A CARIBBEAN STORY: THE ROLE OF SCIENCE STANDARDS AND BIOLOGY TEACHERS' ACCEPTANCE AND UNDERSTANDING IN SHAPING EVOLUTION INSTRUCTION IN BELIZE

By

ELVIS ENRIQUE NUNEZ

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2009

To my mom; my loving partner; and all who guided my learning and provided unconditional support

ACKNOWLEDGMENTS

I thank the chair of my committee, Dr. Bruce MacFadden as well as Dr. Rose Pringle, Dr. Betty Dunckel and Dr. Colette St. Mary for their unconditional support and mentoring. I thank the research participants for supporting this project and providing honest responses. I also thank my parents, my sisters, and my partner for their constant encouragement during this study. I would like to extend my sincerest gratitude to everyone that has contributed in one-way or another to the completion of this thesis. Especial thanks go to Kevin Showalter for assisting with the data collection and revision of the thesis, Choi Bongsam for his assistance with the Rasch Model, Ms. Olga Manzanero for assessing the content and face validity of the instrument, Mr. Jude Lizama for his expertise on the CSEC examinations and Melania Lopez for facilitating the delivery of the thesis. My research was primarily funded by the Dickinson Fellowship awarded by the Florida Museum of Natural History and the Alumni Fellowship awarded by the University of Florida.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CXC	refers to the Caribbean Examinations Council
CSEC	refers to the Caribbean Secondary Examination Certificate
MATE	refers to the Measure of Acceptance of the Theory of Evolution

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science

A CARIBBEAN STORY: THE ROLE OF SCIENCE STANDARDS AND BIOLOGY TEACHERS' ACCEPTANCE AND UNDERSTANDING IN SHAPING EVOLUTION INSTRUCTION IN BELIZE

By

Elvis Enrique Nunez

December 2009

Chair: Bruce MacFadden
Major: Zoology

Belize, a sparsely populated, English-speaking nation with a high school system modeled after strict Caribbean standards presents a unique opportunity to investigate the current state of evolution instruction in the region. Worldwide studies have shown that teachers' personal views and understandings can shape their instructional approaches and influence the content taught in science classrooms regardless of predisposing science standards. This study investigates the current level of acceptance and understanding of evolution as given by 97% of all high school biology teachers in the country using a well-supported survey instrument and a collection of local and regional science documents. Overall, biology teachers had a poor understanding of evolution with teachers scoring between 9.5% and 80.9% ($\bar{X}$ = 47.9%) on the knowledge test. The disconcerting results span the entire teacher population irrespective of differences in sex, academic qualification and school location. This study also looked at some of the factors associated with teachers' acceptance of evolutionary theory. A positive correlation was found between teacher acceptance and understanding of evolution. In addition, both acceptance and understanding were

positively correlated with increasing years of teaching experience in biology. The analysis of course outlines and regional examinations suggests that evolution plays a minimal role in science standards and standardized tests in the Caribbean. Although non-significant, teacher acceptance and understanding of evolution increased with increasing use of the CSEC biology standards. The overall results suggest that although poor science standards and inadequate levels of acceptance and understanding afflict Belize, there is room for improvement since a majority of the teacher population is conflicted about evolutionary concepts and 57% self-proclaim to be unprepared to teach evolution.

CHAPTER 1
GENERAL INTRODUCTION

Importance of Evolution

Evolution is the major unifying theory in the biological sciences (American Association for the Advancement of Science, 2002; National Academy of Science 1998,1999; National Association of Biology Teachers, 2000; National Science Teachers Association, 1997). As one of the most significant scientific contributions of the last two centuries (Bybee, 2002), evolution has helped to explain fundamental features of the natural world, such as: "similarities among living things, diversity of life and various features of the physical world we inhabit" (National Academy of Sciences 1998, p.3). As the most contemporary problem-solving tool available to biologists (Scharmann, 2005), the theory of evolution has the potential to explain both the unity and diversity of life (Kampourakis & Zogza, 2008). In addition to explaining the natural world, evolution contributes to a more holistic understanding of the nature of science and the dynamic state of scientific knowledge (Anderson, 2007; National Academy of Sciences, 1998). Furthermore, this well supported theory provides the major conceptual and organizational idea behind diverse components in the life sciences (Bybee, 2002). The famous geneticist Dobzhansky said it eloquently when he stated that "nothing in biology makes sense except in the light of evolution" (p. 125) - a claim widely accepted by most scientists today (National Academy Sciences 2008a).

Despite being a controversial topic, the theory of evolution has survived a century and a half of scrutiny, ridicule and experimentation due to the incontrovertible evidence supporting it in nearly all aspects of life on this planet (Rutledge & Warden, 2000). A deeper understanding of the theory of evolution and its relationship to our planet will be indispensable as human societies strive for sustainable ways of living and interacting with the natural environment (National Academy of Sciences, 1998). Facing the contemporary challenges that afflict our planet will require proper standards of evolution instruction that will provide teachers, students, and the public with the necessary tools to take a proactive stance. The underlying principles of evolution provide an essential framework to understanding the role of human societies as individual yet cohesive units within a complex and ever-changing world (Brem et al., 2003).

Although the theory of evolution is well supported and mostly non-controversial within the scientific community, its ideas like many others in science have yet to make the transition into mainstream thought (Allmon, 2006; Rutledge & Warden, 2000). This disparity is largely the result of decades of ineffective communication on the part of researchers, educators, and the general public (Rutledge & Warden, 2000). The overlap between science and society further complicates the dissemination of evolution into the classroom, leading to less competence in discussing controversial issues (Cobern, 1994; Hermann, 2008) since teachers are influenced by their cultures and societies (Hokayem and BouJaoude, 2008). Although the theory of evolution is applicable in all areas of the life sciences, for example, agriculture, health care, and conservation, the communication of unbiased accounts of the theory at all levels of the education system remains a daunting task (Crawford, 2005).

Fostering an understanding of evolution is central to improving scientific literacy (Cummins et al., 1994; Prinou et al., 2005). But it is only through the integration of evolutionary theory into mainstream thought that we can lead to more scientifically literate and environmentally conscientious societies. Scientific literacy, itself, can only be enhanced if we address the most important mediators in the education system: teachers - the primary mediators of scientific knowledge between the scientific community and the general public in most developing countries. Teachers have the authority to choose what is placed in the curriculum and taught in the classroom, thus determining the quality of science education presented to students (Abell, 2007). Since teachers could very well impact the quality and nature of evolutionary content in the syllabus, or distort it with other theories, the possibility of teachers cheating our future scientists of scientifically accurate content is all too great. For this reason, research on teachers' attitudes, content and pedagogical knowledge is salient in the quest towards curriculum reform as it pertains to evolution instruction.

