represent them. The board added a statement to their biology standards which mandated that students be made aware of intelligent design and other theories of evolution. They also added that the topic of the origin of life was to be removed from the curriculum. Additionally, the board required biology teachers to read a disclaimer in their biology classes which declared that evolution is a theory and not a fact, that gaps exist in the theory for which there is no evidence, and that intelligent design is an explanation that differs from Darwin’s view. Teachers were also mandated to mention the name of an intelligent design textbook and where students could find it (Lebo, 2008).

Eleven parents of students at Dover High School, joined by the American Civil Liberties Union, American Unified for Separation of Church and State, and the National
Center for Science Education, filed suit against the school district. In *Kitzmiller, et al. v. Dover Area School District, et al.* the plaintiffs wanted the Intelligent Design policy to be rescinded for fostering “excessive entanglement of government and religion, coerced religious instruction, and an endorsement by the state of religion over non-religion and of one religious viewpoint over others” (Coyne, 2005, p. 33). Although the trial was sometimes referred to as “Scopes II,” it had several significant differences. For one, the Dover trial had scientists arguing for the merit of evolutionary biology on the side of the plaintiffs, while John Scopes sat in the defendant’s chair. Clarence Darrow, Scopes’ defense attorney, tried desperately to bring scientific testimony in support of evolution before the bench. The expert witnesses he had brought to the trial were not allowed to testify. Eighty years later, however, they would get their chance. Several scientists, as well as philosophers of science, presented days of testimony in favor of evolution as well as clarified the nature of scientific knowledge. They also introduced testimony that poked holes in the intelligent design claims. Cleverly, the plaintiffs even put religious scholars on the stand to demonstrate that this was not a case of science versus religion.

Meanwhile the defense, including microbiologist Michael Behe, maintained the validity of intelligent design. Despite its earlier involvement, the Discovery Institute was concerned that this would be a test case and worried that the defendants on the school board had earlier displayed their religious motivations. This tension led to disagreements with the Thomas More Law Center and the withdrawal of three Discovery Institute fellows as defense experts prior to their depositions (Lebo, 2008).
The trial ended in a decision similar to previous evolution-creationism cases—with the natural science of evolution prevailing over the philosophic pseudoscience of creationism. U. S. District Judge John E. Jones, who ironically was appointed by George W. Bush, claimed that the insertion of intelligent design into the science curriculum violates the constitutional separation of church and state. He claimed that “the secular purposes claimed by the board amount to a pretext for the board’s real purpose, which was to promote religion in the public school classroom” and that the mandated disclaimer:

singles out the theory of evolution for special treatment, misrepresents its status in the scientific community, causes students to doubt its validity without scientific justification, presents students with a religious alternative masquerading as a scientific theory, directs them to consult a creationist text as though it were a science resource and instructs students to forgo scientific inquiry in the public school classroom and instead to seek out religious instruction elsewhere. (Associated Press, 2005)

Needless to say, the CSC was displeased with the ruling and criticized the judge for political grandstanding and judicial activism, as well as merely copying the ACLU’s “Findings of Fact and Conclusion of Law” (West & DeWolf, 2006). Several papers and books were published to air their discontented response. Nevertheless, although the decision seemed to deliver a seemingly fatal blow to the movement, it did not reach beyond the district. Though bruised, and arguably humiliated, the intelligent design movement would have to change their tactics yet again.

Many scientists and educators argue that the new strategy comes in the form of the “Academic Freedom” legislation being put forth in several states. Over the last few years, bills have been introduced in several state legislatures that are purported to protect
teachers and students from retaliation when they voice opposition to evolutionary theory. According to the language of the Louisiana Science Education Act (2008), this legislation extends permission to teachers to help students understand, analyze, critique, and review in an objective manner the scientific strengths and scientific weaknesses of existing scientific theories pertinent to the course being taught. Tennessee lawmakers have recently proposed a bill that would allow teachers to question evolution under the guise of helping students learn “critical thinking skills” (Mervis, 2012).

Opponents of these bills state that there are no credible weaknesses in evolutionary theory, and the claims that evolution is in crisis are merely ploys by intelligent design proponents to cast doubt on a well-supported and peer reviewed theory. The allegations of intimidation and retaliation on critics of evolution are unreliable and greatly exaggerated, and the bills are merely the latest attempt for intelligent design proponents and creationists to get their ideas taught in the forum of public education. These accusations are not far-fetched, since the bills’ language is largely drafted by the Discovery Institute.

Yet another strategy to get intelligent design into the public education science curriculum is to simply change language in the state standards. Of course, the words “intelligent design” need not be mentioned explicitly. In 2005, the Kansas Board of Education decided to change their definition of science from “the human activity of seeking natural explanations for what we observe in the world around us” to "a systematic method of continuing investigation that uses observation, hypothesis testing, measurement, experimentation, logical argument and theory building to lead to more
adequate explanations of natural phenomena” (Overbye, 2005). Proponents of evolution state that the change was made for one reason and one reason only—to allow for supernatural explanations in the science curriculum (Scott, 2006). Since supernatural explanations are not subject to experimentation and empirical measurement, the new language opens the door to any explanation whether it is rational or not. Nevertheless, Kansas is not the only state where science standards have been revised.

Opponents of the state of Texas’s newly adopted state standards believe that the 2008 revisions in the documents also open the door for intelligent design. Though the requirement that students analyze the “strengths and weaknesses” of the theory of evolution was removed, students must now “analyze, evaluate and critique scientific explanations in all fields of science” (National Center for Science Education (NCSE), 2009). In addition, special attention is paid to the critique of specific scientific ideas, such as “explanations concerning the complexity of the cell” (NCSE, 2009). These new standards have caused an uproar among proponents of evolution, who claim that this is nothing more than the “irreducible complexity” that Michael Behe argued for in the Kitzmiller trial.

In September 2010, the Alberta Human Rights Act was enacted which gives parents the right to have their children opt out of school instruction dealing with religion, human sexuality or sexual orientation without academic penalty. Although the spokesman for Alberta Education, Terence Harding, stated that “evolution will not be included under the notification requirement… evolution is taught as scientific theory and not in any religious sense” (qtd. in Brooymans, 2010, para.7), many in the United States
are watching this unfold with more than a passing interest. Creationists in the U.S. would undoubtedly argue that evolution and the origins of life have religious implications—opening the door to easily remove their students from learning about evolutionary theory. In August of 2012, Missouri voters passed an amendment that has a clause stating “that no student shall be compelled to perform or participate in academic assignments or educational presentations that violate his or her religious beliefs” (Storr, 2012, para. 2). Science teachers worry that those words give students the legal right to avoid any evolution instruction if they feel it conflicts with their religious teachings. Perhaps this strategy will be the next arrow to be pulled out of the creationist quiver.

**Effects of Antievolutionist Influence**

Regardless of the court decisions of the evolution/creation trials, it is clear that threats remain for evolution education. Antievolutionist efforts have had a large impact on the general acceptance of evolutionary theory. Excluding the country of Turkey, the acceptance of evolution in the U.S. is lower than almost all other European countries as well as Japan (Miller, Scott, & Okamoto, 2006). One Gallup poll, conducted on what would have been Charles Darwin’s 200th birthday, indicated that only 39% of Americans “believe” in the theory of evolution (Newport, 2009). This number drops to 24% among those who attend Christian churches regularly. Moore (2008) found that more than half of 1400 college students who completed a high school biology course claimed that their knowledge of evolution was average. More than a third claimed their knowledge of
evolution was below average, and only 14% claimed it was above average. These numbers are unimpressive when considering how much importance biological scientists place on the theory.

Students’ understanding of evolution may suffer for a variety of reasons. Biology teachers themselves may prefer creationism and personally reject evolution (Aguillard, 1999; Moore & Kraemer, 2005; Shankar & Skoog, 1993; Trani, 2004). Teachers may be ignorant of the law forbidding the teaching of creationism (Moore, 2004), or may not understand the theory well themselves (Rutledge & Warden, 2000) and do not feel prepared to teach it (Aguillard, 1999; Griffith & Brem, 2004). Teachers may simply want to avoid the controversy or may choose to deemphasize evolution in the curriculum (Alters & Alters, 2001). The fact that many American students lack sufficient knowledge in the area of biological evolution may lie in the political and legal endeavors of antievolutionists in this country. Strategies to teach only creationism, present creationism or intelligent design as alternative scientific theories to evolution, undermine the theory of evolution, or keep evolution out of the curriculum altogether have only served to confuse students and inhibit students’ understanding of the theory. Moore (2008) found that 3% of the 1400 college students had high school biology classes that taught creationism but not evolution, 24% reported receiving both evolution and creationism instruction, and 22% received neither evolution nor creationism. Fifty-four percent of students who received creationism in their public school reported that creationism was taught as a scientific alternative to evolution, while 20% said it was taught as an “equal idea” to evolution. Many scientists and science teachers would consider the teaching of
creationism or intelligent design in a public school’s science curriculum to be what Moore (2008) calls “educational malpractice” (p. 84).

Personal opinions about evolution and creationism can influence how students view and study the sciences in general. McKeachie, Lin, and Strayer (2002) reported that students who did not accept evolution were more likely to drop a biology course than those who accepted evolution. This could be due to the cognitive dissonance students experienced during the course. Students who identified themselves as creationists also did not do as well in the biology course as those who accepted evolution. On a Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1993) steadfast creationists, in a course that challenged their beliefs, began the course with higher motivation for grades and lower interest, were more anxious, and scored lower in intrinsic motivation, self-efficacy, and task value. Their scores were also low on the learning strategy and thinking scales. This data indicated that they memorized more and thought about ideas less. Alternately, the study showed that firm evolutionists had high intrinsic motivation and self-efficacy, and good learning strategies. The students who moved from a position of non-belief in evolution to belief in evolution began the course with high intrinsic interest and task value and less concern about grades. It has even been found that the degree to which science teachers and science teacher educators would engage in learning about evolution strongly depended on their personal ideas (Meadows, Doster, & Jackson, 2000).
Educators Respond to Improve Evolution Education

Science educators and scientists who advocate for evolution have not been passive and merely let the courts speak for them. Since the Dover trial, there has been a push to get evolution into the science standards at earlier grades. Although the National Science Education Standards (National Research Council, 1996) provides biological evolution standards for grades five through high school, none currently exist for younger students. Proposals have been made to extend evolution standards to the kindergarten through fourth grade (Wagner, 2010). Researchers from the Concord Consortium and Boston College have devised the Evolution Readiness project, which uses computer-based models to help fourth graders understand natural selection. In 2008 Niles Eldridge, the co-author of the concept of punctuated equilibrium in evolutionary theory, became the editor and chief of *Evolution: Education and Outreach*, a journal aimed to promote understanding and comprehensive teaching of evolutionary theory for a wide audience. This journal, which not only targets K-16 educators but also scientists, provides peer reviewed articles for classroom use, lesson plans, and other teaching tools. In 2010, the Monkey Bible Project sponsored a contest challenging educators to create evolution lesson plans which are scientifically valid, but respectful to people of faith (Outer Rim Press, 2010). In 2004, Michael Zimmerman created the “Clergy Letter Project” in order to “to let the public know that numerous clergy from most denominations have tremendous respect for evolutionary theory and have embraced it as a core component of human knowledge, fully harmonious with religious faith” (para.1). As of 2013, over 13,000 religious leaders have signed it.
Regardless of when evolution enters the curriculum, there have been many papers written and countless lesson plans developed outlining the best way to for teachers to approach the topic. Emphasizing the nature of science in the classroom is often regarded as a successful strategy to increase students’ understanding of the theory of evolution. Flammer’s (2006) program, the “Evolution Solution,” is a series of lesson plans specifically sequenced to build interest and suspense. He suggests two or three weeks on the nature of science to reduce misperceptions about the workings of science. Using inquiry-based teaching methods, he recommends that teachers ask questions about the diversity of life and the fossil record before even mentioning the term evolution. By having students seek to answer common biological problems, they come to the conclusion of the unifying concept of evolution on their own. Similarly, Desantis (2009) proposed that evolution could be taught by first building understandings of uncontroversial science topics. She proposes a lesson sequence consisting of stratigraphy and aging fossils, classifying with cladistics, and natural selection. The word evolution isn’t referenced until supporting evidence of the theory and its driving mechanism are discovered. “Evolution” is then referenced specifically during the discussions which unify the students’ findings. The National Science Teachers Association and the National Academy of Sciences have also published guides for teachers dealing with the relationship between evolution and the nature of science (Bybee, 2004a; Jensen, 2008; National Academy of Sciences, 1998; National Academy of Sciences Institute of Medicine, 2008; National Science Teachers Association, 2000).
Teaching what science is, what it is not, and how it works is a good prelude to demonstrating that evolution fits the bill as a science. However, even the best lesson plans can be fruitless if students are already resistant to learning about evolution or reject it completely. In his book *Why Darwin Matters*, Michael Shermer (2006) gives five specific reasons that people reject evolutionary theory:

1. A general resistance to science.
2. Belief that evolution is a threat to specific religious tenets.
3. The fear that evolution degrades our humanity.
4. The equation of evolution with ethical nihilism and moral degeneration.
5. The fear that evolutionary theory implies we have a fixed human nature. (p. 30-31)

In short, a simplified creationist thought process might be: “Evolution states we are descended from animals. If that is true, then we are animals ourselves. If that is true, then we are not made in the image of God. If that is true, then the Bible must not be true. Therefore, I must reject evolution. If evolution is not true, what else does science teach that is not true?” Peculiarly, Brem, Ranney, and Schindel (2003) showed that both self-described creationist and evolutionist students viewed the acceptance of evolutionary theory as having negative consequences—such as greater selfishness, a decrease in spirituality, and increased racism. With such a perceived negative aura surrounding the acceptance of evolutionary theory, it is little wonder that teachers face resistance and see student strife as they go down uneasy routes of critical thinking. For this reason, it would be beneficial for teachers to understand a little about cognitive dissonance.
Cognitive Dissonance

Cognitive Dissonance Theory began to receive attention when Leon Festinger sought to explain why a doomsday cult actually increased proselytizing after their prophecy failed (Festinger, 1957). The cult members actually became more convinced that they were right after the predicted day of mayhem came and went without incident. Festinger (1957) explained that two opinions, or beliefs, or items of knowledge are dissonant with each other if they do not fit together that is, if they are inconsistent, or if, considering only the particular two items, one does not follow from the other. (p. 25)

When people experience the discomfort of cognitive dissonance, they try to eliminate it—often going to great lengths to do so. According to Festinger (1957), this can take any or all of three forms:

- the person may try to change one or more of the beliefs, opinions, or behaviors involved in the dissonance; to acquire new information or beliefs that will increase the existing consonance and thus cause the total dissonance to be reduced; or to forget or reduce the importance of those cognitions that are in a dissonant relationship. (p.26)

Students who are taught at home or in their places of worship that they cannot believe in God and the theory of evolution may be more likely than other students to experience cognitive dissonance.

According to Tavris and Aronson (2007),

Dissonance is disquieting because to hold two ideas that contradict each other is to flirt with absurdity…and we humans are creatures who spend our lives trying to convince ourselves that our existence is not absurd. (p. 13)

A person’s perception of himself or herself as a competent and moral person forms one of the cognitions that leads to dissonance arousal (Aronson, 1992). Festinger’s cognitive
dissonance theory deals with how people make sense out of contradictory ideas and lead lives that are perceived as consistent and meaningful. It is little wonder that many students hold so tightly to religious ideas that provide meaning to their lives rather than be drawn to a scientific concept that is sometimes regarded as impersonal, cold, and random.

In a sense, the legal history of evolution in the United States mirrors how students may deal with cognitive dissonance between evolution and creationism—outlawing the teaching of evolution, fighting for equal time for creationism, attempting to undermine the validity of evolution, and trying to change the definition of science. Teachers can expect some students to completely reject the theory and refuse to learn about it, ask the teacher to teach creationism along with evolution, challenge the teacher with a number of questions or creationist rebuttals, or undermine the theory in a number of other ways. Although some teachers may believe that presenting solid lesson plans outlining the evidence for evolution will change the hearts and minds of resistant students, they would be mistaken. Dissonance theory shattered the idea that humans can always be relied upon to process information logically.

In his book *On Being Certain: Believing You Are Right Even When You’re Not*, neuroscientist Robert Burton (2008) makes a stunning claim—that “certainty and similar states of ‘knowing what we know’ arise out of involuntary brain mechanisms that, like love or anger, function independently of reason” (p. xi). Festinger (1957) realized that the more dedicated a person is to a belief, the harder it is to abandon, even in the face of
overwhelming incongruous evidence. Kurt Wise (1999), a geologist who studied under
the famous evolutionary biologist Stephen Jay Gould at Harvard, demonstrates this point:

I had to make a decision between evolution and Scripture. Either the Scripture
was true and evolution was wrong or evolution was true and I must toss out the
Bible….It was there that night that I accepted the Word of God and rejected all
that would ever counter it, including evolution. With that, in great sorrow, I
tossed into the fire all my dreams and hopes in science….If all the evidence in the
universe turns against creationism, I would be the first to admit it, but I would still
be a creationist because that is what the word of God seems to indicate. (p. 355)

If a student of Stephen Jay Gould, one of the most influential and widely read scientific
writers of his time, could not “convince” his own graduate student to accept evolutionary
theory, what chance does a high school teacher have? The short answer may be, to the
chagrin of some teachers of evolutionary theory, very little.

Teaching students about a theory that may go against belief structures that are
developed at a young age, reinforced over many years, and entrenched in powerful
emotions is by no means easy. It may even work against a student’s biology. In one
study, subjects were asked to evaluate contradictory statements made by presidential
candidates of their own political party and the opposing party (Westen, Kilts, Blagov,
Harenski, & Hamaan, 2006). The subjects all severely criticized the candidate of the
opposite party, but justified the inconsistencies of the candidate of the party to which they
belonged. While doing this, the most active part of the brain, as measured by an fMRI,
was the orbital frontal cortex—which is involved in the processing of emotions. The
dorsolateral prefrontal cortex, which is associated with reasoning, was inactive.
Furthermore, once subjects had arrived at a conclusion that they felt emotionally
comfortable with, there was an increase in activity of the ventral striatum—the part of the
brain associated with rewards. Instead of using logic and reasoning to analyze the candidates’ statements, the subjects had an emotional reaction to conflicting data. They diminished the portions that didn’t fit with their preconceived beliefs about a candidate, and they received a reward from their brain—most likely a hit of dopamine. It is not a difficult stretch to believe that people with strong ties to one side of the evolution-creationism controversy react the same way when assessing evidence on both sides. Emotions can overrule logic and reasoning when there is a lot at stake.

One significant aspect of the nature of science is emphasizing that science is a philosophy—a way of knowing. By highlighting the ground rules by which science must abide, teachers can point out that it is not the only way of knowing. Indeed, all people have gut feelings that they are correct about some things. It is difficult to determine if these are unconscious decisions, moods, or emotions, but they are clearly recognizable mental states. Burton (2008) calls this feeling of conviction, rightness, certainty, or correctness the feeling of knowing (p. 3). He argues that this feeling of knowing is so powerful that ordinary rational thought can seem wrong or irrelevant if it is in conflict with that feeling. To demonstrate how powerful this phenomenon is, one can look at the remarkable case of Nobel Prize winning mathematician John Nash. Nash once rejected a full professorship because he believed he was “scheduled” to become the emperor of Antarctica. He also believed that aliens from outer space were communicating with him through encrypted messages in newspapers and magazines. Later, when asked how such a logical man could believe such extraordinary things, Nash replied that both ideas had come to him in the same way—they felt right (Nasar, 1998).
Another study demonstrating the power of the *feeling of knowing* was conducted right after the Challenger space shuttle exploded. Within one day of the disaster, Ulric Neisser, a psychologist studying “flashbulb” memories, asked over 100 of his students to write down details of where they were and what they were doing when they heard about the explosion (Neisser & Harsch, 1992). Two and a half years later, the students were interviewed to see if they could recall details about what they were doing at the time of the event. One-fourth of the students’ subsequent accounts were very different than their original journal entries, despite expressing a high level of confidence that their false recollections were correct. Even when confronted with their own handwritten journals, some of the students demanded that their recollections were inerrant. The *feelings of knowing* were more convincing than the evidence presented by their own handwriting.

It is important to note that I am not insinuating that creationists possess abnormal mental tendencies like John Nash, nor am I equating the belief in extraterrestrial creatures speaking through the media with the belief in a god or an intelligent designer. I am also not implying that the theory of evolution can be proven to antievolutionists as easily as one can demonstrate that a specific person did indeed write a journal entry two years before. I use these examples to illustrate how those feelings of being right are not easily undone and frequently trump logical thinking based on empirical evidence. As Burton (2008) states, “Internal bias and misplaced *feeling of knowing* routinely overpower and outsmart the intellect” (p. 149).

Although there have been studies where teachers induce cognitive dissonance in science classes in order to change student attitudes toward science in general (Misiti &
Shrigley, 1994; Steiner, 1980); where teachers create dissonance to help students change their preconceptions about some isolated scientific concepts (Major, 2006); and papers proposing how to teach evolution as a controversial issue (Bridges, 1986; Hermann, 2008; Hess, 2001; Reiss, 1992); there is little research on how teachers help students deal with cognitive dissonance regarding the creationism/evolution controversy. I am interested in the stories that teachers have about helping students with cognitive dissonance, and how they came about the strategies that they use. I want to learn more about how science teachers contend with an issue that some people might consider the battle for America’s soul.
Chapter Three: Methodology

Why Would a Science Teacher Choose Qualitative Research?

As a long-time science teacher, I was typically drawn to scientific, and therefore often quantitative, research. As the old adage goes, “Without data, you are just another fool with an opinion.” Scientists would undoubtedly consider the data in this phrase as “hard data” while qualitative studies are traditionally considered “soft.” I have found, however, that qualitative studies do not limit themselves to means, medians, and modes, but have another lens through which to examine the educational process—the individual stories and experiences. As educational researcher Kathleen Fisher stated,

One of the things that has happened in educational research is that we used to look at huge groups of people and get averages. That’s like trying to study a mountain chain by looking at averages. You lose all the peaks and the valleys. So what we do now is to look at an individual struggling to understand. (qtd. In Schneps & Sadler, 1997)

Scientific research seeks objectivity, logic, independent lines of evidence, peer review, utility and fecundity. However, it is not the only research method that values such attributes. As I will argue, qualitative research not only abides by the fundamental rules of science, it can also add depth through interpretation.

To get to the heart of validity and reliability, science seeks objectivity when looking at evidence. In science, opinion and “facts” must be corrected when faced with solid evidence to the contrary. The goal is to study phenomena without bias or subjectivity and eliminate mysticism or dogma. Valid observations and experiments
must be replicated under controlled conditions and get the same results. In this way, science can correct itself. Poor scientific procedures or interpretations can be flushed out in this self-policing manner. However, some observational or historical sciences do not lend themselves to direct experimentation and must be studied in other ways. The question of validity and reliability in these particular fields of natural science is similar to that of the social sciences, especially qualitative educational research methods.

In *The Enlightened Eye*, Eisner entitles a chapter “The Search for What is Real.” In it he explains that true ontological objectivity eludes even the most experienced researcher. What researchers “wish to see and know is not some subjective, make-believe world created through fantasy, ideology, or desire, but what is really out there” (Eisner, 1991, p. 43). One would not be surprised to find the same chapter title and quote in a science book. He also states that the aim of educational researchers “is to use a procedurally objective set of methods in order to gain an ontologically objective understanding of the events and objects under study” (Eisner, 1991, p.44). To achieve true objectivity, one must see the world as it actually is. This requires one to know reality, as well as know how one perceives it. If one knows the prior, the latter is unnecessary. Humans have not discovered the instruction manual to the universe. In the natural world, there are no answers in the back of the book. We write and continuously revise that instruction manual based upon what we have discovered for ourselves through observation and experimentation. Researchers and scientists do what they can to manage all variables in order to make reality predictable and repeatable under controlled conditions. This may be possible when dealing with inanimate matter or energy, but is a
different enterprise altogether when dealing with human subjects. For this reason, many believe that personalization undermines objectivity. Nevertheless, although it is the aim of procedural objectivity to reduce subjectivity and judgment, Eisner believes there is richness and value in personal interpretation.

Eisner understands the concern about the validity of qualitative research, but takes issue with those who feel that verificationists have a monopoly on the truth. People can shift their frame reference to get different perspectives on a state of affairs, and still be right. Jon Haught, a witness in the Dover trial which pitted evolution against intelligent design, emphasized this point in his testimony (Chapman, 2007). He asked the court to imagine a teapot boiling on a stove and someone asks for an explanation as to why it is boiling. One person might say that it is boiling because the water molecules are moving around in an excited state and the liquid state is being transformed into a gas. At the same time, another person could have just as easily answered that it is boiling because someone turned the stove on. Yet another could answer that he wanted some tea. All answers are correct, and don’t conflict with each other because they are working at different levels. It would be considered a mistake to say that one of these explanations is true and the others are not. A plurality of levels of explanation is possible, and problems only occur when someone assumes that there is only one level. Drawing on Dewey’s work about transaction (Dewey, 1938), Eisner states that neither pristine objectivity nor pure subjectivity is possible. To avoid the dichotomy between the two, Eisner proposes the idea of “transaction”—the locus experience we gather from the interaction of our perceived objectivity and subjectivity rather than viewing them as independent entities.
This blending of perceptions is important to qualitative research in order to gather data at all desired levels of information.

Scientific theories are considered strong if they are supported by what is known as independent lines of evidence. This means that several separate sets of data all point to the same conclusion. Facts and tested hypotheses that stand alone may only be observations that have been repeatedly confirmed, but when a common explanation unites these facts, the theory is supported on multiple levels. The theory of evolution demonstrates this point beautifully, as it has supporting evidence found in the areas of paleontology, geology, genetics, medicine, embryology, animal husbandry and plant breeding, population ecology, and molecular biology. The qualitative analogy for independent lines of evidence is structural corroboration—also known as triangulation. This refers to how well different pieces of information are interwoven to support the conclusion. In qualitative research, the independent lines of evidence that corroborate to support an idea may come in the form of observations, documents, interviews, and other means.

Scientific ideas must be considered to be logical and rational if they are to be considered at all. There must be a logical, rational line of thought that leads to a particular conclusion. Science does not tolerate unexplained gaps in reasoning, nor jumping to large conclusions based on scanty evidence. Similarly, Eisner (1991) calls for “coherence” in qualitative research, or the strength of the argument being presented. The power of the argument is based on how logical it is, whether any anomalies can be satisfactorily explained, and the quality of the evidence. Rationality, to Eisner (1991),
means “the exercise of intelligence in the creation or perception of elements as they relate to the whole in which they participate” (p. 51). As in science, qualitative research seeks cause and effect relationships.

Eisner discusses consensus as also being significant for believability. He states, “With respect to qualitative research and evaluation, affirmative consensus confirms the researcher’s conclusions” (Eisner, 1991, p.56). Investigators or readers must agree that the researcher’s conclusions are consistent with their own experiences with a similar observation or phenomenon. This is analogous to the importance of peer review in science. Ideally, before new information is published and acknowledged in the scientific arena, claims are repeated and verified by others with the appropriate expertise and equipment. Of course Eisner concedes that researchers may have strong attachments to their own ideas and resist consensus if new information is contrary to their beliefs. In science, it a cardinal mistake to cling to one’s own pet theory if evidence is shown to disprove it. However, it is not uncommon for two scientists to look at the same evidence and come to different conclusions. For example, there is a feud among two prominent paleontologists about whether the infamous dinosaur, *Tyrannosaurus rex*, was a hunter or a scavenger. Both scientists are well-educated on the skeletal features, but use the same evidence to support their own beliefs. Despite popular belief from outside of the scientific field, disagreements between scientists are not one of the weaknesses of science. On the contrary, disagreements promote further research and conversation, and only increase the depth of the working body of knowledge. The same can undoubtedly be said about qualitative researchers.
A good scientific theory has utility and is useful in real life. Additionally, a strong theory has fecundity and provides direction for future research. It will establish what new questions need to be investigated next. Instrumental utility, according to Eisner (1991) is the most important measure of any qualitative study (p. 58). In addition to the usefulness of comprehension, where a researcher can shed light on an otherwise perplexing situation, he talks about the ability of a qualitative study to serve as a guide. Guides not only highlight, explain, and provide direction to the user, but function as a means to focus attention on areas that might ordinarily be overlooked. Once again, qualitative research and science share similar criteria that help them to gain credibility.

Since what we know about the world is a result of our own inquiry and is “mediated by the mind,” (Eisner, 1991, p.52)—and since we have biases, prejudices, and preconceived ideas, we need to understand that findings are never one hundred per cent reliable. Because of this fact, both quantitative and qualitative researchers do the best they can to shed light on reality. Since both ventures are human endeavors, it is understood that absolute objectivity is not a possibility. Instead of talking in terms of “truth,” validity in quantitative and qualitative research is discussed in terms of “certainty” or “warranted assertions” respectively. For my research, a qualitative study can beautifully illustrate the blending of a scientific idea with the experiences of those who teach it. Although there are many methodologies of qualitative research, despite any flaws they may have, when performed correctly and honestly they are excellent techniques for achieving what they are trying to accomplish and reveal.
Why Educational Criticism and Connoisseurship?

Eisner (1991) defines connoisseurship as the “ability to make fine-grained discriminations among complex and subtle qualities” (p. 63). An educational connoisseur should be able to look beyond what is obvious to the common observer and tease out the finer nuances that may be ordinarily neglected. A connoisseur should be able to examine the plurality of levels that are present in a classroom. It is only when the researcher delves into these multiple levels that a comprehensive understanding can be achieved.

In addition to paying attention to the multifaceted qualities of a school, classroom, or instructor, a connoisseur should be aware of “the conditions that give rise to these qualities” (Eisner, 1991, p. 65). There is significance in the history of an educational setting. According to Eisner (1991), the “knowledge of that history can have a bearing on our ability to experience its qualities” (p.65). It would be difficult to interpret things that are noticed if the observer was not grounded in the history of the situation. Indeed, the history of the participants, as well as where they teach, is very much a part of their story.

At the onset of this study, I believed my level of connoisseurship would be aided by the roles and experiences I have had over my nineteen years of working in education. I have taught middle school, high school, and adult classes in public schools, teacher colleges, and places of worship. I have been a classroom teacher, club and activity sponsor, athletic coach, mentor teacher, dean of students, and assistant principal. I have taught independently and worked with other teachers in co-taught classes.
coached, mentored, observed, and evaluated the rookie, marginal, and master teacher. Additionally, I have extensive training in the Teacher Advancement Program (TAP) evaluation system which utilizes an extensive rubric to analyze nineteen areas of instruction. Hundreds of these extended TAP evaluations, combined with the training and experience of countless ten-minute walk through observations, has helped me to observe and perceive many of the nuances of a classroom.

Prepared with these experiences, I intended to not only interview participants, but observe them teaching in the classroom setting. However, while trying to gain permission to observe classes during instruction on the theory of evolution, I was denied access by one district’s institutional review board. After submitting my proposal, clarifying the potential benefits of the study to the board, and answering several questions about the purpose of the study, I was told that the subject was “just too sensitive.” I explained that I would not be speaking to students, providing curriculum, or interfering with instruction in any way. I would only be observing what is being done in the classroom already. Nevertheless, my appeal was unsuccessful.

I was also denied access to the classroom of another potential participant. When I spoke to the principal, she was originally excited that one of her teachers would be a participant in a dissertation—until she learned of the subject. After I told the principal that the topic of my study was the teaching of evolution, I was told, “You will not be doing that research in my school.”

These two stories are presented in order to provide perspective of the culture of the school districts in which my participants teach. In order to gain access to my
participants, I revised my proposal to focus on data gained by personal interviews and document analysis. These participants wanted to tell their stories, and were able to be more candid when interviewed away from school property without the need for permission of their supervisors or school districts.

My personal experience with the subject matter directly lends itself to the connoisseurship method of research. Having been trained as a biologist, as well as taking many professional development courses and seminars, I understand the theory of evolution as a scientific theory as well as a controversial topic in the classroom. I have been teaching about the theory for most of my career—in the classes of biology, geology, astrobiology, paleontology, and a theory of knowledge class. I have taught “Nature of Science” courses to teachers, as well as an adult lecture series entitled “Creationism and Evolution” and “Religion and Science” in churches. Additionally, I have dealt first hand with those who oppose the teaching of evolution. Therefore, I have made it a point over the years to be aware of any antievolutionist strategies popping up around the country—especially in the state of Colorado. My understanding of the community and its history in this regard will greatly enhance my understanding of the conflicts that the participants discuss. These personal experiences, along with the data I gathered through personal interviews and document collection, provide structural corroboration for my research. I also sought verification from the participants themselves to enhance accuracy of my descriptions and interpretations.

Whereas educational connoisseurship is typically a private event, educational criticism “provides connoisseurship with a public face” (Eisner, 1991, p. 85). The goal of
the critic is to interpret and illuminate all that has been gathered through the lens of the connoisseur, and provide the reader with context and appraisal of what was experienced. In this way, practitioners of this method must become photographer, investigator, background researcher, and reporter all in one. Eisner provides a structure of four dimensions of educational criticism: description, interpretation, evaluation, and thematics.

Description, as the name implies, is a detailed narrative about a place or event. The critic must provide a portrayal which allows the reader to understand all the necessary ingredients that make up all that is being described. For each participant, I attempt to create a visual depiction of his or her pedagogical strategies, curricular selections, word choice, teacher affect, and relationship with students.

Interpretation adds meaning to what is observed. It can also mean “illuminating potential consequences of practices observed and providing reasons that account for what has been seen” (Eisner, 1991, p. 95). Understanding the teacher’s choice of particular words, activities, or content may be dependent on the teacher’s history. Understanding the community’s motivation behind any antievolutionist sentiments may be relevant in comprehending any resistance observed in the classrooms. However, I must realize that each student may have a different reason behind his or her resistance. Eisner (1991) warns that the researcher must strike a balance between what to look for in order to be more efficient and not overlook things that are not a part of the expectations.

Evaluation, Eisner’s third dimension, is to not only make value judgments on the interpretations, but to determine what is educationally virtuous and contribute positively
to the educational field. After collection of my data, I evaluated the practices of my
participants and identify any pervasive qualities, or themes,—the fourth dimension of
educational criticism. According to Eisner (1991), these themes “provide a summary of
the essential features” (p. 104) which unify a situation or scenario. The themes that
emerge, along with my evaluation of what takes place during my data collection, enable
me argue in favor or against particular strategies or practices in the classroom.

**Study Design**

While attending a seminar in the summer of 2011 hosted by the Evolution Outreach
Committee out of the University of Colorado, I mentioned the topic of my study—at least
where I believed it was going at the time—to the attendees. Several people approached
me and disclosed that they were teaching evolution in an area where resistance was
commonplace, and felt it was not only their job but their duty to deliver solid education in
evolutionary theory. I gathered their contact information in order to discuss my study
later. Three out of five of these educators agreed to be part of my research. The other
two decided they were not interested in participating—deciding that they were too busy
with coaching or teaching responsibilities. I also found two participants who were
recommended to me by the director of the Biological Sciences Curriculum Study. After
speaking with them, I determined that their experiences would add a great deal to my
research. They agreed to be interviewed, and I settled for a total of five participants.

One participant is a biology professor at a military academy. He was the only one I
interviewed in the institution where he taught. The other four are high school biology
teachers in Colorado—each from a different public school district along the Front Range. Two are male, and two are female. I have used pseudonyms to protect their anonymity.

Through interviewing participants, I strived to understand the “lived experience of other people and the meaning they make of that experience” (Seidman, 2006, p. 9). I interviewed each participant individually, and collected relevant documents which supported their answers. I considered how significant the teaching of evolution is in these teachers’ curricula, how they emphasize that importance, and how they create a learning environment conducive to student learning of a controversial topic. I learned about each participant’s history in this area, presuming that “the meaning people make of their experience affects the way they carry out that experience,” (Blumer, 1969, p.2).

All interviews were recorded, transcribed, and read several times. The purpose of the first reading was to get a general overview of the participants’ responses. The purpose of the next reading was to develop a system of codes by highlighting words, phrases, and significant participant quotes that struck me. All initial coding and marginal remarks were done by hand on a hard copy of the interview transcripts. Transcripts were read again to collapse codes into larger categories. The outcome of this coding and analytic reflection became themes.

The textual data collected through these methods was interpreted through the tradition of educational criticism and connoisseurship, as outlined above. As Seidman (2006) and Eisner (1991) recommend, I conferred with the participants to see if they agreed upon what was important or of particular interest. All were very interested in the themes that emerged.
Limitations

There are a number of potential limitations to this study. As with many qualitative studies, the number of participants limits any generalizations that might be made. Additionally, since each participant teaches in a different school district (and one institution of higher education), the school communities may not be similar. Strategies that may work with students in one district may not elsewhere. Finally, the spectrum of beliefs that students have may range from biblical fundamentalist creationism to philosophical naturalist evolutionism. Therefore, when creationist views or opinions are discussed, it does not necessarily refer to all creationists. The degree of cognitive dissonance, when experienced, will undoubtedly vary, and may reflect the extremes of their worldviews. What is meaningful to one student may not be to another. Despite these possible limitations, this study has provided authentic insights into my research questions.
Chapter Four: Description and Interpretation

Eisner (1988, 1991) outlines one way to think about subject matters of educational connoisseurship in what he calls the “ecology of schooling.” He outlines five interactive dimensions—intentional, structural, curricular, pedagogical, and evaluative. Uhrmacher and Matthews (2005) provide two additional dimensions in school and community, and administration. In this chapter I provide detailed descriptions of each of the five participants and interpret those descriptions using several of these dimensions as a conceptual framework.

The description of each participant will begin with an introduction to provide a background to their profession. It will include where they are currently teaching, how they came by their own understanding of evolutionary theory, and how they became teachers of it. These factors undoubtedly shaped the way they currently teach evolution and how they interact with their students.

A description of the school and community follows. Presuming schools are microcosms of society, the subject of this dissertation demands a glimpse into the community in order to give the appropriate context of the conflicts that the teachers experienced. The description will include: 1) some background information on the district in which each participant teaches, 2) interactions or clashes with staff, students, parents, or community members regarding the teaching of evolution, and 3)
misconceptions or preconceived ideas that students have that may interfere with their understanding of evolution and where those preconceived ideas originate.

The intentional dimension will shed light upon the goals and aims that the participant strives to achieve in his or her classroom. These are not always the biological, content-related goals found in a state standards document or a textbook, but what teachers want for their students regarding the study of evolution as it pertains to science or the students’ overall worldview. It begins with the importance of evolution in each participant’s classroom and how they express that importance to their students. I also ask what, in an ideal world, do the participants wish their students came with before entering their classroom as well as what they hope their students leave with. Although Eisner (1991) speaks to the importance between the intended aims and operationalized aims, I was unable to gain data on the latter. Without being able to observe classes over a period of time, I focus on what the participants provided to me through the interview process and document analysis. For this same reason, the dimensions of school structure, administration, and evaluation are not addressed, though information about some of these came out during our conversations.

The curricular and pedagogical dimensions will follow the intentions. This section will describe where the topic of evolution fits into each participant’s curriculum, how they prepare students for the study of evolution, and what strategies and activities the participants use when teaching it. How participants make their classrooms intellectually safe will also be described, as well as how they recognize and react to students’ cognitive dissonance. Participants will reveal how their own understanding of
evolution has influenced how they teach it, as well as how their practice has changed over time. Finally, I will describe what training each participant has had regarding the evolution-creation controversy.

As stated in the methodology chapter, I was denied access to observe classrooms due to the “sensitivity” of the subject. Therefore, the portraits I try to create are a blending of description and interpretation. I attempt to not only create a clear picture of what my participants have experienced, but try to explain the meaning behind it.

Aaron—The Fundamentalist Turned Evolutionist

Introduction. Aaron has been a biology professor at the United States Air Force Academy for the last eight years. He has taught a wide variety of life science classes over his career, but currently teaches general biology to freshmen cadets as well as courses on evolution and a senior capstone seminar class for biology majors. He is the Deputy Head of Research at the Academy, and has taught some aspect of evolutionary theory for the last twenty-six years. At the time of this writing, he has thirty publications and has given thirty-three presentations—several of them addressing evolution education or the creation-evolution controversy. The path that led Aaron to become a teacher and defender of evolutionary theory is an interesting one.

Aaron was born into a creationist household. The son of a fundamentalist minister, he grew up reading creationist literature that was present in the house from the time he was ten years old. Because of this upbringing, Aaron aggressively defended his religious beliefs in the science classroom.
I was the teacher’s antagonist. I was the guy the teacher did not want to have in class. I was always bringing up challenges in everything I had written and so forth. I was out to… I was the ardent creationist—well equipped with creationist arguments and openly aggressive about it.

Despite his defiance against evolutionary theory during his high school years, Aaron made an important personal decision before leaving for college. It was a decision, well beyond his years, that would influence not only his future career, but his entire worldview.

I did a strange thing when I left home to go to college. That summer I decided I was going to intentionally erase all preconceptions and kinda start over with virtually everything involving ethics and evolution—basically everything. I thought I would wipe the slate clean and see what happens when I went to college.

Aaron decided to major in wildlife conservation—a field of study which required an extensive amount of biology classes. The topic of evolution was addressed frequently throughout his coursework, though a course in evolution was not explicitly taught. However, he was exposed to evolutionary concepts in multiple classes which “added the meat to the skeleton that was already there.”

Aaron came by his understanding of evolution gradually, so “there was never one defining moment when the clouds parted and I knew evolution was true.” However, he does remember a moment of clarity when reviewing natural selection with a professor and a few other classmates. While discussing the concepts of differential reproductive
success and survival, “I just had an insight and suddenly I understood. I wanted to see how this worked. That was a big moment for me.”

When Aaron entered college, there was no longer an internal conflict pitting his religious views against the claims of science. He was very intentional about putting aside what he had learned through his fundamentalist upbringing.

There was no dissonance because I already decided which side of the conflict I was going to land on. I never really felt... I never really had a conflict between where the science was really challenging my faith because I went through that intentional erasing process. I didn’t go through the process where the scientific evidence gradually overcame a previous belief. I just decided ahead of time to put that belief on the shelf and be more open. I didn’t have a period of dissonance like I’ve seen in students.