The variations among teachers' personal epistemologies and understandings of evolution, particularly how the theory pertains to everyday life, can have serious repercussions for evolution instruction (Anderson, 2007). As evidenced by survey data in the United States, teachers’ views on the topic are as skeptical as those of the general population (Anderson, 2007; Osif, 1997; Rutledge & Warden, 2000). Skepticism about pivotal topics like evolution, and failure to provide a sound and holistic understanding of science, presents a roadblock in stimulating the intellectual growth and development of students. In contrast, teachers are encouraged to familiarize themselves with research in the field in an effort to deepen and remain current on the science content so they provide students with accurate information. As continuous learners, it is important that teachers build on their knowledge of factual information pertaining to evolution so they provide unbiased accounts of the topic. Failure to do so results in limited conceptions of what it means to be a teacher (Anderson, 2007).

Because students' views about the theory of evolution are so varied, the role of teachers in guiding their learning is challenging but necessary in order to encourage alternative ways of thinking about the world (Anderson, 2007; Crawford, 2005; Tobin et al., 1990). The role of the teacher of evolution is therefore to provide students with appropriate experiences to develop conceptual maps and internalize where and how they personally fit into it.

The teaching of evolution requires that its content be understood from a biological, intellectual, environmental, pedagogical and social context (Anderson, 2007). From a biological standpoint, it has profound implications for understanding: a) the need for genetic variability and high biodiversity, b) the mechanisms underlying genetic heritability, c) the consequences of exploiting natural resources, d) the transmission and virility of pathogens, and e) our connection to and interdependence on all ecosystems. Thus, content communicated to students has profound philosophical and intellectual implications (Anderson, 2007), particularly when it comes to integrating the understanding of different fields into a common understanding of science and its importance to everyday life. The benefits of teaching biological evolution could have profound positive effects on the understanding of social and health related problems such as obesity, disease, and undesirable personality traits afflicting a region (D'Adamo & Whitney, 1997; Hamer & Copeland, 1998). Despite these benefits, low levels of evolutionary knowledge as well as inadequate pedagogical skills continue to prevent the topic from being further disseminated into classroom.

Literature Review

By revisiting the considerable amount of work focused on evolution education, this literature review seeks to set the stage for exploring teacher acceptance and understanding of evolution. It will first focus on the problems associated with evolution instruction, and later move on to address research on acceptance and understanding of evolutionary theory, the role of science standards and standardized tests in evolution instruction, common misconceptions about evolution, and evolution in the science curriculum.

Limitations to Evolution Instruction

Both scientists and major science education policy documents (American Association for the Advancement of Science, 1993; National Research Council, 1996) have endorsed evolution as a unifying theme in biology (Deniz et al., 2008). Over the past three decades, the treatment of evolution in state standard documents in the United States has varied in quality and quantity (Lerner, 2000; Donnelly & Boone, 2007). Since initial reforms in the 1980s, multiple organizations [National Science Teachers Association (NSTA), National Research Council (NRC) and the American Association for the Advancement of Science (AAAS)] have developed national science standards that have been incorporated into state standards (Raizen, 1998). These suggestions, however, oftentimes fail to make it into the classroom because of teachers' personal attitudes, beliefs, and discretion (Aguillard, 1999; Shankar & Skoog, 1993).

The limitations to teaching evolution go beyond the obvious issues with this controversial topic, and manifest themselves in all levels of the education process as either limited or inaccurate content knowledge. Many studies have shown that instruction in this area has been desultory and limited by poor science standards, teachers' personal religious beliefs and insufficient content knowledge (Rutledge & Warden, 2000; Shankar, 1990). Teaching the subject is difficult because its understanding is based on concepts from various disciplines and because acceptance can be influenced by personal epistemologies (Kampourakis and Zogza, 2008). A serious problem arises when teachers take a one-dimensional approach to teaching evolution (Anderson, 2007). When evolution is presented to students as a complex entity independent of other biological concepts, it prevents the intellectual understanding of the topic. Furthermore, studies have shown that evolution is presented as a recitation of historical Darwinian facts, with little meaning or application to daily activities and life processes (Catley, 2006). This highly skewed form of evolution education fails to acknowledge the totality of evolutionary theory (Anderson, 2007).

In particular, macroevolutionary concepts have typically represented a “black hole” in evolution instruction (Catley, 2006). Evolution at the macro-level is poorly presented in many high school textbooks, (Catley & Novick, 2009). Major topics that remain largely unaddressed are: species, phylogenetics, and deep time (Catley, 2006). Of these, the understanding of deep time (Dodick & Orion, 2003; Trend, 2001) and the interpretation of species have resulted in a small body of literature. Research has been focused on the more popular, population-level processes like natural selection, as models to understand how people think about evolution (Catley, 2006). Because evolution instruction is heavily weighed in favor of microevolution, teachers have a poor understanding of the processes that operate at the macro-level (Catley, 2006). It is therefore important to focus on teachers’ understanding of many challenging macroevolutionary concepts, including deep time, natural hierarchy, character evolution, extinction, and synapomorphies (Catley, 2006). Within the classroom, the overarching goal should be to teach evolutionary theory using examples from both micro- and macro- standpoints under the collective theme of molecular, individual, population, and ecological modifications (Catley & Novick, 2009).

Acceptance and Understanding of Evolution

While acceptance and belief are used interchangeably in the literature, belief implies lack of evidence in developing conclusions while acceptance of a concept implies that evidence has been weighed to assess its validity (Hermann, 2008). Many science education researchers (see Demastes et al., 1995, Lawson & Worsnop, 1992) use the term belief for consistency with the literature. For the purpose of this study, I focus on teacher acceptance of the theory of evolution. Because some aspects of the theory of evolution are more accepted than others, it is important to note that non-acceptance does not imply total rejection of evolution (Donnelly et al., 2008; Hermann, 2005). However, non-acceptance of the theory of evolution can seriously hinder classroom experiences during evolution instruction. The acceptance of evolutionary theory is related to an array of complex factors. Demastes and others (1995) posit that a lack of acceptance may result from: a) prior conceptions related to evolution, b) degree of scientific literacy and understanding, c) view of nature, d) view of the biological world, and e) religious orientation. In addition, other factors are potentially correlated with the acceptance of evolutionary theory, including: i) reasoning level (Lawson & Thompson, 1988; Lawson & Weser, 1990; Lawson & Worsnop, 1992), ii) perceptions of the impact of evolutionary theory (Brem et al., 2003), iii) epistemological beliefs (Sinatra et al., 2003) and iv) thinking dispositions (Sinatra et al., 2003). In turn, the quantity and quality of evolution instruction is related to the acceptance of evolutionary theory.