Once the theory of evolution became the basis of Aaron’s understanding of biology, he began to reflect upon the creationist literature with which he grew up. With a firmer grounding in science, he could see straight through the non-scientific arguments. It had a profound impact on him, and he was admittedly angry.

I was deluded by people who must have known they were giving me false arguments. They had to know. People had to know that these arguments were B.S., but it didn’t matter because they were saving souls—their point of view. That’s my take on it. That is what created in me a lifelong interest in the controversy and a lifelong involvement in it—kind of like payback.
This experience led him to pursue a graduate degree not just in science, but in a field where social controversy exists. After a master’s degree in zoology, Aaron earned his Ph.D. in animal ecology—specializing in bird adaptations because “evolutionary biology was a career goal by the time I finished my undergraduate degree.”

**School and community dimension.** Although the United States Air Force Academy lies in a politically and religiously conservative part of Colorado Springs, Colorado, students who attend come from all states across the nation. Although this might be indicative of a student body and that holds a wide diversity of worldviews, Aaron frequently encounters challenges from fundamentalist students when teaching evolution. Most of the challenges “are the same old tired arguments that I’ve heard a hundred times over.” They are arguments popular in the creationist literature meant to convince the true believer that evolution is a fallacy and therefore, by default, creationism must be true. Many students, even those who are not necessarily arguing against evolution, have preconceived ideas and misconceptions that interfere with their understanding. Most of them are misunderstandings of a biological nature—that evolution is intentional with “some sort of effort-based mutation,” that people evolve from monkeys, and that if “they evolved from B, then B must be extinct.” Others are grounded more in the nature of science—such as “whether evolution is falsifiable or not.”

However prominent evangelical Christians are in the student body and the Air Force Academy, the teaching staff was not always religiously unbiased either. Aaron described a “religious intolerance mess” that occurred at the Academy several years ago:
This one arose when some students complained that there was such a strong evangelical presence at the Academy that they were intimidated to express their point of views, that some instructors were so outwardly evangelical. A Jewish student was not at ease and very uncomfortable with going to the office of an officer when he has a Bible sitting on his desk and a cross behind his desk—that sort of thing.

The scandal that Aaron referred to stemmed from a complaint made by former honors graduate of the Air Force Academy Michael Weinstein in 2004. Weinstein claimed that his sons, both Academy graduates, experienced religious harassment and anti-Semitism from senior cadets. He also reported that, when the film Passion of the Christ came out, the Air Force Academy “administration was putting tremendous pressure on the 4,400 cadets and 6,000 staff to go see that movie” (Burrows, 2008, para. 2). Weinstein claims posters were hung throughout the academic halls and living quarters, and flyers were put on plates at the dining hall. His daughter-in-law, also a graduate of the Academy was directed by the commandant of cadets to round up non-Christian cadets and bring them to a production at New Life Church—an evangelical mega-church not far from the Air Force Academy grounds. As an attorney, he dug deeper into matters such as these and found:

that this contagion of unbridled right-wing, Christian fundamentalism had spread not just to the Air Force Academy but throughout the entirety of the United States Air Force, United States Marine Corp, United States Navy and the United States Army. (Burrows, 2008, para. 5)

He outlines the entire experience, as well as his creation of the Military Religious Freedom Foundation, in his biography (Weinstein & Seay, 2006). As a result, the Air
Force conducted a large investigation, adopted guidelines that discouraged public prayers at official events and meetings, and provided training for staff and faculty.

We all got training very quickly about that. Religious icons disappeared. We were told get the religious icons out of the offices and so forth. They went as far as saying, “Get the Darwin fish off of your filing cabinet,” because it was perceived as an anti-religious symbol. The pendulum swung a bit far. In the past year we received subsequent training that was better...look this is what you can do and this is what you cannot do. They’re your personal freedoms in your office, and that sort of thing, so the training has gotten much better. But the consequence of it was that some of these professors were offering a ride to church to their students and things like that in the classroom. They really were stepping over the bounds considerably and that got corrected very cleanly. It was crystal clear that you didn’t do things like that.

In this strong evangelical atmosphere, Aaron found a healthy resistance to bringing evolution into the curriculum within the biology department when he arrived. There was no explicit teaching of evolution, and professors defended their choices by claiming that students would “pick it up along the way.” Aaron, as well as a geneticist on staff, worked hard to bring change to the department and bring the topic of evolution into the limelight. At first, evolution was offered only as a special topic. It took a few years to get an evolution course added to the books as a regularly occurring class offering. However, a complete transformation of the curriculum was not realized until a new department head was hired.
We got the right guy in and as soon as we got him we’d show him some stats that our students did not understand evolution at all. He’s been really good, great—the clouds parted at that point. We could start...the department head said we will teach evolution in an introductory class because it is important. And that’s what made it all happen.

The difficulties of emphasizing evolution in the coursework were not solved by merely changing curriculum or adding courses to the biology major’s coursework plan. Aaron doesn’t believe that all professors in the biology department are proficient in the theory of evolution. He found that unless a professor has formal training in evolution, they don’t understand it well and are not prepared for creationists’ arguments. He claims that “this idea that you can pick it up by taking various courses in your undergraduate career is just not true. You can have a degree in microbiology and know almost nothing about evolution.” This problem is enhanced because of the make-up of staff in the biology department. The biology faculty consists of twenty members—fifteen military and five civilians. Frequent turnover of the military professors can disrupt any continuity that the department strives to keep. Both Aaron and one of his colleagues agree that newcomers are not always on the same page regarding evolution instruction:

Once in a while we will get an Air Force guy in with a Master’s degree in something or other and he will be a creationist. In that case though, he might initially object to something but once again I know the answers to the questions and I can explain why we are teaching what we are and so forth, so the objections don’t last very long. So the challenge goes to the department head to make it
clear to that person that they are expected to go into class and teach evolution as valid scientific theory without a wink and a nod, and without throwing in intelligent design.

The physical setting of the biology wing at the Air Force Academy provides no clue that evolution has ever been a contentious topic. A large “Evolution of Flight” mural cannot be overlooked as one enters the hallway. The painting displays the multitude of organisms that have evolved the ability to fly over the last 400 million years. Hanging on the walls that make up the maze of hallways are posters and display cases showing off animals that fly—birds, bats, insects, and pterosaurs—the avian cousins of the dinosaurs. An image of an Archaeopteryx, a transitional fossil between birds and bipedal dinosaurs, adorns the wall above a case full of casts of small pterosaurs. A life-sized pterosaur skeleton, crafted of lightweight wood, hangs from the ceiling as if it has caught a thermal updraft in the atmosphere. A glass beehive is mounted on the wall so spectators can view the activities of the workers inside and watch the bees leave and take off from small landing strips that open up to the outdoors. If these visuals and specimens are not enough to get across the message that flight is an evolutionary adaptation, a large title of one poster surely does: DARWIN WAS RIGHT. Upon further inspection, the poster is not referring to species that acquired evolutionary advantages over time, but to military planes. It reads:

Mission: In any species, the fittest survive. Individual talents become family traits. Each generation adapts to a changing world. And over time, leaders emerge. Which is why, when the world demands new levels of fighter
capability—new standards in speed, strength, and stealth—new achievements in practicality and affordability—it turns to one family in particular: the fighters of Lockheed-Martin.

In light of the topic, I noted the absence of at least one flying creature in the halls of the biology department—angels.

**Intentional dimension.** One need not look much further than the work Aaron has done in his department to recognize how important the theory of evolution is to him. In his view, evolution is the theme that ties the entire field of biology together. For the science major, the theory of evolution is as important to the discipline as Thomas Jefferson is to political science and United States history. For the non-science major, the theory has epistemological significance. “The importance is not the theory itself, it’s the reasoning that goes behind it—how you distinguish between an empirically valid statement and an empirically invalid statement.” Thus, the nature of science itself is of utmost importance to all learned people. In fact, even though he knows he will be challenged by some students in his classes, he doesn’t deliberately express the importance of evolutionary theory to his students. The emphasis is on how to think.

Aaron highlighted this point when asked what he wished students already understood about evolution or science in general when they come to his class. It was not any specific content that could be found in a particular state’s science standards, but how science works and what it can and cannot do.

Using science class to teach metacognition, thinking about the way you think, I think is much more important than any kind of content knowledge. It teaches
about rationality—how you apply the brain that you’ve got to understand what you see. Specifically what we try to get across about science is that it’s really very successful and as a way of knowing about the natural world it’s unparalleled. The scientific method goes back to Sir Francis Bacon and so forth, and you look at the progress that’s been made by applying this way of thinking to the natural world. It’s incredible. It’s astounding. Everything else, every other way of knowing about other questions looming relative to the scientific method is really bad. And the reason it works is because it follows a certain set of rules of thinking. It would be great if students understood that.

Aaron wants students to understand the rules that science must follow, and that these same sets of rules cannot be applied to other disciplines—such as theology. He wants these aspects of the nature of science included into every science class the Academy offers “until finally it is just hammered into their head. The reason I wish they knew that is that diffuses the whole notion that science is at odds with religion.”

This point is reiterated when asked what Aaron wants his students to leave his class with. After the evolution unit, his emphasis is not on the mechanisms or biological details of evolutionary theory, but on an understanding of the nature of scientific evidence. In fact, he admits he has “dumped content like crazy” over the years to focus less on details and more on logic and examples. He wants students to understand that evidence doesn’t have to be experimental to be meaningful—when applied to the theory of evolution or other historical sciences. He also wants students to know that science is self-correcting and seeks evidence that may refute it—something which is at complete
odds with religious thinking. “In religious thinking, you don’t set out to find out that you are wrong. You set out to further understand what you already know to be true.”

Less content, more cognition. If that is truly Aaron’s wish for his students, it is reflected in the senior capstone seminar class that he teaches for biology majors. The goals of the course, as written in the syllabus, are:

1. Critical Thinking: Cadets will be able to critically evaluate evidence from a variety of sources, and be able to assess its validity, clarify its assumptions, and consider its different perspectives.

2. Communication: Cadets will be able to communicate a clear, logical understanding of the scientific method and scientific thinking.

3. Scientific Method: Cadets will be able to apply scientific thinking to solve problems and analyze issues and compare to other ways of knowing.

Curricular and pedagogical dimensions. Aaron places a strong emphasis on evolution in the biology majors’ introductory biology course—about a fourth of the class. Then, in every other biology class they take, students will see the pattern that biological patterns and phenomena are explained by evolutionary history. However, in the biology classes for non-majors where the instructors “anticipate there might be a little bit of tension,” the curriculum is more strategically mapped out.

We position a lesson about science, about the science depending on empirical evidence, about falsifiable ideas, and how science differs from other ways of knowing. So we’ll contrast to knowing things by virtue of authority, and there’s kind of a religious message behind that. Religion is largely our authority, and the students realize that. And science doesn’t have much respect for authority. So if
you are going to propose a scientific hypothesis it has to be falsifiable and empirically testable—that sort of thing.

This sequence of lessons tends to “do a really good job of taking the edge off.” These points are reviewed and, by the time evolution comes up in the course, students have an idea that “what’s presented is the best scientific explanation for what life is like on Earth.”

In his senior biology capstone class, Aaron provides the opportunity for his students to take on creationist arguments and teach the class about “that particular line of evidence and put the argument to rest.” This moves the focus from what the professor is merely telling students to having them examine the empirical evidence for themselves. In the end, “the students are going to come down on the evolutionary side in class. When you look at it from a scientific perspective of pure science, the creationist argument will fail every time, and fail miserably.”

Aaron knows that the study of evolution can challenge students’ worldviews and potentially make them anxious. His goal is to put students at ease and create an intellectually safe learning environment. First, he lets students know that they are not alone by telling them, “If you were a standard sample of American population, 45% of you are approaching this with very strong skepticism and you may be uncomfortable.” Aaron praises skepticism, welcomes all questions, and encourages students to challenge him on anything they like. They are invited to bring up any questions or concerns in class or privately after class. He assures them that he will not grade anyone more harshly if they do, and will not demean, humiliate, or “chew out” anyone who does. All students
are welcome, whether they are a “young-Earth creationist or a dyed in the wool evolutionist. It doesn’t matter.” He isn’t out to change minds either, as his “intent is to educate, not to indoctrinate.”

This method “seems to do the trick” and students have responded well to it. Aaron will frequently get comments from creationist students on end-of-year course evaluations praising this approach. They will tell him “how good it is to be able to challenge the instructor and have the instructor open to it, and have good discussions that everybody understood.” Non-creationist students, however, are sometimes taken aback at this strategy:

Usually it’s the students who are not creationists and have never been creationists that are kind of surprised by it. And honestly, some of the biggest creationists that ask a lot of questions, some of the other students will get really tired of that particular student always popping up with a question. At the end of the semester they’ll say, you know, stop coddling these guys. Just give us the science and move on.

Even with the established ground rules for an intellectually safe learning environment, Aaron can still recognize cognitive dissonance among some of his students. In fact, he can usually identify it by the expression on their faces:

I’ve been teaching an introductory class and after a couple of times talking about evolution I could point out the students that are having some problems. Furrowed eyebrow, general body language indicates discomfort. I had one today, in the
hour before you got here. I could tell he is still working with this, he’s still real 
uncomfortable with it.

Aaron credits his fundamentalist upbringing for the ability to recognize students 
experiencing internal strife. “Having grown up that way I understand their way of 
thinking. That gives me a big leg up when talking to them.” Students will occasionally 
take him up on the invitation to meet after class, but Aaron is careful not to dominate the 
conversation or tell them what they should be thinking.

Personally, I had a student that said, “I’m going through some bad cognitive 
dissonance. I don’t understand.” I said come talk to me personally, and when it’s 
one on one you can have a conversation as long as the student initiates 
conversation. You can talk about how do you handle a conflict of faith, this is 
what I believe and this is what you’re teaching, what do you think I’m supposed 
to believe—you can have a very personal conversation about that as long as the 
student initiates it. It’s kinda kept rolling by the student, not by you. So I will 
talk to the student like that. In one case last semester I sent a student an essay I 
wrote about cognitive dissonance and said, “Here’s a way of looking at things that 
might help you out.”

The desire to create an intellectually safe environment in the classroom was not 
always a priority for Aaron, and the reactions from his students were indicative of that. 
For two or three years, at another university, Aaron taught evolution in an aggressive, 
confrontational manner. This is difficult for me to imagine, as Aaron presents himself 
with a calm demeanor in a voice that is soft and soothing. He is extremely articulate and
very intentional with the words he chooses. Nevertheless, it didn’t take him long to realize that an aggressive manner of teaching was ineffective.

It creates an uncomfortable learning environment. Instead of getting students to open up and listen, you have the opposite effect. They shut down. They are not going to listen to what you say. They may memorize some things for the test, but they are not going to ponder it.

Students wouldn’t demonstrate verbal resistance, but instead would withdraw and disengage. Aaron realized that he needed to change things in his practice—be more objective when speaking about the controversy, welcome criticism and encourage skepticism, and allow civil, intelligent conversations. As he began to change his approach and invite challenges, he told students he would “shut it down” if the conversation turned aggressive. However, with his new approach, he has never had to do that.

Aaron has received no formal training regarding the social controversy surrounding evolution and creationism. His way of handling things comes exclusively from personal experience. “You get a question, and you find out the answer, and you know a little bit more. After five or six years of doing that, you’ve seen most of the common questions that will be asked.” However, he has put together training for his department members with the intentions of “getting all of the faculty up to speed on what to expect and how to handle it.” The trainees respond positively, and Aaron makes it a point to check in on them to see if they have had any issues. He has become the unofficial “go-to-guy” for questions about potential challenges or content questions. It is
not uncommon for colleagues to approach him and say, “I got this question or that question and didn’t know how to respond. I said I would answer your question after I talked to Aaron.” Because of this, Aaron would like to publish a booklet that addresses common creationist arguments and market it to textbook companies as a supplement.

In addition to the evolution-creation controversy, Aaron sees the need to provide some training on the nature of science itself. Since the lessons on science as a way of knowing have become such an important part of the biology curriculum, he wants to ensure that other professors are proficient in them. He finds that this is not always the case:

The understanding science lesson, that’s really interesting because...it’s an interesting one because we’ll sit in on our new instructors, and sometimes you’ll want to smack yourself in the head because you’ll realize they don’t understand it well enough to teach it. So we’ve come to the realization that in the summer we are going to need to take our new instructors and give them a few days of instruction about science as a way of knowing because they make some pretty fundamental mistakes sometimes.

Aaron, like all good teachers, is not satisfied with where he or the department currently is. He keeps up on the literature and uses data to inform his practice. Recently he has been using a survey with his students, which determines if evolutionary knowledge correlates with acceptance, and the MATE, which is a measure of assessment for the acceptance of evolution. One thing that he is excited about is that a single biology
course “bumps up both knowledge and acceptance.” He is currently using the same tests with his staff.

Aaron’s passion for the topic and the students he serves will always drive him to improve the science and art of his craft. He continues, like all good teachers, to keep bettering himself for the benefit of his students.

**Brett—Darwin’s Bulldog: A Modern Thomas Huxley**

**Introduction.** Brett has been teaching in the public arena for twenty-four years. Although he has had secondary teaching positions in two other districts for short periods of time, he has been in his current district for twenty years—one year in middle school, the rest in the same high school. In all twenty of those years he has taught the theory of evolution.

Educating young adults was not always in the cards for Brett. Although he had a degree in population biology, of which evolutionary theory is a major component, he held a number of jobs after college. He worked for a construction business and was also a professional musician. Eventually, the band he was in broke up and went their separate ways. Brett was ready for a career change, but did not know what to do next. His bachelor’s degree was ten years old, and he hadn’t been doing anything in the science field since he left school. Help with his decision came from a neighbor.

A neighbor friend of mine, a neighbor of my parents, said, “Hey, you used to help my son and his friends when they were in college and you would sort of be a tutor. Why don’t you think about teaching?” And I thought, “Wow, great idea!”
And I looked very quickly and saw that there was a master’s program in town and
I started with that program and I have been teaching ever since.
That master’s program consisted of coursework and student teaching—all of the
components necessary to get a teaching credential in the state. Brett’s new career had
begun.

Although Brett had a life outside of science ten years, he considers himself a
student of science for the better part of four decades. He credits his interest in science to
his upbringing overseas, where he would explore and collect insects and other things of
natural beauty. While growing up in Asia, he was “surrounded by a lot of diverse
organisms—plants, animals, whatever. Then we would come back to the States and I
would see a huge variety of things.”

Brett’s story has some interesting parallels to the poster child of biological
evolution—Charles Darwin. Darwin was known for his extensive collections of natural
things—especially beetles. He also had trouble deciding what to do for a living—
spending time in medical school and the seminary. One of his professors, a friend of his,
recommended that he apply to be a naturalist on a ship that was getting ready to sail
around the world—primarily to map the South American continent. Darwin went, and
collected thousands of specimens from all over the Earth. It was the vast diversity of
organisms, as well as the striking similarities, that helped him develop his concept of
natural selection and evolutionary theory.

Brett wasn’t exposed to the theory of evolution, or Charles Darwin, until college.
He personally never felt any dissonance with any prior beliefs he held. The theory “made
sense to me right from the beginning. I didn’t have any objections to it, and in fact, I
didn’t even really know there were any objections to evolution until I started teaching it.”

**School and community dimension.** The school district in which Brett teaches
lies in a county renowned for its conservative views on politics and religion. It
encompasses over 100 national and international evangelical Protestant organizations—
many of them prominent on the national stage. Politically, the district is primarily
Republican. In 2004, Bush received 67% of the presidential vote, while McCain received
59% in 2008 (City-data.com, 2012). Four military installations are in the county—one in
the district attendance area.

Antievolution sentiments run high in the district—perhaps due to the large
number of fundamentalist evangelical Christians. It is not uncommon for parents to
complain about the teaching of evolution, despite the topic being one of the state science
standards. At least two former candidates for the district’s school board favored
creationism and intelligent design to be included in the classroom. Additionally, at least
one outside institution made contact with the former superintendent attempting to
pressure him into bringing intelligent design into the biology curriculum.

Brett has had experiences dealing with antievolutionist pressures from both his
students and the staff he has worked with. He experienced this for the first time while
teaching a middle school lesson, entitled “Change Over Time.” While writing notes up
on the board, a student asked if the lesson pertained to evolution. When Brett told him
that it did, the student became irate, exclaiming, “That’s illegal! You are not allowed to
teach that!” At that time, five or six students stormed out of the classroom. Brett
admitted that he really didn’t know what the laws were regarding the teaching of evolution at the time, but he was following the textbook and curriculum that was provided to him by the school. During the next period, Brett knew the word was out. No sooner had he put the words “Change Over Time” on the board that students began yelling, “This is not right! You’re not allowed to teach this! We don’t want to hear it!” Ten more students left class in a huff.

At lunch, Brett was called into principal’s office. When asked, he showed the principal what he was teaching and the chapter it came from. The principal agreed that it looked like he was following the curriculum, but told Brett to “tone it down a bit.” Brett told him, “I don’t know how to tone it down, I mean, I’m just covering this information.” The principal, not really knowing how to respond, left Brett to finish the lesson in his own way. That afternoon, more students protested—though Brett says it was “probably not as vitriolic. I don’t know if kids stormed out, but they objected.”

Thinking the commotion was over for the day, Brett was approached by another teacher who heard about the day’s events. He told Brett about a common student of theirs who was upset about the teaching of evolution. The teacher asked if Brett had ever considered “giving an alternative viewpoint to evolution.” When Brett asked what he was talking about, the teacher replied, “Biblical creation. Did you think about teaching that in your class at the same time? Have you thought of giving equal time to those two things?” At this point, Brett realized what was happening.

Right then and there, this was an epiphany. It was a pivotal moment for me—a paradigm shift. Something in the back of my head just clicked and I thought,
“Wait a minute. I know what’s going on here.” Even though I hadn’t encountered it.

Brett then asked if the teacher truly wanted him to be fair and objective in the matter, and teach creationism alongside of evolution. When the teacher answered affirmatively, Brett asked, “Which creation myth do you want me to teach?” When the teacher replied that there was only one, Brett let him have it. “Oh buddy! I grew up in Asia, and I have Native American friends. I can probably tell you twenty different creations stories. Which one do you want me to teach?” Again, the teacher said he should teach “The One.” Brett then replied, “There isn’t one. But hang on a minute, none of those is science. I’m going to stick to the science. All of those other things are wonderful, but I’m gonna stick to the science.” Brett later found out some background on this particular teacher:

This teacher had a reputation. I found out on his desk he had a giant copy of the Bible. One of these—a foot thick, three feet long, three feet wide, huge—one of those things. This was always in his class he was constantly reading from it. Now, he’s a social studies teacher, or was. Look, in our culture if you’re not Biblically literate, you don’t understand a lot of idioms. And that’s fine, but I think he crossed the line on a regular basis in class. But the fact that he even wanted to challenge me, and I quite frankly think he wanted to intimidate me, and he certainly wanted to see if I was going to toe his line.

This was not the only incident that Brett had with colleagues in that building. Several other teachers, including his department chair “who was an ardent creationist”
made his last few months difficult for him. He decided at that time that not only was he
not going to come back to that particular building, he wanted to teach in high school.

High school, however, was not a refuge from antievolutionist sentiments among
the faculty. One year, Brett discovered that a physical education instructor teaching a
health class was spending “about a month at the beginning of the school debunking
evolution—talking about flood geology, talking about lack of evidence.” Another was
showing the film Expelled in health class—a movie which tries to link the theory of
evolution to racism, communism, eugenics, and other societal ills (Craft, Ruloff, &
Sullivan, 2008). Brett became aware of this when one of his biology students, who was
also in that particular health class, complained about the situation.

The only reason I became aware of it was one of the gals, one of maybe twenty
students, nineteen of them were die hard creationists, but she was constantly
railing against this and being penalized. Her grade was being penalized as a
consequence. But she came to me and said, “Hey, is this appropriate that we are
watching this movie in class?” I said, “Well, first of all, it’s not appropriate in
school because it’s not science, but it’s also being shown in a health class. So not
only is it inappropriate, it doesn’t pertain to the curriculum.”

Brett turned the information over to his principal who agreed with his assessment of the
situation. The principal put an end to the practice, but Brett discloses that “the P.E.
department then had me in their radar, and I have since suffered some of their slings and
arrows of outrageous fortune.”
These incidents led Brett to start reading about and collecting information on the controversy. He has become educated not only on creationist arguments, but on the court cases legalizing the teaching of evolution and outlawing creationism in public schools. He has “an extensive library of creationist books—many of which I’ve read, many of which I can’t finish reading because they’re absurd, but I’m very well versed in their arguments.” He uses this information to rebut the “myriad of letters” he has received from parents and community members over the years—most of them raising objections and asking “if I was aware of alternative viewpoints, that sort of thing.” Brett has developed a very professional and cordial response to these letters which not only outlines evolutionary theory as a cornerstone of biology, but highlights the legal and ethical matters of teaching it. In one instance, an employee of a large, nationally recognized religious organization contacted Brett asking if he was “fully aware of all the scientific arguments against” evolution. Brett responded that he would love to hear them, if they are indeed scientific arguments. “I don’t get any kind of response to that because they know full well there aren’t any.”

Another event also sticks out in Brett’s mind. A former principal, different than the one dealing with the health class incident, came to Brett’s room holding an article that Brett distributed to his Advanced Placement Biology class. The article, published in Scientific American, was entitled “15 Answers to Creationist Nonsense” (Rennie, 2002). The principal told Brett to “stop this immediately” because the article is “biased and inflammatory.” Brett responded, “This is simply rebutting. This is an appropriate use. I am showing this to my students to rebut the non-science.” The principal claimed that it
was pejorative and inflammatory to call it “nonsense.” Unwavering, Brett told his supervisor that he had to disagree and that it was a “freedom of speech issue and this is perfectly appropriate.” The principal left unhappy, but the two agreed to disagree.

Brett expresses worry about other teachers in the district who inform him that they “don’t teach evolution,” “water it down,” or “dodge the issue” altogether. He struggles with these people and asks, “How can you teach biology with any conscience by eliminating what is the most important aspect of it?” He also had a colleague who was teaching intelligent design to his honors biology students and was setting up a debate in class. Originally believing that this was a lesson in exposing the non-scientific arguments of intelligent design, Brett was intrigued. However, when the teacher informed him that she uses Behe’s book *Darwin’s Black Box* as the “guidelines to teach her class,” Brett reported it to his department chair. “Using that as your guideline for teaching biology is unconscionable.”

On occasion, Brett even finds himself in the middle of controversy and debate with people who are not closely affiliated with his classroom. One time, on a field trip, as he was taking a group of high school students around the region to look at the geology and ecology of the area, he noticed a group of people on the trail “waiting for my group to come up to them.” With a couple of adults surrounded by a number of kids, they seemed to be on a field trip of their own. As Brett’s class proceeded to walk by this crowd, “one of the kids would kind of intersperse themselves among my group.” Some of the adults asked Brett what he was doing there, and he responded that he was taking his class on a field trip to learn science. At that moment, the war of words had begun.
When I told them I was a science teacher, they immediately engaged me in evolution, or antievolution questions. And I looked at them both and I said, “Guys, this is your bad day. This is the wrong day.” I said, “You picked the absolute worst person you could to try to challenge.”

Armed with the knowledge he had collected over time, Brett rebutted these counselors for about twenty minutes. But after realizing that other kids were instigating debates with his own students, he told the counselor that they need to “immediately cease and desist.” He explained that he was in charge of these students and “I don’t want parents to question why I was allowing this to happen.”

The students in Brett’s class often have preconceived ideas that interfere with their understanding of evolution. In these cases, he tries “to let science speak for itself.” It is frustrating for Brett to “hear the same inane arguments over and over again” and is astounded by “how these inaccuracies really do circulate even after they’ve been rebutted logically year after year.” However, he does admit that there are students who leave his class convinced that evolution is a fallacy, regardless of his efforts. “I don’t think anybody can get to them. I’m not saying I’m that good, but I’m pretty good at it. And if I can’t do it, it isn’t what they want to do.”

**Intentional dimension.** The theory of evolution is “absolutely and fundamentally critical” to the understanding of biology, according to Brett. He quotes Theodosius Dobzhansky (1964), who was fundamental to the synthesis of evolution and genetics, who claimed that “nothing in biology makes sense except in light of evolution” (p. 449).
You can’t understand the age of the earth or how organisms have changed over time without understanding evolution. It is the cornerstone of biology.

Absolutely. I mean, there’s no facet of biology that cannot or does not have some evolutionary context, and I do stress that throughout the year. I tell my students you can’t understand biology fully without understanding the mechanisms of evolution.

Brett makes it a point to mention evolution all year long, so that by the time they get to the unit dedicated to the theory, they are familiar with it. “I don’t want to use the word ‘desensitizes’ them, but it makes them more comfortable with the term.”

If Brett had his druthers, students would enter his classroom knowing “how science operates and science’s limitations—understand that it is empirically based, that the reason experiments are conducted is to confirm and verify questions that we have.” He would also prefer that students were more clear about the terminology used in science as compared to everyday language—words like “theory,” “fact,” and “truth.” This point is expanded upon when asked what he hopes students leave his class with—either in terms of evolution or science in general.

One, the fact of evolution—the fact that organisms...you know, there’s the fact of evolution that organisms have changed over time. That’s something I want them to understand. And number two, I want them to understand the theory of evolution—the “how did that fact come about?” Look, the fact of evolution, in my opinion, is incontrovertible. It simply is. How that came about is the theory
of evolution and that’s where we as biologists, geologists, whatever, use that framework to explain the fact of evolution.

Brett believes that if he can get students to understand the fact of evolution, then it leaves them “curious to figure out the how, and the when, and the where, and to some extent the why.”

**Curricular and pedagogical dimensions.** The first class period during the unit of evolution, Brett makes a startling confession to his students. “I want you to understand that I don’t believe in evolution.” Many students, especially the ones that have heard rumors about him, are flabbergasted. “What do you mean you don’t believe in evolution? I thought you were a science teacher?” they respond with confused looks. Brett continues:

I don’t believe in evolution any more than I believe in gravity. Look, a belief in gravity isn’t going to protect me if I walk off a building. I’m gonna fall. I’m gonna break my legs. It’s not a function of belief. It’s a function of do I understand the mechanism? Do I accept it based on the empirical evidence?

This opens the door to another lesson on semantics—“belief” versus “acceptance.” It also brings students back to the beginning unit of the year, a unit on the nature of scientific processes, the scientific method, to show them the empirical process, how science differs from other ways of knowing, and how we use the methodologies and the process.
He engages students in a discussion about the difference between accepting something based on evidence and believing something based upon faith. Admittedly, he is very intentional with the language he uses.

I’m very careful because our kids come from a myriad of backgrounds, and I don’t want to offend any kid. I don’t want to offend any of their belief systems—and I don’t. The role of science is science, so I make it very clear that what they believe is perfectly valid. And that’s their right, and that’s what they should do, but I try to clearly separate the two, and tell them that there are plenty of scientists who are religious, spiritual, whatever, that have no problem accepting evolution based upon the evidence.

This discussion makes students “feel pretty good about that. They don’t have a problem with it.” Although he invites students to bring up questions they have, he is adamant that “evolution is not a debate. I will not debate with my students.” However, if students continue to bring up creationist arguments which take too much time away from his lesson plan, he will invite them to speak to him after class. He assesses whether they feel intellectually safe in class by the number of questions that are asked in the spirit of true curiosity. “The fact that I get so many questions, I think that’s affirmation. If you shut kids down, if you’re demeaning, you won’t get those kinds of questions.”

Weaving evolutionary theory throughout the units over the course of the year, combined with revisiting the nature of science, seems to head off a lot of contentious interactions. He does it not only to ease into the three to four week unit on evolution, but demonstrate that “biological evolution fits all of the parameters of the scientific process.”
Brett claims it mollifies most of his students. With others, he has to show more empirical evidence, give students copies of recent scientific articles, do more interactive labs, and emphasize the distinction between religious and scientific thinking. Every one of the students “pretty much gets that.” All of this he does without being “condescending, pejorative, or demeaning” to the students—or risk losing them. “You have to present the science with compassion and be dispassionate at the same time. You just have to present it as is, but not be a thumper.” Rarer are the students who truly do understand the creationist arguments but are so “vehemently opposed to evolution and have been so indoctrinated” that they “don’t see the logic of the science end.” Those students, although Brett says he can count them on one hand, have asked to leave his class for another teacher’s.

Brett closely monitors his students’ writing and answers to his questions for pre-existing dogma that may lead to cognitive dissonance. When students come to him for help with their discord, he ensures them that “I’m not here to tell you what to think,” but “how to think.” If they don’t get it in class, he will “try to show them that there are tangentially different ways of viewing the world.” But the key is to let them come to their own conclusions.

The thing I would stress, and I learned this because I’ve made mistakes, just, if you tell kids they’re wrong, you won’t win. You never will. You show them the evidence, you give them the bodies of knowledge, you show them why it’s important. I use enthusiasm because I’m passionate about it, and then you let them make up their own minds.
Brett’s approach to teaching evolution has changed over the years. He used to wait until the formal unit to bring up evolution, but realized “it sort of takes them by surprise, and appear more confrontational than it would otherwise.” By weaving evolutionary terminology and concepts throughout units of study and referring back to the nature of science, “it isn’t any big deal when we finally get to the unit itself.” Brett believes he is improving each year he teaches, and each year’s experience only makes him more confident of that. “Like a good wine, I get better with time—unless it’s a white wine, then you don’t.”

With regard to formal training in the evolution-creation controversy, Brett has received none. He credits the books and articles he has picked up over his career with helping him to become a better teacher, and how to rebut challenges in class. However, he is very clear that they are not all useful, and some are merely filled with “pedantic ranting.” He has also attended workshops arranged by curriculum developers as well as nearby universities.

Thomas Henry Huxley was widely known around England as “Darwin’s Bulldog” for his public advocacy of the theory of evolution. His debates against antievolutionists, such as Samuel Wilberforce and Richard Owen, became legendary. He probably did more than anyone else to advance public knowledge and acceptance of the evolution after Darwin’s book was published. Brett, like Huxley, is an avid defender of Darwin’s theory. His unwavering commitment to the theory in the face of adversity is a hallmark of who he has become as a teacher.
Paul—Avoidance to Advocate

**Introduction.** Paul’s teaching career, at least up until now, can be divided into three phases—each one significantly contributing to how he teaches evolutionary theory. Phase I, spanning eight years, was spent in the Pacific Northwest. He taught biology, chemistry, and physical science at a public high school. During this time he also earned a master’s degree in curriculum and instruction with a focus on science education. He then left for the Midwest to pursue a Ph.D. in ecology and environmental science—Phase II of his career. Over this five year period, Paul worked as a research assistant, teaching fellow, and teaching assistant at the university he attended. In Phase III, also spanning eight years, Paul moved back west to teach biology and other sciences in a public high school as well as at a local university. He also worked as a chapter writer and science content reviewer for a publishing company for a year.

His first exposure to evolution “definitely wasn’t in high school.” He remembers that his biology teacher was a forest ecologist, so they spent a lot of time collecting insects and leaves. Although he received his bachelor’s degree in biology and chemistry, Paul admits, “If I was exposed to it (evolution), I didn’t retain any of it.” In fact, his earliest memory of evolution was when he had to teach it for the first time. He remembers “that it was a subject that was to be taken very carefully in the teaching of it.” At that time, his own knowledge of evolution came by “the chapter in the textbook that I used.”

Going to church regularly and participating actively in the youth group did not lead to any cognitive dissonance for Paul.
I never really got into the biblical stories as fact or as things that actually happened. I think early on I understood them as stories and parables. Religion was never pushed really hard in my household. We went to church because it was a social gathering and I think my parents thought it was important that I had that aspect of growing up in the Midwest. Most everybody went to church.

By the time that he was learning about evolution, he had become much more intellectual about religion and spirituality. Paul came by his understanding of the theory gradually, and it “all seemed to make perfect, reasonable, scientific sense to me.” There was no personal conflict, and he never felt like he had to reject any prior belief systems. Additionally, “the church I went to was full of college professors, so there were always very intellectual conversations about things.”

Evolution was not a strong part of the curriculum during Phase I of Paul’s teaching career. Paul was in a “pretty conservative school,” and had “heard lots of stories about the teaching of evolution in schools and how you get all this backlash from the community.” However, he did attempt it near the end of the year. He told the students, “I have to teach this. It’s part of the curriculum, so that’s what we are going to start tomorrow.” With that announcement, some students brought in some creationist pamphlets from their church. They would say, “Here’s this pamphlet. What do you say about that?” One argument that Paul remembers from this literature detailed how horses were designed by God to carry things for humans. “I had no response to that because I didn’t know the horse evolutionary history. And that was a really scary experience for me because there went my credibility as a science teacher.”
Paul was confident enough to teach some areas of the curriculum, such as how a cell worked, but he “certainly didn’t know enough about how science worked to be able to respond effectively to the students.” From then on, Paul admits he doesn’t remember teaching evolution. He would leave the topic until the end of the year, as a lot of teachers do, “and then you conveniently run out of time.” Paul refers to a study by Berkman and Plutzer (2010) which claims that 60% of American teachers are teaching evolution poorly or are avoiding it altogether. “I was one of the ‘cautious 60.’ Because of the experience I had in my first attempt to teach evolution, that really set me back and really made me uncomfortable.”

That discomfort began to ease for Paul during Phase II. After the third year of his doctoral program, one of his committee members looked at his coursework plan. Paul had taken a lot of “ologies”—mammology, ichthyology, and others—but hadn’t taken any evolution courses. On the advice from his instructor, he enrolled in one and the textbook “became my bible for a while.” This course helped him greatly regarding the content of the theory, but Paul’s real understanding of evolution and the social controversy surrounding it came during Phase III.

While Paul was teaching at the university after he moved west, a professor at another school invited him to co-write a book regarding evolution and creationism. Researching and writing the book helped Paul tie evolutionary theory and the way science works together. This immensely impacted how he taught biology to high school students during the third phase of his career.
In addition to his book, Paul has written two other book chapters, nine published articles, several posters, and numerous talks and presentations—including an interview on National Public Radio. He has written curriculum for a number of schools and organizations, has been awarded numerous grants, and has won several teaching awards. He has recently been nominated for the National Association of Biology Teachers Evolution Education Award.

**School and community dimension.** The town in which Paul teaches is well known to be one of the most left-leaning towns in the state. In 2004, 66% of voters in the presidential election tried to elect Kerry, while 73% voted for Obama in 2008 (City-data.com, 2012). According to Paul, the district is a “community where there is a lot of liberal thought”—much different than the school he taught in while in the Pacific Northwest region. Students do not challenge him in class as much as they did during his Phase I teaching. Nevertheless, “there are some fundamentalist kids and some of them are pretty vocal.” One night, at an open house at his school, a parent approached Paul to ask if he taught other explanations for how life came about, such as “creationism.” When he responded that he will only teach science, the parent said, “Well, there are lots of holes in evolutionary theory. Do you teach about all of those gaps and holes and things?”

Paul has also had a dispute with a chemistry teacher in his building regarding the teaching of evolution—or more precisely, that he cannot mention religion in class. Paul reminded her that he can talk about religion in general, which he does “to emphasize things and illustrate points and compare things.” But Paul also pointed out that
“chemistry is a subject that you can easily teach and be absolutely, fundamentally creationist. And you can get away with it.”

The biggest misconception that students have regarding evolution is “that it’s optional.” Paul spoke about where this misunderstanding originates after attending a church program for a relative.

Without God we still could have love, forgiveness, helping each other—but the way these kids are being trained to think about these things, they were all products of God. So at an early age in a lot of churches we really push this idea that God is required, God is essential for living in the world. So students are led to believe that these are black and white issues. If I’m going to accept evolution, I have to reject my belief system.

This idea trains children to think that they can pick and choose what scientific facts they can accept and they can reject others. “If you don’t believe, what you’re saying is you reject it, so that means you are rejecting all science because it’s based on the same scientific practices.” This is common fallacy that Paul and his co-author address in their book.

**Intentional dimension.** Paul believes that it is “absolutely critical” for students to understand the theory of evolution. After graduate school, it began to “make sense to me that everything in biology makes sense because of evolutionary theory. Biology is naked without it.” He expresses the importance to his high school students “every day. Every day there are evolutionary concepts and explanations.”
It would be ideal for Paul if students entered his class with an understanding of how science works, but “they really fail in that.” Additionally, he would like them to enter biology with “kind of a zoo education. They’ve been to the zoo, they understand diversity, they see all of the differences. That gives us something to work from—variation.” He wants students to be inquirers and ask the “why” questions that will lead to greater understanding of biology.

Upon leaving his class, Paul wants students to have “a solid understanding of how science works—and that they can’t pick and choose what scientific knowledge fits.” This would be very risky behavior. Without this understanding, Paul fears that students will begin to “believe Kirk Cameron, Jenny McCarthy, and just these loonies out there that are extremely influential.” Cameron, of 1980’s sitcom fame, became a Christian evangelist and founded a ministry with antievolutionist minister Ray Comfort. In 2009, Cameron went to several universities and distributed altered versions of Charles Darwin’s *Origin of Species* which had missing chapters, infused creationist arguments, and Darwin’s introduction replaced by one written by Comfort (Gilgoff, 2009). McCarthy has launched a public campaign to proclaim that child vaccines cause autism—a claim dismissed by medical researchers over thirteen years ago (Stehr-Green, Tull, Stellfeld, Mortenson, & Simpson, 2003). Paul fears that blind acceptance of junk science or pseudoscientific ideas, merely because they are promoted by popular culture figures, will only hurt students’ understanding of the nature of science.

**Curricular and pedagogical dimension.** All of Paul’s biology classes begin the year with evolutionary theory, and “kind of wrap everything up with evolutionary
theory.” He wants students to have a good foundation at the beginning so that “as we go through cell biology and plant biology and physiology, they can see the evolutionary explanations.” He continuously links different areas of content back to evolutionary relationships and connections. He stresses the two types of questions that biology asks: the how question—which requires a mechanistic answer—and the why questions—which have evolutionary answers. “There is constantly an evolutionary moment in the classroom.”