Teachers' acceptance and knowledge of evolutionary theory are important predictors for instructional approaches to evolution (Aguillard, 1999, Rutledge and Mitchell, 2002; Shankar and Skoog,1993). Teachers who do not accept or understand evolutionary theory may actively choose not to teach its concepts, regardless of whether it is prescribed in the syllabus or not. Many teachers fail to teach the theory of evolution because they do not accept it (Aguillard, 1999; Eve & Dunn, 1990; Shankar & Skoog, 1993), do not thoroughly understand it (Aleixandre, 1994; Rutledge & Warden, 2000) or feel ill prepared to teach it (Aguillard, 1999; Griffith & Brem, 2004). Other studies have ascribed a limited understanding of the nature of science (Rutledge & Warden, 2000), and a failure to understand the laws and protections related to the teaching of evolution to poor evolution instruction (Moore, 2004). Some teachers find evolution instruction to be stressful and conflicting with student and community beliefs (Chuang, 2003; Griffith & Brem, 2004; Scharmann & Harris, 1992; Tatina, 1989; VanKoevering & Stiehl, 1989), or too advanced for students (Aguillard, 1999). This list is by no means exhaustive since there are many interrelated factors at work when it comes to evolution instruction.

Research on the relationship between knowledge and acceptance of evolutionary theory is a growing trend among science education researchers. Studies have found that increases in knowledge of evolution can lead to positive changes in the acceptance of evolution (e.g. Lawson & Wesner, 1990), including increased instruction time. Because concepts contained in the theory can be difficult to grasp for students of all levels (Brumby, 1984; Greene, 1990; Johnson & Peebles, 1987; Lawson & Thompson, 1988; Moore et al., 2002; Woods & Scharmann, 2001), teachers' knowledge of the theory of evolution can either have positive or negative impacts on student learning.

Thus, if our aim is to improve evolution education in schools, research on the importance of teacher education as well as on the interrelated factors, acceptance and understanding, cannot be overstated. Such studies, however, require ethical considerations and must be approached with caution (Meadows et al., 2000).

Science Standards and Standardized Tests

Science standards can play both positive and negative roles in the classroom (Moore, 2002). However, even excellent national or regional standards are not always reflected in the curriculum (Korte, 2003; Moore, 2002). There are various reasons for the disconnect between state standards and the teaching of evolution: 1) many high school teachers do not accept evolution, and 2) some high school teachers who accept evolution are reluctant to teach a theory that may upset or clash with the views of students and/or their parents. Many teachers view the theory's potential for controversy as too costly in terms of classroom time, and therefore opt to leave evolution out of the curriculum (Dean, 2005). Furthermore, those topics not included in standardized tests are given least priority in the classroom, defeating the purpose of having national or regional science standards.

The use of standardized tests can have several negative impacts on science education. Some teachers view standards as creating overcrowded and disconnected curricula that cannot be successfully covered in detail (Settlage & Meadows, 2002; Wood, 1988). Most standardized tests are designed to test what students know rather than how and why they construct such knowledge. One of the major drawbacks to these tests for both teachers and students is the lack of theoretical perspectives on how scientific knowledge is developed, tested, and applied for purposes beyond the standardized test. But, although there are numerous negative attributes associated with science standards, there is evidence that good science standards can foster reform in the teaching of evolution (Donnelly & Boone, 2007; Skoog & Bilica, 2002). Thus, teachers need to do more than develop curriculum materials and instructional approaches whose goal is to inform. Teachers must bridge the gap between evolutionary content, the nature of science and the natural world in a way that is intellectually stimulating.

Misconceptions

Studies have shown that even though a majority of teachers show significant decreases in misconceptions about evolution and natural selection after being properly educated on the subject, there is still little improvement with respect to their internal epistemologies about science and evolutionary concepts (Nehm & Schonfeld, 2007). Teachers come to class bearing similar misconceptions as those held by the general public. This inherently contributes to the low levels of evolutionary knowledge and the high levels of evolutionary misconceptions held by high school biology students (Demastes et al., 1995). This alarming trend supports the need to address the loopholes associated with teacher content knowledge about evolutionary theory and their understanding of the development of theories and the nature of science. One of the most common misconceptions in evolution is the Lamarckian concept of heredity (Demastes et al., 1995; Jensen & Finley, 1996; Smith et al. 1995; Zuzovsky, 1994). To make matters worse, there is confusion over the definition of a “theory”. While in vernacular English a theory refers to a “mere guess or opinion”, in science it is understood as a scientifically valid explanation based on rigorous experimentation yet open for changes in light of new evidence. It is of interest to evaluate whether these misconceptions and others hold true in regions outside the United States, with varying cultures and education systems.

Evolution in the Science Curriculum

The controversy surrounding evolution instruction is viewed as predominantly an American phenomenon (Downie & Barron, 2000) mainly due to pervasive fundamental religious beliefs, the politicization of science and poor understanding of genetics, among other factors (Miller et al., 2006). A significant percentage of high school biology teachers in the United States are skeptical that evolution is central to the understanding of biology (Osif, 1997; Rutledge & Warden, 2000; Tatina,1989; Weld & McNew,1999; Zimmerman, 1987). Studies have shown that most American high school biology teachers either allocate very little time to evolution or omit evolution from the curriculum (Moore, 2002; Rutledge & Warden, 2000; Weld & McNew, 1999). In Louisiana and Texas, 60% and 55% of biology teachers, respectively, spend less than five instructional days on evolution (Aguillard, 1999; Shankar & Skoog, 1993). South Dakota teachers spend an average of 5.3 days on evolution (Tatina, 1989). During these times, evolution is only “briefly mentioned” or even avoided when possible. After countless courses in biological science, some teachers still disagree that evolution is central to biology (Osif, 1997), indicating that teachers are not treating evolution as an organizing principle in their classes (Donnelly & Boone, 2006).

In the United States, the treatment of evolution varies from state to state, with close to 40% of them being identified as having unsatisfactory science standards (Lerner, 2000). Lerner (2000) found that Ohio’s state standards were “useless or absent” and thus assigned them a grade of F. On the other hand, Indiana’s standards pertaining to the theory of evolution were “exemplary, and straightforward” (p. 14) and therefore were assigned a grade of A. Interestingly, however, a survey of high school students by Bandoli (2008) found that the coverage of evolution in public high schools in Indiana and Ohio was not influenced by state standards. In both states it appears that the modal time devoted to evolution was less than a week. In addition, 30% of the students suggested that evolution was not mentioned or was mentioned but not covered in their biology class. These results are consistent with the results of a 1995 survey of 552 Indiana high school biology teachers that found that 33% spent fewer than three days on evolution and 43% avoided or only briefly mentioned the topic (Rutledge & Mitchell, 2002). Alarmingly, since Lerner’s (2000) study, the number of states receiving A's or B's has declined over the years. Gross (2005), identified only 20 states as A's or B's pertaining to the treatment of evolution in their standards; 23 received either a D or an F. This de-emphasis on evolutionary instruction in state mandated curriculum shows that there is a great need for reform in state standards regarding science education.