The first day of class is spent talking about the characteristics of life—one of which is “permanent biological change through time.” In regards to evolutionary theory, Paul’s students “hit it right from the gun” without any preparation or warning. They then spend a couple of weeks discussing how science works, the boundaries science has, the rules science follows, and what a testable hypothesis is. He prepares his students to learn about evolution by “hammering how science works.” Paul’s hope is that students will understand what science is which will lead them to see that evolutionary theory is one of the areas of science.

Paul does a lot of the traditional labs and activities with his students—changes in allele frequency, predator-prey games, and cytochrome C analyses. However, he also has students analyze real scientific data to organize evolutionary relationships into cladograms. With these, he will “emphasize that evolutionary relationships are hypotheses themselves, and stress that these are ideas that we constantly test with new data.” Having students review the same evidence that scientists do, and come to the same conclusions, can be a powerful strategy.
According to Paul, some of the things he does in class “may be a bit questionable, but they are merely an attempt to hook students into thinking differently about something.”

For example, I start second semester reading from Genesis. I read parts of the story of Noah, and the students are kind of confused. They wonder if I’d had some kind of paradigm shift over Christmas break. And I get to the end and I say, “So, what’s missing from this story? If we were to take this as the literal truth, this story, then what is the problem? What’s missing from it?” And one or two kids from the class will raise their hand and ask, “Where are the plants?” So I say, “Exactly! Where are the plants? We forget about plants.” And that begins our plant unit because when we think about living things, we tend to forget about the plants. And the plants were here first. So, that may make some students feel uncomfortable, I don’t know. It gets a good smile out of most of them, and they have a good time with it. But I’m not disrespectful, I’m merely saying here is a very well-known story that has some missing parts to it. If we are to take it literally, we have some pretty serious scientific problems.

Although Paul believes he is always respectful to the students, he admits that he doesn’t know if his classroom is an intellectually safe learning environment. He understands the need for it to be safe, but he is open to the possibility that he may “approach the teaching of biology in a way that is intimidating to students.” His hope is that students of all worldviews “can think about their belief system and they can learn about how science works” without being daunted. He wants students to understand that
what he is presenting is scientific fact, and it shouldn’t force students to have to make a choice. However, he does express to his students that:

we all have things we believe in and that we want to be true and that we hope for, but they can’t contradict science. When a belief, religious or other, is in direct conflict with known scientific fact, the belief must be reconsidered. Otherwise, you’re setting yourself up for failure in the natural world.

When students do display cognitive dissonance, Paul is happy to engage in conversation about it. Some students do not outwardly say that they are having issues with the class, but will tell about family members’ objections. One student told Paul, “I’m really struggling with my grandpa because I talk about things we learn in class and it just makes him mad.” Paul realizes that this might be a reflection of the student’s dissonance instead. If students do not engage in personal conversations with Paul, he is quick to point out classes where they have philosophical conversations about religion, such as the Theory of Knowledge course in the International Baccalaureate curriculum.

The antievolutionist pressures that Paul experienced early in his career greatly influenced his practice. It made him “more forceful” in his teaching of it, and stirred up the desire to understand evolutionary theory more. Those teachers that aren’t confident about their knowledge are the ones that are frequently challenged by students. Clever students can sense when an instructor is merely teaching a topic at a surface level, and will “speak out when they see an opening.” When Paul didn’t understand it, he was “pathetic at teaching it, and even avoided it.”
 Keeping up with evolutionary knowledge isn’t easy because new information is being discovered regularly. “If I just taught from the textbook in my senior class, I’d be missing the last four years of amazing discoveries in evolutionary biology....They’d be missing all this.” Because of Paul’s new appreciation and understanding of evolutionary theory, “it’s gone from being completely neglected to showing up every day in my curriculum.”

Paul has not received any formal training regarding the evolution-creationism controversy. He credits the information gathered while researching his book, and is now asked to speak and participate in workshops on a regular basis. Training, however, would make a great deal of sense. “Where we fail in teacher education is in making sure that before teachers step into the classroom, they know how science works, they know what the limits of science are, the boundaries, and evidence based factors.”

Lindsay—From Writer to Practitioner

Introduction. Lindsay has spent the better part of twenty-four years in education, though she only spent nine of those years as science teacher in a public high school. After getting her bachelor’s degree in molecular, cellular, and developmental biology, she worked as in a medical school in the oncology department as research assistant. After a few years, she moved to the West Coast and became a laboratory manager and research scientist in the bioengineering department of a large university. While there, Lindsay became acquainted with a professor who was very much engaged in educational outreach. She enjoyed this aspect of her position, and began writing inquiry-based curriculum for both high school students and K-12 teachers. Finding that she “loved the
outreach program,” she decided to get her master’s degree in curriculum and instruction, focusing on science education. While working toward that degree, Lindsay worked as an education program coordinator at the university as well as a program manager and teaching scientist for a cancer research center. Eventually, Lindsay left the coast and got a job developing curriculum for a nonprofit educational organization. She found that she “loved being in the classroom going around the country working with teachers and students, so I decided I wanted to get experience with that.” She secured her teaching license and was hired in a public high school teaching Advanced Placement biology, general biology, honors biology, genetics, and physical science. While there she was awarded a number of education grants and was nominated for the district’s Apple Teacher Award. However, after nine years Lindsay became “very frustrated with the decisions being made” in the district, and began to feel that the “state of the district was very poor.” She decided to join an educational research company as a lead consultant. In this position, Lindsay is responsible for “curriculum development, teaching teachers, doing some research, writing grants, all kinds of different things trying to find my niche right now.” At the time of this writing, Lindsay has fourteen published articles and a few presentations to her credit.

As a biological sciences major, Lindsay was exposed to evolution during many courses. She remembers the first time she was exposed to the social controversy aspect. I majored in molecular cellular developmental biology and I had a friend who questioned me about believing in God because I’m Catholic. She said, “How can you major in biology and believe in God?” And that question had never been
posed to me in the past. I said, “What do you mean? I don’t understand the question.” She brought up evolution, and she didn’t think I could study biology while believing in God, because evolution is a big component of biology. So that was the first time I heard about any type of discrepancy.

She learned more about the controversy while working for the nonprofit organization. The inquiry approach curriculum and professional development that she worked on had a big component of evolution to it. They taught her “how (that organization) perceived evolution” and she began to write lessons and activities around it. It was these lessons that Lindsay used in her high school classes.

**School and community dimension.** The school district in which Lindsay taught is the third largest school district in the state. It is well known to be solid, Republican territory (Rosen, 2009) with 66.5% of presidential election voters supporting Bush in 2004 and 58.3% supporting McCain in 2008 (City-data.com, 2012). The district is home to four evangelical “megachurches” as deemed by the Hartford Institute for Religion Research (2011). The school district made news when, in June of 2011, the newly elected conservative school board unanimously approved a “Choice Scholarship Program” which would support religious schools with public dollars. They are currently being sued by Americans United, the American Civil Liberties Union, and other human rights organizations. Many people feel the vouchers would be a violation of the Church and State Amendment. One person involved in the lawsuit claims, “It’s poor public policy to say we’re going to give public money to a school that teaches that the earth is only 6,000 years old. That’s not in the public interest” (Boston, 2011, para. 12). Still
another attorney involved in the case claims, “The voucher program will take millions of taxpayer dollars – intended to educate public school students – and spend it on private schools, including schools that teach creationism and exclude students with different religious beliefs” (Boston, 2011, para. 35).

Lindsay’s first year of teaching “opened her eyes.” She personally never felt that religion and science were a dichotomy. “It was never mutually exclusive to me, that you have to choose one or the other.” However, her students and others in the community didn’t always feel the same way. She “started getting questions about dissonance and misunderstanding.” When teaching evolution in class her first year, one student tried to undermine her teaching.

He started questioning me, not in front of me, but underneath, kind of in his own little, small group. He would go from small group to small group. And then he emailed the entire staff that taught science and talked to them about how evolution was wrong.

When Lindsay was offered $500 to debate evolution with a local creationist pastor, she realized that this may not be an isolated sentiment. This offer was made by one of her students who was instructed by the pastor to challenge her in front of the class. She didn’t accept the challenge, however, “because I explained to my class it’s not a debate—it’s not one or the other.” Lindsay also discovered that antievolutionist sentiments were widespread in the community by reading letters to the editor of the local paper which proclaimed the validity of creationism and intelligent design and demonized evolution. Letters such as these “probably informed me a little bit more about where they
were coming from, and what kind of environment they come from at home and what their parents are telling them.”

The antiquity of the Earth seemed to be a particular concept that Lindsay’s students repudiated. Students would search the internet to find anything that disproved the scientific age of the Earth or gaps in the fossil record.

I think the span of time is huge for kids. They don’t understand that what we are talking about is over billions of years. But then you can bring in bacteria resistance now, and how that’s more quickly. But I think that getting at the really huge span of time that evolution occurs over...trying to get them that concept of time. That’s a preconceived notion that they don’t understand that it doesn’t go from an amoeba to a human.

Some of Lindsay’s students did not object as overtly as others. They would inform her that they would study the topic, but refused to believe in it.

These types of incidents were not limited to her own classroom. Lindsay remembers an episode involving a long-term substitute in her building.

He was teaching evolution and he had a student who disagreed so much that she took it to the administration. And the administration told him to excuse her and another person from the teaching. I didn’t like that. I thought that the administration excusing them was wrong.

Lindsay didn’t receive much help from other teachers in her department. Two of her colleagues, who also taught biology, “were very strongly involved in their churches, and I don’t think their churches believed in evolution.” Lindsay respected these
gentlemen greatly, and she assumed that they taught evolution since it was in the curriculum. However, they were of little help to her regarding the controversy. “We never talked about it, but I know if it was brought up in the lunchroom, the subject would change.”

**Intentional dimension.** Evolutionary theory, according to Lindsay, “encompasses everything in science. I think it basically underlies all of biology.” She refers to the relevance and fecundity of the theory when discussing antibiotic resistance and the evolution of viruses. She didn’t come right out and declare that “this is the most important thing that you’ll learn about,” but she did tie all of the big ideas in biology back to the theory.

In an ideal world, students would have entered her class really understanding how to ask questions and try to be inquirers in the nature of science.

I wish they were really solid in that—where they could really pursue questions that they have and be able to provide answers for themselves based on evidence that they either collect themselves or that they read, or that they can synthesize based on real research that’s out there so they can actually create their own understanding and not rely on teachers to give them answers.

She wanted the same things for students when they left her class, but stresses scientific literacy. She wanted to teach students how to look at data and evidence so they “don’t believe everything they see and read.” She wanted students to approach the subject with confidence and “not a fear of science or intimidation of science.” Lindsay made it a personal goal of hers to change the mind of students who enter her class saying “I’m not
very good at science,” or “I hate science.” These were frequent exclamations that she encountered at the beginning of her classes.

**Curricular and pedagogical dimensions.** Although evolution used to be the topic of a unit in and of itself, Lindsay eventually reworked her curriculum so that it was a thread throughout her units. Her time spent on the topic is difficult to quantify, since she kept bringing the topic up, but the unit itself had varied between three to four weeks up to two months. The unit originally was taught at the beginning of the year, but “because of the issues that were brought forward,” she later began the year with a unit on the nature of science. This unit was entitled CONPiTT, standing for six criteria of science—consistent, observable, natural, predictable, testable, and tentative. The lesson was intended to help students distinguish between scientific and non-scientific statements by checking to see if they stand up to the CONPiTT criteria. Lindsay would have students examine a number of scientific concepts, such as the circulatory system, as well as some non-scientific ones, such as magic carpets or love. When students became familiar with how to use the checklist, Lindsay would have them evaluate the theory of evolution. She would then describe the difference between belief and evidence.

Then I’d say, “How many of you believe in angels?” and I’d raise my hand. I’d have probably three-fourths of the class raise their hand. And I said, “You know, there are a lot of us that believe in angels, but does it adhere to CONPiTT? No. Is it a belief that you have? It doesn’t mean that it’s not right. There is a lot of belief out there, but that’s not what we will study in science.” And then I’d take off on evolution.
This strategy helped Lindsay ease any tension that she anticipated. She did several things to provide an intellectually safe environment in her classroom. She would let students know that she believed all students can learn and gave them opportunities to do so. She would never disregard them. She would do all she could to provide the environment where students felt safe and comfortable enough to talk, but would still manage and control the classroom. However, the other strategy she used is not readily taught in teacher preparation courses or pedagogical texts.

I think this sounds kind of funny, but I think the thing that I did the most was I was nice. I was nice to kids and I respected them. And I think that that mutual respect was huge. If I was having an issue with a kid I would have a private conversation with them and try to find out what was going on.

Lindsay believes “having a relationship with students huge” when it comes to helping students deal with their own cognitive dissonance. Being open to communication, in addition to setting up a safe environment, is important so that students “are able to discuss their questions instead of just bearing it.” Admittedly, that teacher-student relationship is what Lindsay misses most about being a classroom teacher. Once she changed her approach to teaching evolution, she claims she has never had a relationship with a student “go south. I’ve never had one disrupt a relationship.” Lindsay feels that being open to discussing something that is potentially “a scary thing for them to talk about” without judging or telling students that what they believe is wrong “really builds the relationship.”
With a good basis for communication and discussion established in her class, Lindsay could really spell out the evidence for evolution. She did a number of activities outlining the supporting evidence of fossils, evolutionary trees, epigenetics, and cladistics. If she were back in the classroom today, she would really “weight the lines of evidence” of evolutionary theory, as well as spend more time on genetics—a topic that helps students rid evolution of its stigma.

Lindsay tells of a story of a girl who, on the creation-evolution spectrum, “was all the way over here to creationism.” After reviewing the lines of evidence for evolution and learning about inheritance and variability, she had an epiphany.

She kept asking questions and we talked through it and talked through it and the last minute she said, “This is just genetics!” And I’m like, “Exactly! Bingo!” And it was like this big “aha” for her. So she had this dissonance, but then she started seeing the science part of it. When she identified it as being about genetics, it was the coolest thing for me. I’ll never forget it. It was huge for me my second year of teaching, that that happened—to see her kind of open up to other ideas based on evidence.

The realization that “being much more aware and open-minded to what students are coming in with” has greatly influenced Lindsay’s teaching practice. She has grown not only in her understanding of the theory of evolution itself, but “how to work with kids—in creating an environment where they can look at it more objectively.” Although she did write curriculum regarding evolution for educational companies, she has had no formal training regarding the social controversy. She has attended conferences at
universities in the state as well as those organized by curriculum developers, but never any that were offered in her district or school. For Lindsay, the real education came from delivering the curriculum that she had spent years writing to her actual students.

**Tina—A Tale of Two Cities**

**Introduction.** Tina has been a teacher of evolutionary theory for eleven years. However, teaching was not intended to be a long term profession. Admittedly, Tina “just kind of backwards fell into it.” While looking into graduate schools, she found a master’s program in secondary education. She loved what she saw and got a job teaching biology and anatomy and physiology in a small town in the southeastern part of the country. She taught in this part of the “Bible Belt” for five years. Despite her lack of experience, she also served as the science department chair.

After five years, Tina moved west and found a job where she teaches both general and Advanced Placement biology, anatomy and physiology, and animal behavior. She has also worked as a teacher researcher in the ecology and evolutionary biology department of a large university, as well as serving on her school district’s science curriculum committee. She continues to build science programs at her school.

Tina is unusual in that she remembers her first exposure to evolutionary theory in ninth grade. For her, the theory “just made sense right away.” Even though raised in a Catholic home, she had little personal cognitive dissonance between what the theory taught and her own religious beliefs. She remembers becoming interested in the theory in high school, reading more about it on her own, and discussing it with friends. Her
internal struggle with it lasted “for about maybe five seconds. It just made so much sense to me.”

**School and community dimension.** The first five years of Tina’s teaching career left an impact on how she would teach evolution. Like many states in the South, creationist sentiments ran deep in the small community in which she taught. The state is home to TASC—the Triangle Association for the Science of Creationism, as well as fifty churches reaching megachurch status (Hartford Institute for Religion Research, 2011). In 2008, the state school board made national news when it proposed to teach creationism alongside evolution (Ribeiro, 2008), and again in April of 2012 when a teacher was told not to teach creationism in his classroom (Hui & Goldsmith, 2012). Although these incidents occurred after Tina had already left, she was well aware of antievolutionist sentiments in the community. As soon as she would mention the name Darwin, students would respond by saying, “Oh, this is evolution. Well, we don’t believe in that.” Students would bring in videos and literature from their churches with the disclaimer, “My preacher told me to give this to you.” Parents would confront her at conferences with similar arguments that she heard in class. Finally, Tina knew that she must do something about it.

It would just turn into this fight. I kept getting sucked into these fights and I was like, “What’s going on, I can’t do this, this isn’t working.” So I had to figure out how to not get drawn into a battle because you can’t win. I did a lot of reading and I really learned that they are either going to think that you don’t understand,
that you’re miseducated, or they are going to hate you. I learned that the most
important thing is to not get in a situation where you can be in a battle at all.

When Tina moved west, she was hired in a school district that was not free from
the evolution-creationism controversy. One former teacher in the district has published a
couple books regarding intelligent design and debunking Darwinism and allegedly
published a church newsletter discussing how he would lead students to antievolutionist
essays he wrote (Myers, 2007). However, students’ misperceptions about evolution in
this district are not as grounded in religion, but more in terms of evolutionary processes
and mechanisms. For example, they struggle with such concepts as vestigial structures
and “they tend to go very Lamarckian at first.” When questions about religion and
evolution come up, Tina feels that she knows how to deal with them. Her prior
experience made her “have to figure out a way to do it better, which is how I came up
with the strategies that I use now.”

**Intentional dimension.** Evolutionary theory, to Tina, is “the core theme of all
biology.” She questions whether students can understand biology well without
understanding the theory. Although she typically spends three to four weeks on the
evolution unit itself, she intertwines the concept throughout her curriculum.

It’s woven into everything I’m teaching from the beginning of the school year all
the way through. We are constantly discussing it. I think the big question, with
anything in biology, is “How did that happen?” Evolution is really the answer to
that.
Tina believes students would benefit greatly from a knowledge of what science is in general—especially knowledge of what a scientific theory is. She finds that students tend to use a layman’s definition of a theory, such as a hunch or guess, when dealing with evolution. They claim that cell theory is “not just a theory” because they personally feel more certain about it—perhaps because it relies less on historical data and is perceived as more tangible. Tina finds that students “always resort to what they learned in elementary school.” Despite what science instructors are teaching about laws and theories, “when in doubt, they go back to that elementary school thing. It’s what they fall back to every time.”

After students leave her class, Tina has similar hopes for them. She wants students to really understand that science is the testing and operation of the natural world. “I think if they get that, they can go into any science.”

**Curricular and pedagogical dimensions.** Even with the importance of evolution continuously stressed in her curriculum, Tina believes her “most important lesson of the year” deals with a real-life murder case. After teaching her unit on genetics, she presents a scenario based on Lacey Peterson—a pregnant woman who went missing on Christmas Eve in 2002. Tina provides the extenuating circumstances of Peterson’s disappearance and asks students to explain the evidence at the crime scene, who the perpetrator was, and a possible motive. Students’ explanations turn into a discussion of evidence that can be used in a court case. From there, Tina throws more monkey wrenches into the scenario. For example, she asks, “What if there is evidence that the suspect was somewhere else at the time of the murder?” Students then revise their
explanations. This process is repeated until Tina believes “everyone’s feeling topped out.” She will then ask why no students came up with an explanation that pointed to the work of a ghost or an alien from outer space.

And they eventually figure out that there’s no evidence. So then we discuss, “What do we mean by scientific evidence?” They get to this whole idea that it’s something in nature that you can see or feel or touch or test somehow. We really talk about that difference between a natural phenomenon and a supernatural phenomenon. The purpose of being in any science class is to discuss natural phenomena that can be tested. And we really just lay that out and we get into the difference between a theory, a law, a hypothesis, a concept, an idea, and a fact in terms of scientific facts. We discuss how facts are tentative. I tell them that it used to be a fact that the Earth was flat—a scientific fact. Why is that not a fact anymore? Then they realize that when we get better technology we can discover more things and observe better. So truly that’s how I do it. After that day evolution is actually pretty easy.

This activity has been very helpful when religion is brought up in class during the evolution unit. Tina finds that when students do bring up special creation or an intelligent designer, other students will say, “Hey, that’s supernatural, so that’s why it’s not science.” She will rarely have to discuss the issue further. If students are “still stuck” on the religious implications of the theory, she will engage students in a discussion about religious versus scientific ways of knowing. Tina emphasizes that what she is teaching is
agreed upon by the scientific community, but what students “religiously believe is totally fine. It’s a valid way of knowing—it’s just not science.”

In order to create a safe learning environment conducive to discussions and risk-taking, Tina will have her classes form “connection circles.” These are done every couple of weeks for the last ten to fifteen minutes of class. Students sit in a large, continuous circle where each student can make eye contact with everyone else. Tina will pose several questions, and every student must answer. If they choose to pass on answering one of them, they must answer another. Tina lets them know that there is no right or wrong answer, and there is no “cross-talking” while some else is speaking. It is an exercise in active listening and getting to know each other to build community. At the beginning of the school year, students will answer more questions about themselves—what their favorite band is, favorite color, what they did last weekend. When students become use to the format and begin to get comfortable, more thought-provoking questions will be asked: “Where do you think the line is in being human versus being an ape? Where is that line? Is it culture? What’s the difference?” Tina believes the strategy is a good one.

Kids in the classroom in a big group normally won’t talk, but because they know they’re gonna, they really talk and you get a bunch of different viewpoints. I think you have to make everybody connected to each other, and get everyone comfortable with each other, and feel free to talk and speak their mind. It creates community where they know each other a little bit. It takes away bickering, it creates a safer classroom. I just believe it. It doesn’t take very long. It’s
amazingly fast, but effective. I just believe that you are less likely to harm someone else that you know.

These circles allow Tina to learn a lot about her students. In the Southeast, Tina struggled to see why students didn’t understand the logic behind evolution and be as accepting of it as she was. Admittedly, it took her a “long time to learn that patience.” Strategies like the community circle allow her “to get in their shoes and figure out where they were coming from and what they were hearing growing up.” This knowledge better prepares Tina to help students deal with their own cognitive dissonance. She can explain things using their terms and meet them where they are when “they’re trying to explain what they are thinking to you. Sometimes they are so way out in left field that it’s hard to get where they are so that you can bring them back on the fly.” Tina finds that the relationship between her and her students gets stronger during this process.

A lot of them will say to you, “Oh! It’s not what I thought it was.” And when they found out it’s not what they thought it was, not this big, bad, evil—then it’s like relief for them. And that makes our relationship better as teacher-student. I love that when they have that moment of “Oh! That’s it? That’s all there is?”

Tina’s current approach to teaching of evolution was greatly affected by her time spent in “the Bible Belt.” “It’s gone from just trying to teach back and get into arguments to ‘facting’ them into it without them even know what’s happening, and then watching them have these ‘aha’ moments.” Still, there are always a few students who are still resistant to learning about the theory. Even after the discussions between religion and science, the nature of scientific evidence, and how science works and doesn’t work, there
are a few “sticklers.” As a last resort, Tina will let them know that it is her job to teach what the scientific community thinks and to teach the standards agreed upon by the district and state. She lets students know that if they choose not to learn them, they will not understand the standards for the class and will struggle on assessments and laboratory work. However, she lets them know they are graded based on what they understand about the course, not what they choose to believe. She will also tell them, “If you disagree the best thing to do is to know the other side of the argument.” This doesn’t happen very often anymore. Tina strives to make the class as interesting as possible so students are fully engaged at all times.

Neither district nor school in which Tina has worked has provided training regarding the evolution-creationism controversy. She seeks out conferences when they are available, and frequently attends the annual evolution workshop run by a local university. However, this interview has ignited an interest in creating a workshop for biology teachers in her district. Undoubtedly, she will draw upon her experiences in both cities to help teachers teach evolution and the controversy surrounding it effectively.
Chapter 5: Evaluation, Thematics, and Implications

Evaluation

Drawing from the description and interpretation of the portraits of five biology teachers, I turn to the evaluation of their practice. Since the goal of educational connoisseurship and criticism is to improve educational practice (Eisner, 1988; 1991), I chose the five research questions below to guide this study.

1. How are teachers prepared to deal with the issues that accompany the teaching of evolutionary theory?

2. How do teachers handle external resistance to the teaching of evolutionary theory?

3. What strategies do teachers use when teaching evolutionary theory to classes where resistance may occur?

4. How do teachers create what they perceive to be an intellectually safe learning environment for students who may disagree with evolutionary theory?

5. How do teachers help students with the cognitive dissonance that they may experience when learning about evolution?

I use the participant’s responses to answer, and indeed appraise the value of, these questions.
Research Question #1: How are teachers prepared to deal with the issues that accompany the teaching of evolutionary theory? When asked if their school or district—or in Aaron’s case, university—provided any formal training regarding how to deal with the evolution-creationism controversy, or even evolutionary content, all said no. Even in schools where antievolution sentiments run high, no training has been provided by the school or district.

If no training regarding evolution is offered by individual schools or districts, even when biology is usually a graduation requirement for high school students, perhaps it is a commonly held position that college science classes and teacher education programs do enough to prepare teachers in this area. A meta-analysis relating to teacher education showed that the effect size of teacher education on subsequent student outcomes was negligible (Qu & Becker, 2003), though Sparks (2004) showed that teachers trained in the field they are teaching in were more effective than those not so trained. I asked the participants if they felt high school teachers know enough about evolution to teach it properly, and the overwhelming response was that they do not.

As noted in the description chapter, Aaron discusses that even university science professors can know “almost nothing about evolution” if they didn’t take enough graduate courses on the topic. This does not bode well for high school teachers. Brett stated,

Most science teachers, and sadly, biology teachers included, do not have an adequate evolution background. I don’t know how many times I have heard gross
misconceptions concerning evolution come out of the mouths of biology teachers.

It is tragic, pathetic, and inexcusable.

Paul was also very blunt with his answer when asked if most teachers are adequately prepared and knowledgeable by proclaiming, “Not even close.” Referring to a study by Berkman and Plutzer (2010), Paul stated:

Sixty percent of high school biology teachers are either teaching creationism—about ten percent are teaching creationism, and that alone is a pretty scary proportion—or they are avoiding teaching evolution altogether, like I probably was when I started teaching. Or they are so uncomfortable with it that they are teaching science poorly and they are opening up the opportunity for all of these non-scientific explanations.

Tina also had a strong opinion on whether teachers are prepared to teach evolution competently.

Not all of them—because I didn’t at first. I think you go in and there is definitely a learning curve. I know that there are science teachers out there that still don’t understand or think that evolution really happens and I think that’s a sad fact for science teachers. Do high school teachers know enough about it to teach it properly? I would say any high school science teacher starting off—no way do they know enough about it to teach it properly. I think part of teaching it is just how you get to know it well enough to teach it well. I hope that experienced teachers know it well enough to teach it well.
The research backs up their opinions. Rutledge and Warden (2000) found that biology teachers in at least some states had a low understanding of evolutionary theory—well below what would be expected among science teachers and closer to the levels of understanding of that of the general public. They argue that teachers are not sufficiently trained to “possess a thorough knowledge of evolutionary theory and its place in the discipline of biology” (Rutledge & Warden, 2000, p. 29).

Shulman (1987) articulated the importance of pedagogical content knowledge, which seems obvious—teachers must have solid understanding of their content in order to understand what must be taught and how to teach it. Moore (2002) argues that if teachers took more evolution-related courses, their increased understanding of evolution would translate into better education for students. Self-confidence gained by this knowledge is an important contributor to how teachers approach the teaching of evolution (Griffith & Brem, 2004; Rutledge & Mitchell, 2002). However, Darling-Hammond (2006) indicated that subject matter knowledge will only influence teacher effectiveness up to some level of basic competence, but less so thereafter. Furthermore, and perhaps ironically, Ahn and Choi (2004) found a very low effect size between teacher content knowledge and student outcomes—at least in some disciplines. In short, a solid understanding of evolutionary theory by the instructor may not be a silver bullet, but it can be a less stressful topic for those teachers who are more confident and comfortable with the material, and the teacher may dedicate more time to it in class (Griffith & Brem, 2004).
The topic of evolution presents different challenges than other topics in science. Over the course of their teaching journeys, the participants in this study learned that just knowing how the theory of evolution works does not address the political and philosophical issues surrounding it. An effective training should include much more than learning biological concepts. All participants agreed that training would be beneficial, and schools or districts would be wise to develop one that all biology teachers would be required to attend. A couple of participants have even expressed interest in creating a workshop of this type, and Aaron has already developed a training for his department members. However, Lindsay doesn’t know if expecting all biology teachers to get training in this area is realistic, despite agreeing that high school teachers do not know enough about evolution to teach it effectively.

There are so many expectations for teachers right now. To increase their content in evolution is just yet another layer. I think it’s important, but there are so many requirements of teachers and expectations of teachers right now that I think it’s just very difficult.

Despite not being offered professional development by their respective schools or districts, and being saddled by the ever-increasing demands of the classroom teacher, each participant sought training for help. Though each participant did a lot of research and reading on their own, other information was gathered through conferences, lectures, or workshops run by universities, curriculum developers, or other organizations. The participants almost always have to pay out-of-pocket for these trainings without funding...
by their districts. Nevertheless, they were motivated to increase their knowledge about the controversy and the theory itself.

This motivation was sparked by negative experiences early in their teaching careers. Tina and Paul were burdened with requests (if not demands) to respond to creationist literature brought in by students. Lindsay was publicly offered money to debate evolution with a local minister. Aaron and Brett dealt with not only antievolutionist challenges from students, but with colleagues as well. Most of them also had parents challenge them at one time or another.

Many teachers, while facing the risk of appearing unconfident and therefore losing credibility with their students, would bow down to the external pressures and deemphasize, undermine, or omit evolutionary theory altogether. In fact, many do (Berkman & Plutzer, 2010). However, these participants responded not by acknowledging that something was amiss with the theory of evolution, but with the manner in which they approached teaching it. Their desire to teach solid science in the face of adversity inspired them not only to learn more and gain confidence, but to rework their curriculum and create a classroom environment conducive to learning about a controversial subject.

**Research Question #2: How do teachers handle external resistance to the teaching of evolutionary theory?** External resistance can be defined as that which comes not from the students themselves, but outside of the classroom. This may be from colleagues, parents, community members, or institutions. As stated in the literature review, this resistance sometimes manifests itself in the establishment of policies
changing state standards to undermine evolution, expose students to intelligent design, give equal time to creationism, point out perceived problems with evolutionary theory, or change the definition of science altogether. It has been shown that when evolution is emphasized in state standards, more days are spent on the topic and it is accentuated more that it may be otherwise (Donnelly & Boone, 2007). Perhaps this is why several state boards of education, under creationist influence, have fought so hard to deemphasize evolution in the standards, and include language which paints evolution as an unsubstantiated idea or a theory in crisis.

Although these organized movements, if successful, may change teachers’ practice because of policy change, the teachers may not have to deal with the controversy directly. However, in districts where evolution remains part of the content standards, the external person or organization may believe they can persuade teachers to change how they teach evolution. Sometimes, teachers give in to the pressure and avoid teaching evolution altogether (Cavanagh, 2005; Moore & Kraemer, 2005). Other teachers, who want to shift responsibility to the policy makers or who are personally against the topic, may point the standards to justify its teaching (Donnelly & Boone, 2007).

Brett uses this argument primarily as the coup d’état when forced to defend why he teaches evolution. Perhaps it is the easiest and most succinct way to end the argument—merely claiming that “it’s the law.” But though he resorts to this as his final point, Brett has crafted a response that he has used dozens of times over the course of his career. He explains how evolutionary theory is the “cornerstone of biology and therefore by all accounts I should teach it” and then highlights the Supreme Court cases that
established the legality of teaching evolution as well as the illegality of teaching creationism. Brett doubts that the external parties are truly interested in learning about evolution as a unifying theory, but they tend to understand the legal responsibilities of public school teachers.

Brett is more confrontational with colleagues who question his teachings. When approached by a colleague who asked him why he didn’t teach the creation story, he became the aggressor—pointing out that there were a number of creation stories in the world, and none of them is based on science. He tells colleagues who question him, “If you can come up with an alternative theory for evolution that fits the empirical model, then by all means present it to me.” None has been proposed to Brett to this day.

Aaron experiences little resistance outside of the classroom. Perhaps this is because he teaches at a major military academy, and outside groups believe that they would have little influence on such a prominent institution. Local school boards and individual teachers may be perceived to be less shielded and be a more suitable target for external pressure. However, Aaron did sense a lot of antievolutionist sentiments throughout the campus. Colleagues were openly evangelical and explicitly encouraged cadets to partake in Christian events on and off campus. This evangelical aura may have emboldened cadets to raise questions and challenges in Aaron’s biology classes. He, however, has made a career of accepting these challenges and using them as teachable moments.

Paul was one of the teachers that caved in to external pressure. He “had a lot of content knowledge” but was unprepared to deal with the social controversy. Parents
would approach him at conferences and question his teachings. He left the topic of evolution until the end of the year, and more often than not, didn’t get to it before the semester ended. After working on his book, he gained the knowledge and confidence to deal with the social aspects as well as learning about the legal issues. He now relies upon this knowledge and understanding to combat the “backlash from the community.”

When Tina was teaching in the Southeast, she would frequently be presented with creationist materials from parents, preachers, and community members. She learned quickly that “the most important thing is to not get in a situation where you can be in a battle at all.” Like Brett, when she realized that the people exerting pressure on her were not interested in learning about the virtues of evolution in a biology class, she turned to the final argument. “When in doubt, always refer to the standards. It’s in the standards.”

Lindsay had superficially known that there was the potential for external resistance in the community, but was surprised when she was actually faced with it. Letters to the editor in the local paper showed that antievolutionist sentiments were strong, and she was challenged to a debate by a local minister. In fact, debate requests were not unknown to any of these participants. Although some teachers are confident enough to get into the meat of these types of debates, most teachers would do best not to engage in them, and for good reason.

Rodger Bybee (2004b), director of the Biological Sciences Curriculum Study, proposes several reasons not to debate creationists. For one, regardless of the evidence presented, teachers will most likely lose the debate in the eyes of the public. The debates are rarely about evolutionary concepts, but about politics and power. Questions are
seldom asked in order to gain an understanding, but to trap or confound teachers and leave the audience with the impression that the teacher—and therefore the entire theory—is inadequate.

Secondly, debating evolution and creationism usually turns into a debate about science and religion. Gould (1999) famously argued that the two are non-overlapping magisteria, and a debate between them is pointless. Science and religion have different purposes, goals, and rules to which they abide. Empirical truth is different than religious truth, and the two need not be in conflict.

Finally, debates about evolution and creationism often hinge on issues related to inquiry and the nature of science. For example, the term “theory” is often misused by non-scientists where, instead of meaning a well-substantiated set of universal statements that explains some aspect of the natural world, it means guess or hunch. Creationists are fond of claiming that “evolution is only a theory.” This misuse of terms was instrumental in the thinking of the Kansas Board of Education when they tried to undermine evolution in the state’s science standards in 1999 (Backhus, 2004). In scientific terms, a confirmed idea elevated to the status of “theory” is the ultimate support. Nevertheless, professional creationist debaters often have their own characterizations of science which is not shared by most scientists. According to Brian Alters (2005),

Almost all types of creationists want the scientific community to recognize, as part of science, some form of supernatural or intelligent extraterrestrial causation….Science should not seek only naturalistic explanations but, when “necessary,” should permit nonnaturalistic explanations as legitimate scientific theory. (p. 37)
It is difficult to debate one philosophy over another when the two do not abide by the same rules. This may be precisely what the Kansas State Board of Education had in mind when it wanted to change the definition of the term “science” in 2005.

In formal debates the goal is often about winning or leaving doubt in the minds of those who don’t have a firm position. Rarely are the resistant parties seeking an educational dialogue, and the debate formats do not leave the time or structure for explanations about fundamental principles or terminology. Similar to political debates, the audience is often more interested in the “zingers” thrown between candidates than listening to detailed explanations.

External resistance and pressures to stop teaching evolution are not always directed at the individual teacher. School board members, principals, or others who have decision-making powers may be the target of such movements. However, students are often armed with challenges to evolution and are instructed to contest or undermine teachers in the classroom. Strategies that teachers use when dealing with students in their own classroom look considerably different from those used when dealing with external resistance.

**Research Question #3: What strategies do teachers use when teaching evolutionary theory to classes where resistance may occur?** The argument from state or district standards does not often go very far with high school students. Telling students that they must learn something merely because some faceless board of educators (if not politicians) thinks they need to can be unsatisfying. Students learn better when teachers communicate the intentions of lessons and understand how a learning objective
is relevant to their lives (Fendick, 1990). Additionally, the argument that students must learn something “just to pass the test” is not particularly motivating for deeper understanding. Such words may give the impression that the students can merely forget what they’ve learned as soon as the unit is completed. This would be in stark contrast to all of the participants’ emphasis to their classes that the theory of evolution is the one unifying theory in all of biology. Therefore, the participants had to handle resistance in the classroom another way.

After years of experience, these participants realized that arguing or aggressively defending evolution was not productive. It neither led to further understanding nor an atmosphere conducive to intellectual risk-taking. Eventually they found other ways to respond to the requests and demands to incorporate non-scientific ideas into the biology curriculum. Interestingly, few of these strategies pertained directly to evolutionary content. Instead they focused on how science works and how the philosophy of science—the way of knowing something scientifically—differs from other methods of knowing. However, the participants did much more than rely upon a single lesson or concept strategically placed in an evolution unit, they revamped their entire curriculum using the nature of science as a foundation. Instead of only reacting to resistance or antievolutionist challenges as they came, as they had in the past, these teachers designed their curriculum by front-loading a lot of information that would head off potential contentious interactions.

Despite the five participants’ passion for the topic of evolution, every one of them declared that in an ideal world, students would come into their class with—and also leave
with—a better understanding of how science works. This is not to say that biological concepts are unimportant, but a deep understanding of the workings behind the discipline of science can provide a lens through which all scientific concepts can be viewed. This basis of logic and reasoning can provide a scaffolding for which biological content—and especially evolutionary theory—can be assimilated. Many creationist arguments stem from a misunderstanding of how science works (Alters, 2005; Alters & Alters, 2001; Berkman & Plutzer, 2010). These participants have created a curriculum which solidly builds the framework of the nature of science which preemptively addresses many or those questions and challenges. Tina’s lesson on Lacey Peterson addresses the quality of scientific evidence and the lack of focus on supernatural mechanisms to explain natural phenomena. Paul reads from the book of Genesis to illustrate that religious dogma has little place in science. Brett announces that he doesn’t “believe” in evolution which leads to a discussion of accepting a scientific theory based on empirical evidence rather than believing something through faith, as well as dismissing the notion that evolution is “just a theory.” Lindsay uses the CONPiTT lesson to demonstrate how ideas stand up to the scientific criteria of consistency, observability, natural explanations, predictability, testability, and tentativeness. Aaron teaches an exercise in metacognition in which students evaluate how they know things, how the different ways of knowing contribute to their knowledge base, and how reliable these ways of knowing are.

Lessons such as these are usually taught prior to any mention of evolution, and the learning outcomes of these activities are referred to throughout the course. The groundwork has already been laid, so if questions arise about evolution, students can
readily see that it fits all of the scientific criteria of a solid theory. A solid understanding of the nature of science promotes scientific literacy, and one would be hard pressed to understand evolutionary theory without being scientifically literate.

Although the participants in this study developed these strategies by struggling through contentious interactions, they are supported by the research. A solid understanding of the nature of science has been shown to help students understand what to do with scientific knowledge—what sense to make of it and how to negotiate the science that comes to them in everyday life (Bell, 2007; Settlage & Southerland, 2007). Cherif, Adams, and Loehr (2001) found a strong relationship between students’ beliefs and understanding of evolutionary theory and their understanding of the nature of science. Rutledge and Warden (2000) found that a similar relationship exists with not just students, but high school biology teachers. Davis (1997) showed that students with fixed or static views of science are less likely to understand scientific theories than those students who view science as tentative and revisable. Cavallo and McCall (2008) demonstrated a significant positive correlation between students’ beliefs about the nature of science and acceptance of the theory of evolution. In both pre-and post-evolution instruction, if students viewed science as a tentative process, they were more likely to accept evolution. The more that students viewed science as fixed and authoritative, the more likely they rejected the theory of evolution. Another study showed that students who had a more sophisticated view of the nature of science were more likely to hold more positive beliefs about the theory of evolution (Sinatra, Southerland, McCounaghy, & Demastes, 2003). Findley, Lindsey, and Watts (2001) found that when students were
taught the nature of science prior to learning about evolution, they found the theory to be less challenging or uncomfortable. Larry Flammer (2006), the webmaster of the Evolution and Nature of Science Institute (ENSI), reported that his program of evolution instruction effectively minimized conflict as students came to recognize many misconceptions and understood why evolution is considered a strong scientific theory. Butler (2009) found that college students that engaged explicitly and reflectively on specific tenets of the nature of science not only developed a better understanding of the nature of science aspects but also a better understanding of biological evolution. Simply put, these participants have discovered that the evolution demonstrates the relationship between scientific processes as well as the structure and development of a theory.

In addition to front-loading the nature of science into their curriculum, these participants do not treat the topic of evolution as just another chapter in the textbook. They expose students to it early and the theme is interwoven throughout the biology curriculum to be referred to often. Evolution becomes the standard answer to the question, “Why does it work this way?” All participants proclaim that the theory of evolution coalesces all concepts of biological science, and they treat it as such—using it to tie their curriculum together. In this manner, resistant students can ingest the theory with small, manageable nibbles rather than feeling forced to swallow large, unpalatable bites. If too large of gap exists between students’ current knowledge level and a desired state of knowing, students are likely to be deterred from attempting to gain the new knowledge (Loewenstein, 1994).
Regardless of how well these participants proactively insert the nature of science into their curriculum to head off potential questions and weave the theory of evolution throughout their units, some students are still resistant to learn about it. They may either continue to vocally challenge the teacher, or sit in passivity reluctantly doing work—or not. Regarding the vocal students, Aaron and Brett encourage the philosophical challenges if they have not been answered within the context of the nature of science. They encourage skepticism and let students know that challenges are valuable, as long as there is substance and reasonable thought behind them. They are quick to move on if the arguments become exclusively religious in nature and the students refuse to accept the rules of science, or if the conversation becomes disrespectful to other students in the room. In the end, several participants have said that they leave their students with this thought: “I am presenting a well-supported theory which is agreed upon by the vast majority of scientists. If you disagree with it, it is to your advantage to know both sides of the argument.”