Unlike the United States, most countries do not experience a public backlash regarding the teaching of evolution (Hermann, 2008). However, the few studies that have addressed the theory of evolution in countries other than the United States have traditionally been limited to pubic opinion and are only now beginning to investigate teachers' epistemological beliefs on the topic and factors that contribute to both acceptance and understanding (See Deniz et al., 2008; Hammeed, 2008; Lee & Yeoh, 1998). Miller and others (2006) found that European countries including Iceland, Denmark, Sweden, France as well as Asian countries like Japan, have much higher acceptance of the theory of evolution than do countries like Cyprus, United States and Turkey. Specifically, Deniz and others (2008) explored factors related to the acceptance of evolutionary theory among Turkish pre-service teachers and found that teachers' thinking dispositions (degree of open-mindedness and reflective thinking), understanding of evolutionary theory, and their parents' educational level are all positively correlated to their acceptance of evolutionary theory. However, these three factors account for only 10.5% of the variance in acceptance of evolutionary theory, leaving a majority of the variance unexplained. In addition, a substantial number of the participants did not endorse evolution as a scientifically valid theory. Although there was a positive correlation between intelligibility (understanding of evolution) and plausibility (acceptance of evolution) ($r=0.20$, $p < 0.05$), the intelligibility alone only explained 3.3% of the variance in plausibility. In a similar study, Lee and Yeoh (1998) assessed senior and junior high school teachers' knowledge about the theory of evolution in Singapore and found that both groups of teachers had inadequate knowledge levels, with senior high teachers having a significantly better grasp of the content.

Although research pertaining to evolution acceptance and evolution instruction has been conducted in several countries, the scarcity of published work indicates that there is need for more research that looks specifically into teachers' acceptance and understanding of the theory of evolution.

Rationale for Study

Why High School Teachers?

Research that focuses on teachers' acceptance of evolution and their state of knowledge is of relevance because teachers have a profound influence on the educational setting and on the quality of knowledge transmitted to students and diffused into communities. Prior to making recommendations on how to address the theory of evolution, it is important to evaluate teacher views on the topic, as well as their teaching confidence. The personal ambiguities of teacher understanding are valuable starting points for implementing professional development programs to minimize significant roadblocks in the advancement of student learning (Anderson, 2007).

As mediators of canonical knowledge, teachers have the authority over what and how topics are presented in the classroom. It is therefore expected that teachers have a sound grasp of the nature of science and that they are capable of making professionally responsible instructional and curricular decisions (Carlesen, 1991; Rutledge & Warden, 2000). After all, the teaching of evolution depends on the individual classroom biology teacher and the attitudes that guide personal decision making (Goldston & Kyzer, 2009). Teachers' personal and professional attitudes toward selected topics can be transferred to students who will someday be teachers as well. According to Bransford and others (2000), students learn best when presented with factual knowledge and a conceptual framework that guides their organization of knowledge. Fostering such learning process is extremely important, particularly in regions where 1) teachers serve as the primary mediators of scientific knowledge, and 2) students are drafted in or out of science during early high school years. Failure to introduce students to the theory during those critical high school years can present serious problems because not all students go to college or take introductory biology courses. And even if they do take these classes, not all introductory courses teach evolution.

Setting the Stage for New Research

Research indicates that evolution instruction has been popularized and limited to the United States (Downie and Barron, 2000) and as such, little is known about its status around the world. From previous studies spanning decades, it is clear that even with the level of attention placed on evolution standards in the United States, the country is still plagued by low levels of acceptance and understanding (Lerner, 2000; Miller et al., 2006). Researchers, however, are now turning their attention to Africa, Asia, Central America and the Caribbean in an effort to contribute to the worldwide discussion on evolution education. Specifically, the current literature presents a paucity of research on teachers' acceptance and understanding of evolution in the regions of Central America and the Caribbean. This study marks the beginning of research pertaining to evolution education in the region. I, as a Caribbean national with extensive teaching experience and interest in science education, am suited to investigate the state of evolution instruction in the region. Studies like this are crucial in the quest to improve science standards and could eventually serve to expand scientific literacy, leading to a more knowledgeable citizenry capable of making educated decisions regarding the environment, health care, sustainability, and conservation.

Contextual Background on Study

Belize-a link between Central America and the Caribbean

A nation yet to be targeted by studies assessing teachers' acceptance and understanding of evolutionary theory is Belize, a sparsely populated Central American country located south of Mexico and east of Guatemala (See Fig. 1-1). Belize is a small democratic country nestled in the heart of Central America. With a population of about 270,000 people spread over 8,867 sq miles (22,960 sq km), Belize has the lowest population density in Central America and possibly one of the lowest in the world (www.pact.org). It is also one of the most ethnically diverse nations on the planet, with a colorful mix of cultures that include the Garifuna (descendants of African slaves), the

Mestizo (mixtures of Mayans and Europeans), the Creole (mixtures of African slaves and Europeans), and the Maya (Ketchi, Yucatec and Mopan) as well as the Mennonite, Hindi, Taiwanese, Chinese and Caucasians. Though Belize is the only country in Central America whose official language is English, its large Spanish and Mayan populations facilitate interactions with Central and Latin America. On the other hand, its citizens of African decent help the country to maintain strong ties with the Caribbean.

Belize boasts an impressive array of faunal species for a country of its size, including over 500 species of birds and 124 species of mammals Ninety-three percent of Belize's land is under forest cover with 42% of that land (2.6 million acres) being under some form of legal protected status (wwww.pact.org). These 2.6 million acres are subdivided into 92 protected areas, including the only jaguar preserve on the planet and the world renowned Belize Barrier-Reef System, a UNESCO World Heritage Site that serves as an important habitat for a host of threatened species. In spite of this progress, deforestation, pollution, and development continue to threaten the livelihood of these fragile ecosystems.

Education System in Belize

In Belize, the 4 years of high school is guided by Caribbean science standards designed by the Caribbean Examination Council (CXC). Every five years, the Ministry of Education receives a revised syllabus from the CXC that prescribes the content for all subjects, including biology. Although all public schools ascribe to the syllabus, private schools can opt not to. Eight years of education is compulsory for all Belizean citizens. However, only 84.7% of students make the transition from elementary school to high school (Yvonne Flowers, Statistician, Policy and Planning Unit, Ministry of Education, Belize, Personal Communication, November 03, 2009). There are no records of what proportion of these students enroll into college. Higher education in Belize was unified under the University of Belize in 2000. Today, there are four community colleges and a single university in the country.

In Belize, the dichotomy between business studies and the academic sciences in the education system places pressure on students to choose between them as early as the 11th grade. In addition, students typically declare a college major prior to exiting the 12th grade. As a result, students' views of science are fixed early in high school because most students do not take science classes past 12th grade nor pursue careers in science. Such education systems can present serious drawbacks to scientific literacy.

Educating teachers is a step towards presenting reliable accounts of evolution in the classroom and establishing the theory into mainstream thought. Studies focusing on educators are feasible in Belize partly due to its manageable number of high schools and biology teachers. Of the 48 high schools in Belize, only 43 teach biology at the 11th and 12th grade levels, and of these, 37 teach biology based on the standardized syllabus issued by the CXC. Of these, 13 are public schools, 24 are public schools with religious affiliations and 6 are private schools (Figure 1-2; High School Principals, Personal Communication, February 2008, 2009). Sixteen Caribbean nations, including Belize, administer the Caribbean Secondary Examination Certificate (CSEC) in Biology, a standardized test used to compare their performance throughout the Caribbean. Although teachers prepare students in 11th and 12th grade, students do not sit for the exam until the end of 12th grade. According to the only CSEC biology resource official in Belize, CXC has not made radical changes to their biology content in decades. The

2004 revised syllabus, which has served as the 2004-2009 teaching guide for all participating high schools in Belize, is comprised almost entirely of outdated content. The most recent CXC biology syllabus (2004) is divided into five sections lettered A through E: A) Living organisms and the environment; B) Life processes; C) Continuity and variation; D) Disease and its impact on humans; and E) Environment and human activities. Of the five sections, only section C briefly introduces the theory of evolution. Although one of the main objectives of this section is to have students "demonstrate an understanding of the importance of genetic variation in species and how these traits can be altered", there is little mention of natural selection, mutation, migration or conservation in the section.

Biology Education Program

In Belize, the biology education program is a 4-year college degree that prepares future biology teachers for the classroom. The curriculum focuses on both content and pedagogy with lectures being coupled with traditional laboratory classes and a field component at the end of the program. Teachers take General Biology, Human Anatomy and Physiology (I & II), General Chemistry (I & II), Algebra, Teaching Methods, Class Assessment, and Intro to Special Ed, in addition to other prerequisites during the first two years of the program (4 semesters). Biochemistry, Invertebrate History, Microbiology, Lower Plants, Teaching Strategies for Special Needs, Introduction to Curriculum, Philosophy of Education, Instructional Technology, Guidance Counseling, Instructional Techniques and Adolescent Psychology are courses offered in the V and VI semesters. The final two semesters include Higher Plants, Molecular Biology, Science Methods, Measurement and Evaluation, Professionalism in Education, Content Area Reading, Field Experience, Ecology and Evolution and possible elective courses.

As stated in the University of Belize catalog, the course entitled “Ecology and Evolution” is described as:

> An introduction to evolutionary biological analysis. Topics include: ecosystems; introduction to evolution; adaptation; spatial and temporal distribution; life histories; sex and evolution; population dynamics; inter-specific associations; community ecology; speciation, adaptive radiation; co-evolution. A two-to-three day field trip to one of the national protected areas is included for studying conservation.

Even though a bachelor’s degree in Biology Education is likely to guarantee a job as a high school biology teacher in Belize, an associate’s or bachelor’s degree in Biology or related science is often acceptable for the teaching position (personal observation). This is particularly true in the rural areas of the country. As a result, biology teachers in Belize may be underprepared to teach complicated units such as the theory of evolution.

Research Questions and Hypotheses

Research Questions

This study seeks to investigate the current state of evolution instruction in the Caribbean with Belize as the study site. Specifically, it includes an evaluation of biology teachers’ acceptance and understanding of evolution, the position of evolution in the local, and regional science standards and to a lesser extent, seeks to uncover possible misconceptions and limitations to the teaching of evolution in the region. This research is guided by the following four questions:

1. What is the current state of acceptance of evolutionary theory among high school biology teachers in Belize?
2. What is the current understanding of evolutionary theory among high school biology teachers in Belize?
3. What factors contribute to the overall acceptance and understanding of evolutionary theory among high school biology teachers in Belize?

4. How much emphasis is placed on evolutionary content at the local, and regional science levels, as evidenced in the science standards?

Hypotheses

1. High school biology teachers in Belize have low levels of acceptance and understanding of evolution.

2. Teachers with higher levels of teacher academic preparation are more accepting and have a better understanding of the theory of evolution compared to teachers with low levels of academic preparation. Teachers from large, urban, public schools have higher levels of acceptance than teachers from small, rural, private schools.

3. Teacher acceptance of evolution is correlated with teacher understanding of evolution, education level and increase in teaching experience.

4. Evolution plays a minor role in the regional science standards and standardized tests in the Caribbean.

Figure 1-1. Map of Belize depicting its location in Central America and the Caribbean. The number of teachers from rural and urban high schools in each of the six districts in Belize is indicated.

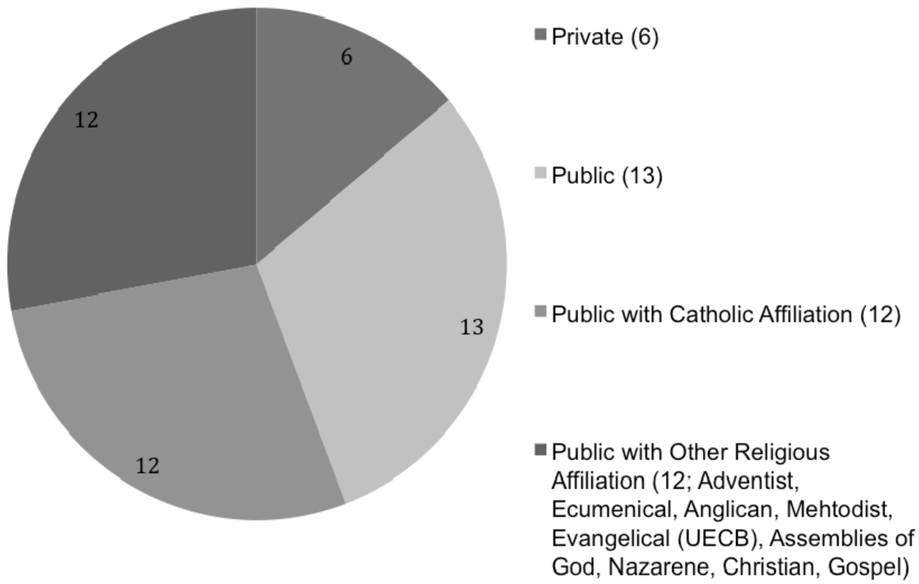

Figure 1-2. Demographics of the 43 high schools Belize that teach 11th and 12th grade Biology.

CHAPTER 2
RESEARCH METHODS

Data Collection

To answer the research questions delineated in this study, a survey employing both supplied-response and open-ended questions was modified from existing instruments used to assess acceptance and knowledge of evolutionary theory. The survey instrument was subdivided into four distinct sections. Section I, comprised of four questions that seek to elicit teacher biographical information such as type of degree and years of teaching experience. Section II was comprised of the Measure of Acceptance of the Theory of Evolution (MATE) instrument, a 20-item Likert scale developed by Rutledge & Warden, (1999). They reported that the content-validity of the instrument was established by a committee of five university professors who have expertise in the fields of evolutionary biology, science education, and the philosophy of science who were asked to rate each item on a scale of 1 to 5, and consequently, no item with a rating of less than 3.5 was included in the scale. In addition, Chronbach's alpha was 0.98 indicating high reliability. Although the instrument was designed to assess the degree to which American biology high school teachers accept evolution, the questions are of general nature and can be used in other countries provided that experts in those countries assess face and content validity. The 20 items addressed concepts such as scientific validity of evolutionary theory, creationism, the evolution of man, the acceptance of evolutionary theory among the scientific community, and the age of the Earth. For this section, the answers ranged from A-E, with A indicating 'strongly disagree' and E indicating 'strongly agree'. To assess teacher understanding of evolutionary content, an existing 21-item scale from Rutledge & Warden (2000) was used in Section III. The original scale was developed by Johnson (1985). These items addressed concepts of natural selection, extinction processes, intermediate forms, genetic variability, environmental change, and the fossil record. Scores were determined based on the number of correct responses. Section IV included 6 supplied-response and open-ended questions regarding biology textbooks, and teacher confidence levels for teaching evolution. This scale was modified from Moore & Kraemer, (2005), Tatina, (1989), and Zimmerman (1987).