Passive students do not seem to concern these participants, though they understand the importance of student engagement. Most are confident that they provide engaging labs and activities for their students. According to Tina, students who initially seem passive “get interested because they can’t stand not to be. They’ll learn it anyway.” The controversial nature of the topic itself may even lead to better understanding. In a meta-analysis of dozens of studies, Johnson and Johnson (1989, 2000) found that students who participated in academic controversy recall more correct information, were better at practical application of knowledge, and were able to use more higher-level reasoning
skills in recalling and transferring information that they had learned. Hahn (1984) reported that students participating in controversial issues acquired better understanding of particular issues, developed stronger analytical abilities, displayed stronger decision-making skills, and displayed more democratic values than students who did not.

Additionally, the participants have spent a lot of time developing inquiry-based labs where students have to interpret evidence for evolution on their own. Students pour over fossils, phylogenetic trees, cladograms, and genetic codes attempting to make sense of them. Often, when students look at the same evidence that scientists do, they come to the same conclusion which may be less threatening. Inquiry-based lessons such as these types of activities tend to be highly engaging and motivating for students, and lead to deeper understanding (Palmer, 2009).

If students are still resistant to learn evolutionary theory regardless of the efforts of the teacher, the participants make certain that the students’ beliefs are validated. Lindsay has had students write on their papers. “I’m doing this, but I don’t believe in evolution.” Paul has had a student tell him, “This is something I gotta do. I’m going to get these right answers, but I’m not going to change my belief system.” This validation may go a long way in making students feel safe in the classroom.

**Research Question #4: How do teachers create what they perceive to be an intellectually safe learning environment for students who may disagree with evolutionary theory?** An intellectually safe learning environment is essential in a classroom where the potential for controversy exists. Students may be less likely to engage in active learning if they feel that their viewpoints are not acknowledged or
respected—instead focusing on survival related cues (Franken, 2002). Intellectual conflict with teachers or peers can decrease both motivation and student engagement (Dörnyei, 2001). Students may not ask questions if they don’t understand, or may fear retribution if they do not accept what the instructor is teaching. However, students can be challenged in their world-views while still feeling supported and safe despite possible discomfort (Schrader, 2004) and intellectual risk taking has been shown to be positively related to interest in science, creative self-efficacy, and perceptions of teacher support (Beghetto, 2009). Therefore, these participants make it a point to create a climate of intellectual safety well before they approach the topic of evolution.

When the participants were asked if it is was important to them that their students accept evolution rather than just understand it, they all responded the same way. Understanding the theory was vital, not necessarily accepting it. Brett stated, “You know, I would far rather have a student leave my class understanding than falsely telling me they accept it. Sure, I would love all my kids to accept it, but that’s not going to happen.” Similarly, Paul stated,

I’d rather they understand it than just accept it. Ultimately, I’m in the business of teaching kids biology and science in general. If I can get them to understand science, then I’m training good voters—because ultimately they are all going to be voters, right? I want them to understand how science works more than the local politician.

Aaron stated that his “job is to educate, not to indoctrinate. But if they understand the theory and they can explain it well, I should be satisfied with that.” Tina admits that she
would like it if they did accept it, “but again, it’s their own heads. They can think whatever they want. If they did, I think they would understand science better.” Lindsay tends to agree:

I think acceptance of it—I think that is just about them. I would hope to lead them to evidence supporting theories, evidence supporting scientific ideas and understanding. So being open to that and understanding it maybe will lead them down the path to accepting it. But if it doesn’t...if I can get them to really look at evolution through a scientist’s eyes and looking at the evidence pieces, then I feel like that’s success.

It is important that these participants express this viewpoint. When discussing the safety students feel in regard to the relationship with their teacher, Noddings (1992) states, “It must be acceptable to admit error, confusion, or even distaste for the subject at hand” (p. 108). Letting students know that their teacher doesn’t have a targeted agenda in this area may be comforting in itself. Students understand that their beliefs are not something to be debunked and replaced. In a sense, they give students permission to learn about the theory without having to change their beliefs. It has been documented that students can understand something and demonstrate that comprehension on a test while still not believing it to be true (Burns, 2006). Aaron tells his students that he acknowledges that some of the topics he covers may challenge their worldview. He invites students to question or challenge him on any topic and he assures them that they will not be graded more strictly or scrutinized if they do. Paul also tries to get students away from the idea that creation and evolution is an either/or dichotomy.
What I hope my classroom is for believers is that it’s a place where they can think intellectually about their belief system and they can learn about how science works and they can realize that, “Oh, this is not scary! This is not a choice I have to make. This is just...these are scientific facts. I can have my beliefs.”

Tina tells students “what you religiously believe is totally fine, it’s a valid way of knowing, it’s just not science.” Brett stresses that he “makes it very clear that what they believe is perfectly valid. That’s their right, and that’s what they should do.” Lindsay clarifies that in her class:

we talk about evidence that supports science, and we are not talking about belief.

That doesn’t mean that you can’t have your beliefs, but this is the focus of what we have in science class.

Clarifying the different ways of knowing—scientific knowledge versus other kinds of knowledge—may help encourage intellectual risk-taking among students. If students can categorize the new information as “scientific knowledge” they may be able to allow themselves to investigate the new concepts without viewing them through the lens of their faith. If they can cognitively separate scientific explanations from religious ones, even if only for the purposes of understanding the courses learning objectives, resistant students may feel less inhibited to understand evolutionary theory. Additionally, most of the participants also recommend that their students, if they are indeed contentious toward evolution and readily admit that they will never accept it, at least learn all they can about it in order to argue against it. That is what critical thinkers do.
Telling students that their acceptance isn’t as important as their understanding not only allows them to feel safer, it is more practical than trying to encourage a change in beliefs. The process of conceptual change is not a simple one. It takes a lot of time (Sandler, 1998) and seems to be an incremental process (Harrison, Grayson, & Treagust, 1999). In fact, Settlage (1994) found that students needed extended exposure to and interaction with evolutionary concepts in order to show growth in understanding. Therefore, teachers may want to view the learning experiences they provide students “as only a stepping stone toward the goal of a more complete understanding” of evolutionary theory (Alters & Alters, 2001, p. 180).

For students who don’t completely trust their teacher, the announcement that it is not important to accept the new teachings may come off as simply lip service. Therefore, the participants invest heavily in making connections with students. Lindsay summarizes this importance:

I think having a relationship with your students is huge—being able to open up that communication, setting up the environment so that they feel safe and they are able to discuss their questions instead of bearing it. I think that’s the biggest strategy I had for setting the environment for safety, for being able to share what they understand. Whether they arrive at a more open mind to it, looking at the evidence or not, it was still up to them. Lindsay also doesn’t underestimate the seemingly simple trait of “being nice” and having “mutual respect.” Aaron reminds students that they are welcome in his class whether they are a “young-Earth creationist or a dye in the wool evolutionist” and wants them to
“realize that I’m not trying to change your mind.” He also emphasizes the importance of mutual respect. Brett monitors how safe students feel by the number of questions he gets in class:

How do I know? I guess by the fact that I get so many questions. I think that’s affirmation. If you shut kids down, if you’re demeaning, you won’t get those kinds of questions…You can’t be condescending, you can’t be pejorative, you can’t be demeaning to these kids. If you do, you’ll lose ninety percent of them.

You have to present the science with compassion and be dispassionate at the same time.

Brett teaches students how to respectfully challenge information, and he respectfully responds.

The research heavily supports the effect of the teacher-student relationship. In a meta-analysis of 119 studies, Cornelius-White (2007) found that in classes with teachers focusing on relationships, there was more engagement, more respect of self and others, fewer resistant behaviors, and higher achievement outcomes. His claim is that to “improve teacher-student relationships and reap their benefits, teachers should learn to facilitate students’ development” by demonstrating that they care about each individual’s learning and to empathize with their students by seeing “their perspective, communicate it back to them so that they have valuable feedback to self-assess, feel safe, and learn to understand others and the content with the same interest and concern” (Cornelius-White, 2007, p. 123).
Teachers earning the students’ trust can go a long way in encouraging intellectual risk-taking. However, even if students trust the teacher, they may not necessarily trust anyone else in the classroom. Peer rejection and maltreatment has been associated with declining classroom participation and school avoidance (Buhs, Ladd, & Herald, 2006), while group cohesion has been associated with positive school performance (Evans & Dion, 1991). Students must not only feel safe from perceived attacks on their ideas by the teacher, but from their peers as well. As mentioned in the description chapter, Tina spends a lot of time creating community in her classes so students feel safe to discuss their ideas and possible disagreements with the content or with each other. She feels that if students know each other and are comfortable talking with and listening to each other, they are less likely to intentionally inflict harm. The other participants also regularly engage their classes in group discussions and activities.

Additionally, it is also important to let students know who is in control of the class, so comments from student to student are not disrespectful. Several of the participants mentioned that, though it rarely happens in their classes anymore, they are aware when some students appear to be becoming aggressive and use their classroom management skills to stabilize the situation. A teacher’s situational awareness and ability to indicate to students what behaviors are appropriate or inappropriate tend to have a high effect on student achievement and students’ sense of safety (Marzano, 2000).

Early on in the school year, the participants set the stage to create an atmosphere which is safe for ideas to be discussed and questioned. Allowing anxiety to remain can hurt student engagement and ability to learn (Ma, 1999). All of the participants welcome
questions about evolution from their students—even if they are not scientific in nature. They let students know that their religious beliefs are perfectly valid and will not be questioned or ridiculed. They build trusting relationships and mutual respect between themselves and students, as well as between students and their peers. The knowledge gained while building these relationships becomes important when the participants try to help students with any cognitive dissonance they may experience.

**Research Question #5: How do teachers help students with the cognitive dissonance that they may experience when learning about evolution?** High school students enter the classroom with a worldview created from the contributions of a variety of sources—their parents and relatives, teachers and spiritual leaders, peers, and popular culture. When science teachers introduce topics that challenge their personal views, students may feel mentally uncomfortable or dissonant. Cognitive dissonance theory contends that when this state of tension occurs, whether it is only minor discomfort or deep anguish, students strive to restore consistency (Festinger & Carlsmith, 1959; Mills, 1999) and spend a great deal of energy attempting to regain consonance in their personal world (Geen, 1995).

The five participants discussed how they tend to recognize situations when students may be experiencing cognitive dissonance. Aaron “can tell it by the expression on their faces. Furrowed eyebrow, general body language indicates discomfort.” Brett and Lindsay can tell by students’ participation in class and depth of questioning. Some students want to talk through the entire argument over and over. Brett also relies on what students are writing, and can often determine not only misunderstanding, but a tone of
resentment if it is present. Paul reports that some students will say that a family member of theirs is struggling with the ideas they are learning about and ask him to go over the dispute a number of times. Tina claims that many of her students who are struggling internally will “usually tell you.”

Not all teachers are able to pick up on subtle cues that indicate mental discomfort, nor are all students able to articulate their thoughts openly and clearly. Fortunately, dissonance theory can predict how students will respond to when faced with clashing ideas. Harmon-Jones and Mills (1999) state,

If the dissonance is not reduced by changing one’s belief, the dissonance can lead to misperception or misinterpretation of the information, rejection or refutation of the information, seeking support from those who agree with one’s belief, and attempting to persuade others to accept one’s belief. (p. 6-7)

All of the participants in this study have seen these responses in their students. As they have experienced, misperceptions and misinterpretations of information can interfere greatly with the understanding of evolutionary theory. It is important for teachers to uncover and understand students’ prior conceptions if they do want to help students replace misconceptions with scientifically acceptable ones (Rea-Ramirez & Clement, 1998). Alters & Nelson (2002) point out several types of misconceptions that students have with evolutionary theory: from-experience misconceptions, self-constructed misconceptions, taught-and-learned misconceptions, vernacular misconceptions, and religious and myth-based misconceptions. The participants are very familiar with all of these types. Aaron sees the same mistakes each year: that evolution is directional, that people evolved from modern monkeys, and that mutations are somehow a conscious choice for the betterment of organisms. Brett refers to “the same inane
arguments over and over,” including how evolution violates the second law of thermodynamics and urban myths such as “Darwin recanted on his deathbed.” He is astounded and frustrated that “these inaccuracies really do circulate even after they’ve been rebutted logically year after year.” Paul sees these common errors in understanding as well. He mentions students’ misunderstanding of the fossil record as a recurring theme in his classes. Tina’s students frequently get hung up on vestigial structures—mistakenly believing that if an animal doesn’t use some part of its body, it will simply vanish. This misconception, Tina believes, may actually be from perceived personal experience. Students see how the muscle mass in an arm or leg wrapped in a cast for an extended period of time will atrophy and shrink. Like Paul, Lindsay also saw confusion over the fossil record as well as misconceptions about the age of the earth and geological dating methods. Her students have struggled with the “huge span of time that evolution occurs over. That’s a preconceived notion that they don’t understand that it doesn’t go from an amoeba to a human.”

This last misconception may be indicative of how students deal with their own cognitive dissonance. A claim such as this, regardless of the fact that the scientific community has never made the claim that amoebas change into humans, is completely unreasonable in the students’ personal experience. Animals simply don’t give birth to different kinds of animals. Students do not take into account the millions of years, billions of genetic changes, and myriads of transitional organisms between the two. They look at the two organisms, and find it inconceivable that one could not have come from the other. The monkey-to-man misconception is similar. A student may say, “I’ve never
seen a monkey turn into a man, therefore this entire theory must be bogus.” Because of this misunderstanding, students can reject the theory without disrupting or replacing their prior beliefs. This is known as the argument of personal incredulity—because I cannot imagine it, it must be false.

Unfortunately, many creationists intentionally proliferate these over-exaggerations in order to make the theory of evolution sound implausible (Alters, 2005). However, all of the misconceptions cannot be blamed on concerted efforts by vested interests to disseminate misinformation. The media has been known to oversimplify and misrepresent scientific findings (Ladle, Jepson, & Whittaker, 2005). Since science is often complex and difficult for the layperson to understand, the details of scientific studies are simplified in order to be effective. Also, people typically prefer simple explanations over complex ones (Chater & Vitanyi, 2003; Lombrozo, 2006, 2007). However, the oversimplification can be greatly misleading and promote gross misunderstanding. People want simplicity and the media delivers—often at the cost of true comprehension.

In addition to misconceptions, the participants in this study have also witnessed refutation and flat-out rejection of evolutionary information. Early in their careers, Aaron used to see students become withdrawn and quiet when dealing with evolution while Brett recalls some students actually seeking transfers from his class when he brought up the topic. This goes to show that students, as well as all people, are experts at filtering out, avoiding, or rejecting disagreeable points of view. In a series of experiments, Brock and Balloun (1967) exposed regular church goers as well as committed atheists to a tape-
recorded message which attacked Christianity. The researchers added audible static to the recording which the listener could easily reduce by pressing a button. Interestingly, the nonbelievers without exception tried to remove the static, while the religious subjects preferred the message that was more difficult to hear and understand. The same results occurred when a similar experiment was conducted that had smokers and nonsmokers listening to a speech about the link between cigarettes and lung cancer. Smokers preferred the static while nonsmokers removed the crackling white noise. The smokers, as well as the church goers, stifled their cognitive dissonance through self-imposed ignorance. Many students, when studying evolution, may choose to just reject the theory without bothering to find out what the actual claims are or the mechanisms by which it works.

All of the participants regularly experience challenges in the form of questions (which they all welcome) or argumentative statements, and some have students who write their discontent on their written assignments or tests. Most of the participants have also had demands to respond to creationist literature that students bring in, and Lindsay was challenged to a debate. Lindsay also spoke of a time when one of her students would go around to different lab groups to proclaim the fallaciousness of evolution to seek support. These students not only sought to resolve their dissonance not only through rejecting what they were being taught, but by seeking safety in numbers. By challenging teachers with common creationist arguments (which undoubtedly stemmed from the literature they brought in), they were essentially saying, “See? I’m not the only one who doesn’t
believe in this theory! There are people who write books and pamphlets about it. If many people believe this is false, then it probably is.”

Recognizing cognitive dissonance in students is not difficult for these participants. What is more troublesome is getting students to listen to and consider evidence that supports evolutionary theory. Cognitive dissonance theory states that when new information is consonant with our beliefs, we accept it readily, consider it well founded, and deem it useful. However, if new information causes dissonance, we tend to consider it biased, irrational, or imprudent (Tavris & Aronson, 2007). Often the need for consonance is so great, that when we are forced to look at disconfirming evidence, we find a way to criticize, distort, or dismiss it so we can maintain our prior belief. This mental contortion is known as the “confirmation bias” (Nickerson, 1998). One study, in which religious and nonbeliever subjects were exposed to a fictitious report disproving the Biblical account of the resurrection, resulted in belief increasing for believers, while nonbelievers became more skeptical (Batson, 1975). Regardless of the support or disconfirmation of the “evidence” presented, the prior belief was strengthened. Munro (2010) has also shown that exposure to belief-threatening scientific evidence can lead people to discount the scientific method itself. People would rather believe that an issue cannot be resolved scientifically, thus discounting the evidence, than accept scientific evidence in opposition to their beliefs. Hugh Molson, a British politician, is attributed with saying, “I will look at any additional evidence to confirm the opinion to which I have already come” (as cited in Tavris & Aronson, 2007, p. 17). Ironically, it appears that if our convictions are strong enough, even contradictory evidence will confirm our
opinion. Cognitive consonance is easily preserved if it is readily decided that new information in opposition to beliefs is untruthful.

Some students, however, are able to incorporate the new information with their prior religious beliefs. They accept evolution as being God’s plan—a concept known as “theistic evolution.” Theistic evolutionists can accept all of the claims that evolutionary theory makes since God planned it that way. God creates through the laws of evolution. This is different, however, from believers of intelligent design. While both believe that there is design in nature, it is only the intelligent design advocates that claim there is scientific basis for this belief—a claim refuted numerous times (Lebo, 2008; Miller, 1999). A theistic evolutionist might believe that while supernatural design is inferred, it does not rely on science to be established. This belief, however, is often criticized by biblical fundamentalists who accept the creation story of Genesis which took only six days. To admit that evolution might occur is to admit that the Bible is not inerrant.

Other students may choose to compartmentalize their religious beliefs and scientific knowledge. They shut out their skeptical, naturalistic thinking when addressing matters of miracles in their faith, and block out supernatural entities when addressing matters of science. To such people, science and religion rarely mix and answer different questions. This may work for most people most of the time, but for students who will contemplate human origins, the cognitive dissonance between what science states and what religion states may eventually have to be addressed.

The participants in this study eventually learned that merely presenting biological content does little to help many students resolve their cognitive dissonance. Students
may perceive the teaching objectives as an affront to their beliefs, and resist learning them or rebel against them to preserve consonance. Therefore, much more consideration than a simple lesson plan must be taken into account. In addition to the strategies the participants use in class—creating a safe environment, presenting and reviewing the nature of science, and weaving evolutionary theory into all aspects of the biology curriculum—the participants recognize the value of making connections with students in the classroom. However, each participant eventually learned that, for those students who are struggling with cognitive dissonance and are motivated to resolve it, a relationship beyond the bell to bell instruction period may be beneficial.

Creationist students tend to be pleasantly surprised when they learn that their teachers know a bit about their own beliefs, and their admiration and respect for that teacher increases considerably when they learn that (Alters, 2005). If students do indeed try to reduce their cognitive dissonance by accepting the new information, a good relationship with a respected teacher can create a safe place where students have the courage to discuss their new beliefs which may ultimately be at odds with their family, friends, or faith community (Catron, 2008; Perry, 1999). Without exception, each participant said that if students are still struggling with mental discord after all of the strategies used in class, they would invite the student to talk to them privately outside of the classroom. Each participant has accounts of this happening, only to help build a stronger relationship between them. Aaron believes that his fundamentalist upbringing gives him an advantage that other teachers may not have since he can relate to what the students believe. Studies have shown that the persuasiveness of a message increases with
the communicator’s perceived credibility and expertise (Eagly & Chaiken, 1993; Petty & Cacioppo, 1986). Since Aaron was able to synthesize his faith (though no longer fundamentalist) and his understanding of science, he can help students do the same—though he talks in terms of what works for him, not the “correct” way to do it. These experiences have even prompted him to write an essay about cognitive dissonance that he refers to students in need. He has received course evaluations from creationists who thank him for his understanding and “how good it is to be able to challenge the instructor and have the instructor open to it.” He also reports one of his “favorite students” is a biology major who rejects evolution, but they maintain a friendly, respectful relationship outside of class.