The instruments used to assess acceptance and understanding of evolution in Sections II and III were selected because they had established content and construct validity as well as reliability. The instruments have also been used in similar studies worldwide (see Deniz et al, 2008, Hokayem & BouJaoude 2008; Korte, 2003). In addition to the pre-approved validity tests, Dr. Colette St. Mary, an evolution expert at the University of Florida assessed each item for both content and face validity purposes. Because sections of the instrument were originally designed to assess acceptance and understanding of evolutionary content by American high school teachers, the instrument was submitted to a science educator at the University of Belize to ensure the items were written and structured in a way that was suitable for the local population of teachers. Prior to implementing the surveys, a pilot study involving high school science teachers in Belize was conducted to assess the clarity of each item as well as the international reliability of the instrument.

In addition to implementing the surveys, 11th and 12th grade biology course outlines (syllabi) were collected from participating schools (only 31% of participating schools provided these documents) to quantify the amount of evolutionary content present in each. Past CSEC biology syllabi (science standards) and examinations from 2000-2007 were also collected from the Ministry of Education to investigate the quantity and quality of evolutionary content tested over the last decade. The 2008 report on student performance in the 2008 Biology CSEC examination was also scrutinized.

The Sample and Survey Protocol

This study targeted 11th and 12th grade biology teachers from public and private schools across Belize. A total of 61 high school biology teachers have been reported in the country (personal observation). Due to this small population, all teachers were asked to participate in the study.

Official letters announcing the study were sent by both email and regular mail to each of the participating high schools in Belize. Included in this letter were both principal and biology teacher consent forms indicating the study's objectives, procedures, potential risks and anticipated benefits, in addition to a statement providing the opportunity to withdraw from the study at any time (See Appendix C & D). All official documents, including consent forms and survey instruments were written in English, given its status as the official language and the only language used for instruction in high schools. Once all institutions received this notification, principals were contacted via phone to confirm their willingness to participate in the study. Meetings with principals and teachers as well as the implementation of surveys were done in person by the author. Only schools whose principals agreed to participate in the study were visited. Upon arrival at the school, but prior to interacting with teachers, the researcher met with the respective principal to obtain a copy of the signed “Principal Consent Form”. Once this was successfully accomplished, biology teachers of participating high schools were briefed on the project and asked to read and sign the “Teacher Consent

Form” if they agreed to participate in the study. Surveys were conducted at the teacher’s discretion, either during free class periods or at the end of the school day so as not to disrupt regular class time. Teacher(s) were directed to unoccupied classrooms and asked to complete the survey as honestly as possible. Teachers were then provided with a copy of the survey, and a “privacy envelope” to place their completed surveys (these were not opened until the data compilation phase). Teachers were given specific instructions on how to complete the surveys in addition to being briefed on the anonymity of the study, the importance of an honest response, and their ability to withdraw from the study at any particular time as indicated by UF IRB regulations (Appendix B). The researcher then left the room but remained nearby to answer structural questions. Following the completion of the surveys, teachers were asked to submit their sealed envelopes. Once the survey(s) was submitted, the researcher was available for questions and feedback on the study.

Delimitations

1. The population chosen for the study was current 11th and 12th grade biology teachers. Thus, additional teachers who had training in biology but were not teaching the course during the academic year of 2008-2009 were not included in this study.

2. This study focused on teachers in Belize and may not be comparable to situations outside the Caribbean. However, because the survey instrument has not been modified from its original version, the results can be compared to studies similar studies in the United States, and elsewhere.

3. Only schools that teach biology were targeted for this study. Schools with 11th and 12th grade science teachers but no 11th and 12th grade biology courses/teachers were removed from the sampling group since the comparative science standards for this study came from the CSEC biology syllabus.

Limitations

1. A response effect is the predisposition of a respondent to provide responses that are socially or professionally acceptable rather than expressing his/her true feelings on a

topic. In order to minimize the response effect in this study, the interviewer was careful not to talk down to the respondent or imply that there are preferable responses. In addition, surveys were short and easy to read, to prevent respondents from becoming bored or fatigued. Moreover, subjects were briefed on the importance of an honest response. Most of what we know about what is taught in high school biology classes comes from teachers' self reports (e.g. Moore 2005; Trani, 2004).

2. Because the sample size for this study was small and the fit statistics for the Rasch Analysis are sensitive to small sample sizes (i.e., n < 200 for our instrument), there is potential for misrepresentation of the MNSQ values.

Data Analysis

Analysis of MATE Likert Scale

The Likert scale from the MATE component of the survey (Section II) was scored 1 through 5, with 5 points indicating strongly agree, 4 agree, 3 undecided, 2 disagree, and 1 strongly disagree. Answers with the highest level of acceptance for the theory of evolution received a score of 5 on the scale. Because item numbers 2, 4, 6, 7, 9, 10, 14, 15, 17 and 19 were stated negatively, the scores for these questions were converted. For example a score of 5, which indicated a response of strongly agree for a negatively stated item was given a score of 1, which correctly identified a low level of acceptance. Thus the sum of the 20 items on the MATE for each respondent was restricted to the range of 20 to100 points. Based on these scores, respondents were split into two categories: an acceptance and a rejection group. Respondents with sums that were greater than 70 were placed in the acceptance group, while respondents with sums less than 70 were placed in the rejection group (Korte, 2003). Scores that were close to the cutoff mark were scrutinized. The scores for the MATE portion of the instrument were used to find the mean acceptance levels of each group. The scaled responses were also ranked per group to determine which items scored the highest for each group and which scored the lowest. To determine if the differences in average scores between the groups was significant, median ranks were tested using a nonparametric Mann-Whitney Test. A Kruskall Wallis Test was used to compare differences among the acceptance, rejection and the entire group of respondents. Differences in MATE scores among sexes, levels of academic preparation and variations in teaching experience were analyzed using the appropriate parametric and non-parametric tests (t-tests, one-way ANOVAs, Mann-Whitney, and Kruskall Wallis; data were Bonferroni-adjusted for multiple comparisons).

Rasch Analysis of MATE Likert scale

MINSTEPS version 3.68.2 was used to apply the Rasch Model to analyze the Likert scale data from the MATE instrument in Section II. This model is suitable for analyzing Likert scales and performance tests because it does not require assumptions about the sampling or normal distributions. The model creates measures that can be utilized in parametric tests by turning nonlinear, ordinal rating scales (Likert data) into linear intervals where the difference between two values is actually meaningful (Wright & Masters, 1982; Donnelly & Boone, 2007). By using mathematical formulas, the model calculates the probability that a person will get an item correct, as well as the probability that a question will be answered correctly. The resulting interval scores for both the difficulty of items and the ability of the respondents are presented in logit units typically reported on vertical rulers. The "ability" score is a perceived ability that is rescaled by the Rasch model to indicate teacher acceptance of evolutionary theory. The higher he ability score, the higher the teacher acceptance of evolution. Similarly, the higher the logit score for the item, the more difficult the item was for the respondents. Thus "difficult items" indicate items teachers disagree with while "easy items" indicate items that teachers are more accepting of. Fit statistics can be used to determine if the probabilities of the data fit the expectations of the mathematic model. Typically, if the mean square (MNSQ) fit statistics exceed 1.5 the data is viewed as being questionable.

The Rasch model also provides many tools to assess validity and reliability (Donnelly & Boone, 2007). For the purpose of this study the Rasch model, or one-parameter item-response theory (IRT) model, was used to verify that the items of the MATE contributed to a single factor and are sufficiently spread along this factor to determine recognizable acceptance levels of evolution. It can also help to evaluate whether the MATE instrument separates teachers into acceptance and rejection groups. Also, it has the ability to contrast item difficulties to see topics in evolutionary biology that are more widely accepted as well as those that are not. This has the potential to help create a “misconception profile” comprised of poorly understood or unaccepted items that can be tackled in future teacher professional development workshops.

Analysis of Knowledge/Understanding Scale

Each respondent was also given a score for Section III comprised of 21 multiple-choice questions used to assess understanding of the theory of evolution. Since there were 21 questions in this section, scores were calculated by computing the percentage of items that were answered correctly for each respondent. For this section, the sample size of the population was decreased from 59 to 55 because one teacher refused to answer the section while three other teachers only completed the first few questions in the section.

Document Analysis

In addition to implementing the surveys, official document records were collected and analyzed to quantify the presence or absence of evolution. The 2004 CSEC biology syllabus was analyzed for objectives, and units pertaining to the theory of evolution. In addition, 11th and 12th grade biology course outlines were collected from participating schools (only 31% were submitted) to quantify the amount of evolutionary content present in each. Past CSEC biology syllabi (science standards) and examinations from 2000-2007 were also collected from the Ministry of Education to investigate the quantity and quality of evolutionary content tested over the last decade. Both the local course outlines and regional syllabus were analyzed for objectives and units pertaining to the theory of evolution. The CXC report on student performance in the 2008 Biology CSEC examination was used to investigate which test questions and corresponding content areas prove difficult for students. Lastly, teacher responses to section IV of the survey instrument, which comprised of open-ended questions were coded and analyzed. The comments and concerns expressed by teachers upon completion of the survey were also used to interpret the state of evolution instruction in Belize.

CHAPTER 3
RESULTS AND DISCUSSION

Final Sample Size

All 43 high schools in Belize that teach 11th and 12th grade biology participated in the study. However, due to conflicting schedules, only 59 of the 61 biology teachers from these schools were able to complete the survey. This represents a success rate of 97%. All 59-study participants completed Section II (MATE) of the survey. However, only 55 completed section III used to assess knowledge of the theory of evolution. Only data from the 55 completed surveys were used in the analysis of interrelated factors between sections II and III. Because this study reflects almost a 100% of the biology teachers in the country, the results should generalize to the target region. By implementing the instrument in person, I was able to obtain a qualitative look at the state of evolution instruction in Belize.

The results indicate that 55.9% of the respondents were females, 78% of respondents were between the ages of 21-39, while 71.9% were from urban schools compared to rural schools. 79.7% of the respondents had at least a bachelor's degree, while 5% of the respondents only had a high school diploma. Teachers' areas of specialization included biology, biology education, pre-med, chemistry, aquaculture engineering, zoology and natural resource management. There seems to be a high turnover rate at the high school level in Belize because over 70% of the respondents have ten years or less of teaching experience and 66.1% of the respondents have taught biology for less than five years. See Table 3-1. for more detailed demographic data on the respondents.

Biology Teachers' Acceptance of the Theory of Evolution

Classical Analysis of MATE Instrument

The first research question investigated the current level of acceptance of evolutionary theory among high school biology teachers in Belize. Of the fifty-nine teachers, thirty scored less than 70 points on the acceptance scale. The results indicate that for the MATE portion of survey, the averaged total score of the respondents was 64.4 out of 100 points (N = 59, SD = ± 18.3). This is an average of 3.2 for each individual item on the MATE, which falls between undecided and agree on the Likert scale (See Table 2-2 for group means and item means). The results indicate that the average total for the acceptance group was 80.2 (N = 29, SD ± 7.9), which corresponds to an average score of 4.0. This group's average was representative of "Agree" on the Likert scale. The rejection group scored an average of 51.0 (N = 30, SD ± 11.8), which corresponds to an average score of 2.6 per item. This item falls between disagree and undecided but leans more towards undecided. The data indicate significant differences between the average of scores of the entire group of respondents, the Acceptance Group, and the Rejection group (K= 40.85, $p < 0.001$; See Figure 3-1). In general, a majority of the teachers have low levels of acceptance. These results are disheartening because non-acceptance has been linked to poor quality of instruction or even omission of topics from the curriculum.

The questions that received the lowest levels of acceptance from the respondent population as a whole were question 6 (M = 2.9, SD ± 1.6) that dealt with the ambiguity of the data supporting evolution, question 15 (M = 2.9, SD ± 1.5) that dealt with human evolution, question 3 (M = 2.9, SD ± 1.5) which also dealt with human evolution, and question 2 (M = 3.0, SD ± 1.3) that dealt with whether evolution was testable (See Table

3-2). The lowest scores for the acceptance group were received by question 6 (M = 3.5, SD ± 1.0), question 11 (M = 3.6, SD ± 1.0) that dealt with the age of the earth, and question 2 (M = 3.6, SD ± 1.2). The lowest scores for the rejection group were question 3 (M = 1.8, SD ± 1.5), and question 15 (M =1.9, SD ± 1.2). These values all fall between disagree and strongly disagree. Also, question 10 (M = 2.1, SD ± 0.9) that dealt with the scientific validity of evolution and question 14 (M = 2.1, SD ± 1.3) that dealt with evolution and the biblical account of creation scored values that indicate disagreement. The results suggest that teachers are not convinced about the testability of the theory, and are unfamiliar with the vast amounts of data from all fields of science that are in support of the theory. Teachers are also in disagreement with human evolution and are undecided about the age of the earth. According to self-reports, the primary cause of rejection is that evolution goes against the story of creation.