Although Brett grew up in a different culture than Aaron, he also informs his students that he reads extensively about both sides of the issue and can articulate the differences in thought. He tells about how he knows he has helped these students.

I’ve got a bunch of emails—I just found one the other day. I’ve probably gotten twenty letters over the last fifteen years from kids that I had real challenges with—who emailed me and said, “Thanks a lot. I was a jerk in your class. I was a real thorn. I didn’t get it. You introduced me to it and now I understand it.” And that’s gratifying. That’s huge. And I have to think that for the twenty that have written me, I’d like to think that there are five times that many that haven’t written me. And so, you know, that’s all we can do.

Tina believes that her experience in the Southeast, where there was a strong resistance to evolution, has helped her to understand where students are coming from and where their
dissonance and misperceptions originate. Before she stressed relationship building, she found that students would “think that you don’t understand, that you’re miseducated, or they are going to hate you.” It is unlikely that students with this perception of their teacher will learn much about a theory that challenges their worldview. Paul has also spoken to students outside of the classroom on a number of occasions. He has even offered to meet with the “family members” who are struggling on his own time, and offered them his book. Lindsay claims that those personal conversations outside of class “really build the relationship” and it positively affects students’ attitudes and engagement in class.

Helping student resolve their cognitive dissonance is not an easy task. It is not simply a matter of teaching and re-teaching content so students understand and transform their worldview. It is a complex issue where teachers must tread lightly—lest students entrench themselves so deeply in their beliefs that they approach the entire process of science with suspicion, disdain, or reject it completely. The participants take time clearing up misconceptions, accept and welcome challenges and rebuttals, and build trusting relationships with their students. Although they may not convince all of their students that evolution occurs, they may at least encourage them to consider the evidence that supports it and help them to understand why scientists consider it a unifying theory in biology.

**Thematics**

Four themes emerged from the five stories that were told. Although all participants were not in the same predicament or situation at the beginning of their
careers, they all did similar things that improved their practice. It is my hope that these themes are shared with all science teachers who find themselves anxiously anticipating the teaching of evolution in their classroom.

**Gain confidence.** New teachers are often given the reassuring advice: Remember—you know more than the students do. While this is probably true most of the time, it does not mean that all science teachers are equally knowledgeable about evolutionary biology or science in general. Although teachers are expected to meet minimum requirements for teacher licensure or certification in secondary science, many have a poor understanding of evolutionary theory (Berkman & Plutzer, 2010; Moore, 2002; Rutledge and Warden, 2000). This information, gathered by personal experience, is well known by all of the participants in this study. To determine if this knowledge is only known only by teachers “in the trenches,” I asked the school board president of a large public school district if he believed that high school teachers knew enough about evolution to teach it properly. He responded:

No, they don’t—particularly a teacher who has only been teaching five or six or seven years. Absolutely not. They might have learned the very structure of it, but they haven’t put it together. And I think for the very experienced teacher—once you put it together, it’s potent, it’s strong, and it makes you a much better teacher.

But do they understand it? Well, absolutely not. And I’ll tell you, once you don’t understand it in the beginning, it’s scary to teach, because you don’t understand it. And to you there’s only people who disagree with it. You’re better off not doing anything. And if you don’t do anything, you don’t get any better. And once you
don’t get any better, you’re in trouble. I mean, you’re in big trouble. (D. Lundberg, personal communication, April 16 2012)

As the board president stated, teachers may find it “scary to teach” a topic that they do not know much about. With a topic that carries the emotional baggage that evolution does, students may be more likely to challenge a teacher—particularly if that teacher displays a lack of confidence or knowledge in the subject. Any wavering on the part of the teacher may be construed as a chink in the armor of the theory of evolution. Unquestionably, this is what the clergy who instructed students to challenge the participants with creationist literature hoped to achieve.

It should be a professional goal of all teachers to increase knowledge and understanding of the topics they teach. This could potentially lead to more relevant activities, problem-based learning, and real-life examples for students. Perhaps even more importantly, it can lead to increased teacher confidence. Evolution can be a highly stressful topic for many teachers, but that stress is reduced for teachers who are more confident and comfortable with the material (Griffith & Brem, 2004). This confidence can be increased by more training. Not only can individuals do research on their own, but they can attend conferences and workshops or at least meet with other teachers to discuss content and pedagogy. Moore (2002) argues that biology teachers need to take more courses in evolutionary theory to not only increase their own knowledge in the topic, but to improve their students’ knowledge of evolution as well.

A solid knowledge of evolutionary theory itself may not be enough to evoke confidence in dealing with the controversy surrounding the topic, however. Teachers
would serve themselves well to be familiar with creationist challenges and appropriate responses. While some teachers may favor ignoring creationist arguments so as to not give credence to them, decades of ignoring such concerns have not succeeded in significantly improving students’ understanding of evolution (Alters, 2005).

Additionally, many of the challenges that creationists pose reflect a misunderstanding of the nature of science. Science teachers require a good knowledge of the workings and merits of science in order to demonstrate the strength, relevance, and utility of the theory of evolution.

Solid pedagogy is also necessary when dealing with teaching the topic of evolution. Since evolutionary theory brings up issues that do not accompany other scientific concepts, an understanding of cognitive dissonance theory and conceptual change theory could be beneficial for teachers. Understanding that students do not readily accept new ideas based on logic and empirical evidence may increase teacher empathy and may help them prepare for possible confrontations that they may experience. It may also lead teachers to approach the topic altogether differently than they normally would.

With a good understanding of evolutionary theory, creationist positions, the nature of science, and how students deal with new concepts, teachers can be confident when they must respond to student questions in class. When teachers realize the strong relationship between the nature of science and evolutionary theory, as well as see how evolution can be a binding theme of all biological units in their course, they can front-load their curriculum in order to divert potential confrontations.
Front-loading curriculum. Most of our participants learned that their students had a poor understanding of evolution, as well as the nature of science, the hard way—when faced with challenges from students in class. Tina referred to this reactionary method as “teaching back”—making important points along the way rather than setting them up as targeted learning objectives. Paul admits that he couldn’t confidently respond to many of the challenges, and Brett was originally surprised that there were challenges at all. Perhaps these teachers took it for granted that high school students understood the characteristics of science as opposed to other ways of knowing. Middle schools tend to emphasize the scientific method and experimentation procedures, but little may be taught regarding science as a philosophy. The participants in this study, after experiencing their students’ lack of understanding of the nature of science and how it related to evolution, decided to be proactive with their curriculum.

Frontloading the curriculum with the nature of science tends to head off potential areas of conflict. Helping students understand that science seeks natural explanations for naturally occurring events helps to divert questions about divine interventions. The fact that science does not base conclusions on authority can help students realize that religious dogma is irrelevant in science when compared to measurable evidence. The tentativeness of science and its ability to be revised when better evidence becomes available is in direct opposition to an inerrant perception of the Bible. Science mandates that theories are falsifiable while religious ideas, specifically in the supernatural realm, are not. Disagreements between scientists are viewed as an asset rather than a liability—it can drive scientists to further study and reach greater understanding. Challenges in science
are expected and welcomed—as long as the challenges are within the boundaries of science and not influenced by politics or religion. Conclusions in science are not foregone. As Aaron stated,

Science corrects itself and is looking for evidence that it got something wrong—which is at complete odds with religious thinking. In religious thinking you don’t set out to find out that you are wrong. You set out to further understand what you already knew to be true. But the idea that you might, at the end of a Sunday school class, conclude that God does not exist does not take place.

Because of these different rules, science does not look to replace faith or religion, and it has no interest in pretending that it can. Science and religion fill different niches in the human psyche. If students understand these important concepts prior to studying evolution, many of the arguments may take care of themselves.

Although many high school biology textbooks have a small section or opening chapter on the process of science, few have the characteristics of science recurring throughout the book, and most, if any, do not have a section outlining the difference between scientific thinking and religious thinking. It is primarily up to the teacher to make those connections. I am not an advocate of strict teaching from the textbook, but teachers new to the profession often have few resources outside of the text and list of state or district standards. As mentioned in the first theme, seeking training or doing individual research is essential to competence and confidence in this area.

It takes considerable time and effort to plan a curriculum which introduces, integrates, and refers back to these ideas over the course of the year. However, if the
nature of science is as important as all of the participants declare it is, it is time well spent. As mentioned earlier, students who are explicitly taught the nature of science have demonstrated statistically significant improvement in their understanding of evolutionary theory.

In addition to the nature and characteristics of science, most of the participants in this study also front-load the topic of evolution. They now teach it early in the year so they can refer to the evolutionary connections in all units of biology. They use it to explain why things work the way they do and demonstrate comparisons among organisms. Brett believes that by mentioning the term “evolution” all year long, it makes students more comfortable with it and reduces anxiety. Several participants teach evolutionary theory alongside of the nature of science. The historical progression of the theory of evolution can be used as an excellent example to demonstrate the development of a scientific theory. With careful planning, the strands of the nature of science and evolution can be woven together to create a rope that ties all of biology together.

It is true that some inexperienced teachers are “keeping one or two days ahead of the kids” in terms of what they are teaching and the pedagogy behind it. While this is understandably necessary in some cases, teachers new to the profession or new to teaching biology courses would behoove themselves by planning their curriculum far in advance. This is necessary if the class is set up with evolution and the nature of science as intertwining themes.

Careful planning of curriculum can help to alleviate some of the questions and challenges that come with teaching evolution. A curriculum exposing students to the
theory of evolution early on, demonstrating that the theory is based on solid science, and filled with lessons and activities that present empirical evidence in support of the theory may help students to understand it much more than if the theory is treated as just another unit of study in biology. However, it may not be enough to convince students to accept it as the best explanation possible.

Educate, don’t indoctrinate.

While conducting this research, I became interested in how students change their opinions. As a scientist, I assumed that any reasonable person would accept a theory when presented with an airtight argument supported by loads of evidence. As a teacher, I learned (as did the participants in this study) that this is usually not the case. Students hold tight to their beliefs, even when they can articulate the evidence against them. Cognitive dissonance theory tells us why. Tavris and Aronson (2007) call cognitive dissonance a theory of blind spots—a theory of “how and why people unintentionally blind themselves so that they fail to notice vital events and information that might make them question their behavior or their convictions” (p. 42). Ironically, the human brain seems to have evolved the motivation to reduce dissonance so people can more easily justify their creationist beliefs in the face of opposing empirical evidence.

Students’ feelings of knowing about creationism, their personal sense of purpose stemming from their faith, or a fear that accepting evolution will link them to societal ills, present a ruthless challenge for teachers trying to convince students to accept evolution. For the participants in this study, that is not a battle worth fighting—for practical or even ethical purposes. As Aaron stated, “My job is to educate, not to indoctrinate.” All other
participants agreed that it is not important for their students to accept the theory, but it is imperative for them to understand it. That may be all that biology teachers can hope for. Burton (2008) summarizes the reason quite eloquently:

Imagine the sense of purpose as a powerful committee member within the hidden layer. It carefully weighs all inputs, positively weighting those experiences and ideas that feel right while negatively weighting those that feel wrong, strange, or unreal. The best that a rational argument can accomplish is to add one more input into this cognitive stew. If it resonates deeply enough, change of opinion might occur. But this is a low probability uphill battle; the best of arguments is only one input pitted against a lifetime of acquired experience and biological tendencies operating outside our conscious control. To expect well-reasoned arguments to easily alter personal expressions of purpose is to misunderstand the biology of belief. If there is to be any rapprochement between science and religion, both sides must accept this basic limitation. (pp. 183-184)

When teachers have a curriculum in place which they are comfortable and confident teaching, and they are relieved of the self-imposed pressure that they must convince their students of the “truth” of evolution, they can focus more on making connections between students and themselves. Emphasizing that it is the objective to have students understand the theory rather than accept it may go a long way in developing the relationship between the students and that teacher. This relationship may be no insignificant matter in students’ understanding of evolutionary theory.

**Building relationships.** Building relationships with students may be the most important thing that teachers do when preparing their students to learn about evolution. Whereas revamping curriculum to feature the nature of science works on an intellectual level, this theme works on an emotional level. As we have seen, many people rely upon emotions more than logic when evaluating conflicting ideas—regardless of the evidence
presented. A trusting relationship with a teacher may be beneficial to a student dealing with emotional turmoil surrounding conflicting beliefs.

It may be difficult for science teachers who do not share creationist beliefs to empathize with students who hold them, but it is a worthy aspiration. Alters (2005) claims:

An inability to empathize with these feelings is one of the reasons why many science instructors have trouble understanding that creationist students feel a strong moral obligation to fight against the teaching of evolution, in addition to their having incredibly strong cultural reasons to abhor it. (p.20)

Taking the time to learn about students’ backgrounds will help teachers understand the nature of their cognitive dissonance and may allow teachers to help their students who are in emotional conflict. If students trust their teacher enough, the students may be able to articulate their inner strife which is necessary to restore consonance. The participants in this study learned that this process can become cyclical. The more students begin to trust a teacher, the more they are open to discussing their dissonance. The more they discuss it, the stronger the trust and relationship becomes. The better the relationship, the more intellectual risk-taking and learning occurs.

A common stereotype about high school teachers, as compared to middle school and elementary school teachers, is that they teach content rather than students. Although high school students are exposed to more in-depth content than in prior grades, the research supports that they are more engaged, motivated, and willing to take risks when they have a connection with their teacher—especially when the content may be construed as controversial. The investment that a high school teacher makes in relationships with his or her students will benefit all individuals in the classroom. As all of the participants
in this study have learned, there is much more to teaching evolutionary theory that
teachers of evolutionary theory. Indeed, gaining confidence, front-loading curriculum,
educating rather than indoctrinating, and building relationships with students would
undoubtedly be assets in any classroom. However, as the stories of these participants
illustrate, it is not that simple. The teaching of evolutionary theory requires much more
than good content knowledge, good lesson planning, and good rapport with students.
Teaching a concept that more than half of the general public does not accept (Newport,
2009) raises issues that are not associated with the vast majority of the high school
curriculum. Weak instruction in evolutionary theory may lead to a lack of trust in or
resistance to science as a whole (Shermer, 2006). In an age where American students are
falling behind their foreign counterparts in science education (Mooney & Kirshenbaum,
2009), the stakes are much higher than in other disciplines.

**Implications, Suggestions, and Directions for Further Research**

If biology is a graduation requirement for most high school students, and
evolution is indeed the unifying theory behind all biological concepts, then it would be
beneficial to students to ensure that the theory is being taught adequately. This can be
accomplished, in part, by training teachers properly. As we have seen, this does not just
mean that teachers should take more courses in evolutionary theory, although that can
certainly help build teacher confidence and reduce stress, but should address common
creationist arguments, a solid foundation of the nature of science, a foundation of
cognitive dissonance theory and conceptual change theory, strategies on creating an intellectually safe classroom, and effective ways of building student-teacher relationships.

Some of the participants, after interviewing with me, realized the importance of the knowledge and experience they had in this area and expressed interest in sharing it. They talked to me about potentially setting up a training for biology teachers in their building. Administrators would be wise to support such a training by giving the teachers time to prepare and provide time for others to attend it. They could solicit the help of teachers with the appropriate experience and strategies to offer training for all life science teachers in the district.

Additionally, administrators could financially support teachers by sending them to conferences run by outside organization or pay to bring in experts to provide appropriate professional development. Providing all science teachers with instructional resources for evolution and the nature of science beyond the classroom text would also prove to be valuable. Administrators can front-load to help with potential controversy as well.

It would also be beneficial for administrators to attend the aforementioned trainings with their teachers. In recent years, several science organizations have realized “that good science education requires consistent and creative support from principals, the most powerful decision makers in almost any school” (Cavanagh, 2008, p. 8). For administrators to recognize if solid instruction is going on in this area, they must understand it as well. With student performance recently entering the conversation
regarding teacher evaluation, administrators need a strong sense of what good instruction in these areas looks like.

When hiring new science teachers, administrators could incorporate interview questions which will shed light upon whether the applicant has knowledge of the evolution controversy and the nature of science. This can inform decisions on who to hire as well as what trainings a new teacher to the building may require. Directing new teachers to the appropriate resources may also help decrease teacher burn out that could be affiliated with a potentially contentious environment where they are frequently challenged and have a lack of confidence.

Teacher preparatory programs would be doing a great service to pre-service science teachers to incorporate nature of science education into their curriculum. Perhaps creating a unit on the nature of science could be a class project which pre-teachers could use when they enter a classroom of their own. Front-loading a curriculum does not have to be done only once a job is secured.

Giving pre-service teachers a better foundation of cognitive dissonance theory and conceptual change theory would also be a wise practice for teacher preparatory programs. Even if the teachers will never dabble in evolutionary theory, there will undoubtedly be times where students’ misconceptions interfere with their understanding of some concepts. Knowledge of how students process information that may conflict with what they already know can only be beneficial to these teachers.

All of the participants expressed that high school was the appropriate place for teaching evolution—both in terms of content and intellectual development. High school
students are becoming aware of how to articulate their own world views and are beginning to be able to identify personal biases. Paul expressed that high school students are questioning authority, and that leads to great conversations. He thinks students are mature enough to be forced to think a bit differently, and to be uncomfortable in class. If not, “then there is no real learning going on.” Aaron believes that parents, even creationist parents, want their child’s worldview challenged as part of their education—but only in later years, and only if the students “come out maintaining a creationist perspective.” However, all participants would like to see much more focus on the nature of science at the middle school and even elementary level. Further research concerning the impact of a strong nature of science education in middle school on the understanding or acceptance of evolutionary theory in high school would be beneficial to secondary educators. It would also be useful to see the impact of such an education on a student’s confidence to learn and perform science.

My research showed that there seemed to be a distinct difference between how male and female teachers approached intellectual safety in the classroom. Although all participants mentioned the importance of building relationships, the female teachers, especially Tina, actually worked these skills into lesson plans and dedicated class time to them. Whether students perceive to be more intellectually safe in the classroom of a male or female teacher may be worthy of further research. The results may be relevant to how students deal with their cognitive dissonance surrounding evolution.

Although on the surface it may seem extreme to go to such lengths on one particular topic, the implications are far-reaching. As repeatedly stated, evolution is a
unifying theory which is critical to understanding the life sciences as a whole. The nature of science gets to the heart of scientific literacy, and we as a nation are falling behind in this area. Perhaps with a solid understanding of the nature of science, students may begin to evaluate other scientific ideas—such as the origin of the universe, global warming and climate change, stem cell research, and genetically modified foods—with logic and reasoning rather than raw emotion.
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Appendix

Evolving Minds—Interview Questions for Participants

Interview 1

1. When were you first exposed to the theory of evolution?

2. How did you come by your own understanding of the theory of evolution?
   a. Were there any individuals that helped you with your understanding?
   b. If so, how did those individuals influence you?

3. Did you ever experience cognitive dissonance between what evolution states and your own personal beliefs?
   a. If so, how did you deal with it initially?
   b. How did you resolve the issue?

4. How did you come to be a teacher of evolutionary theory?

5. How important is it for students to understand the theory of evolution?
   a. If it is important, why?
   b. Do you express the importance to your students?
   c. If so, how do you do this?

6. Where does the theory of evolution fit into your curriculum?

7. How much time do you spend on the theory of evolution each year?

8. How do you prepare your students for the study of evolutionary theory?

9. What activities and teaching methods do you use to help teach evolution?

10. How do you identify cognitive dissonance within students?

11. How do you help students deal with this cognitive dissonance?
12. What strategies do you employ to help students deal with the integration of new evolutionary knowledge with their prior beliefs?

Interview 2

1. Describe your experiences dealing with antievolutionist pressures in the community.
   a. Where does this pressure come from?
   b. How, if at all, has this pressure changed your practice?

2. Outside of students, have you encountered any antievolutionist pressures within your school?
   a. If so, where did they come from?
   b. How, if at all, has this pressure changed your practice?

3. How do you deal with student resistance to evolution in the classroom?
   a. How do you engage students who are resistant to learning about evolution?
   b. How do you respond to verbal expressions of resistance in the classroom?
   c. How do you provide an intellectually safe learning environment in your classroom?
   d. Do students in your class feel intellectually safe if they disagree with evolutionary theory? If so, how do you know?
   e. Has your relationship with your students changed when you address their cognitive dissonance? If so, how?
4. Do students’ preconceived ideas interfere with their understanding of evolution? If so, how?

5. In your experience, what misperceptions do students have about evolution?
   a. Where do you think these misperceptions come from?

6. What strategies or activities do you find the most effective in understanding the theory of evolution?

7. What do you find the most challenging about teaching evolution?

8. Describe any training you have received regarding dealing with the controversy surrounding evolution.
   a. Who provides the training?
   b. What professional development opportunities have you pursued outside of what the school or district provides?
   c. If you have received training or professional development in this area, what was the most helpful to you?

9. In an ideal world, what do you wish students already understood about evolution or science in general when they come to your class?

10. What is the most important thing that you hope students leave with after your unit on evolution, or your class in general?

11. Is it important to you that your students accept evolution rather than just understand it?

12. How have your personal experiences with understanding evolution affected the way that you teach evolution?
13. Has your approach to teaching evolution changed over the time you’ve taught the subject? Why?

14. Is high school the right place to teach evolution?

15. Do you believe most high school teachers know enough about evolution to teach it properly?