There are no significant differences between the acceptance levels of rural and urban schoolteachers, males and females, or among groups with differing levels of academic preparation (e.g., A.A. B.A, M.S). This signifies that non-acceptance was spread throughout the country regardless of location or level of education. There is, however, a significant difference in acceptance levels with increasing years of teaching experience in biology (K = 13.4, $p < 0.01$). Teachers who have taught biology for over ten years have significantly higher levels of acceptance of the theory of evolution than those who are new in the field. Of the fifty-nine teachers in this study, 68% report that they do teach the theory of evolution, although there is much variation in the quality and quantity of instruction. Some teachers only introduce the topic in one class, while others teach it as a unit and still a few others claim to teach evolution as an overarching theme in biology. Contrary to expectation, there is no significant difference between the acceptance levels of those that do claim to teach the theory of evolution and those that omit the theory from their curriculum. This is a troublesome finding because when teachers that do teach the concept have similar acceptance levels as those that reject the topic, the quality of evolution instruction is questionable, desultory and oftentimes presented to students as a controversial viewpoint that lacks scientific rigor. On a more positive note, there is a significant difference between the acceptance scores of those that feel prepared to teach the theory of evolution and those that feel unprepared ($t = 2.25$, $p = 0.03$). Thus, teacher confidence in teaching evolution can serve as an important predictor of acceptance of the theory of evolution. In this regard, teachers' confidence levels can be targeted there is hope of increasing teachers' affinity towards evolution.

Rasch Analysis of MATE Instrument

The range of logits for the high school biology teachers was from 4.98 to -2.05. Item logits ranged from 0.39 to -0.54. The little variation in the item measures indicates that the instrument was reliable and accurately measured the level of acceptance of the theory of evolution. The items were well targeted to measure average level of acceptance by the population. However, some ceiling effects were present (e.g. teacher no. 33 who had almost a perfect acceptance score). The variable map in Figure 3-2. shows that teachers' ability levels were higher than the difficulty of many of the items and thus the results can be interpreted with reliability. Teacher nos. 08, 17, 32, 46 and 33 had the highest levels of acceptance of evolutionary theory, while teacher nos. 13, 29, and 42 had the lowest levels of acceptance. The teachers with the highest levels of acceptance were mainly males with training in Biology and Biology Education.

The teachers with the lowest level of acceptance were mainly females with undefined areas of specialization.

Based on the item logits, the most difficult items were questions 2, 3, 6, and 15, which pertained to the scientific testability of the theory, modern humans as products of evolutionary processes, the ambiguity of data supporting evolution, and human evolution. These results of the Rasch Model are in accordance with the results from Likert Scale Analysis, which suggest that teachers reject statements pertaining to human evolution and the scientific validity of the theory of evolution. The easiest questions were questions 17 and 18 pertaining to the scientific community's acceptance of evolution, and evolution as an explanation for the biodiversity of life. Based on teachers' low acceptance levels and their belief that most scientists accept the theory of evolution, there is a clear disconnect between how scientists think and how teachers view science and its impact on the world. This brings to question the credibility teachers place on scientists and whether teachers are using well supported information in the classroom.

There were seven major misfitting cases in the Rasch model according to the calculated INFIT MNSQ (teachers nos. 5, 13, 23, 35, 41, and 44 and item nos. 19). Teacher nos. 13, 35, 41, and 44 as well as item 19 exceeded the recommended 1.6 MNSQ value, while teacher nos. 5 and 23 had extremely low MNSQ values of 0.18 and 0.26 (See Table 3-3). Because fit statistics are sensitive to a small sample sizes there is potential for misrepresentation of the MNSQ values in our study. For this reason, no teacher or item was removed during additional data analysis.

Although teachers from urban high schools have higher ability levels than those from rural high schools, there is no significant difference between the two groups (See Table 3-4). Similarly, males have higher logit scores than females. In addition, teachers over the age of fifty have higher logit scores than those between the ages of 20 to 49. In this case, “higher ability levels” could be the result of more years of experience or research on the part of older teachers compared to novice teachers. Interestingly, teachers of indigenous backgrounds like Maya, Creole, Garifuna and Mestizo have high logit scores compared to teachers of Caucasian background who have the lowest ability levels and acceptance levels of evolution. It is important to note that the Caucasian teachers are from Mennonite communities and have affiliations with the United States. If the indigenous teachers are more accepting of the theory of evolution, there is hope that in the rural areas of the country, students are being given unbiased accounts of evolutionary theory. An unexpected finding was that teachers with greater years of general and biology teaching experience have lower ability levels than novice teachers (See Table 3-4). Although the differences are non significant, the disparity could be the result of higher quality of biology education in more recent years.

Biology Teachers’ Understanding of the Theory of Evolution

High school biology teachers in Belize scored an average of 47.9 out of a 100% on the 21- multiple-choice questions that tested teacher understanding of evolution. The scores for the entire population of respondents ranged from a 9.5% to 81.0%. Almost 15% of the teachers have extremely low levels of understanding of evolution, with some only answering two of the twenty-one questions correctly. These very same teachers are responsible for providing accurate scientific information. By group, with an average of 52.4%, the acceptance group scored 10.3% higher than the rejection group. The rejection group only answered 42.1% right. There is a significant difference between the knowledge levels of the Acceptance Group and the Rejection group using both parametric and non-parametric statistics ($t = -2.52$, $df = 53$, $p = 0.015$; $U = 244.5$, $p < 0.05$). Of interest is that although there is a significant difference among the groups, both the rejection and the acceptance groups have low levels of understanding of evolution. These results were expected based on variations in training, teaching experience and limited resources.

As a group, teacher knowledge levels are negatively skewed, with most teachers having knowledge levels below 70% (See Figure 3-3). The majority of the teachers have knowledge levels between 30-50%, which I classified as having "Low" knowledge levels. No teachers were classified as being extremely knowledgeable about the theory or evolution, while only 9% were classified as having "High" knowledge levels.

The questions that were answered most poorly across the entire group of respondents as well as within the acceptance and rejection groups were nos., 23, 24, 31, 32, 36, 37, 38, and 40 (See Table 3-5). These questions pertained to the understanding of "deep time", mainly radioactive dating, age of the earth, theory of evolution, extinction, macroevolution, intermediate fossils, and natural selection. The most disconcerting find was that of all the topics addressed in the knowledge tests, the two topics that teachers knew the least about were: 1) the theory of evolution (See Q.24 in Table 3-6), and 2) the theory of natural selection (See Q. 40 in Table 3-6). These results are in accordance with previous studies, which found teachers to have inadequate understanding of the theory of evolution (Rutledge & Warden, 2000), and natural selection (Demastes et al., 1992; Moore, 2000). Over 85% of the teachers incorrectly responded to questions pertaining directly to these two topics. The distribution of responses for these two questions is provided in Table 3-6. Only 13.6% of the respondents correctly described the process of evolution as “the change of populations through time”. A majority of the respondents described evolution as either the development of characteristics in response to need, the change of simple to complex organisms or the change of populations solely in response to natural selection. With respect to natural selection, the respondents were asked which description did not form part of Darwin’s theory of natural selection. The overwhelming majority of the population (55.9%) chose organisms tend to over-reproduce themselves. Only 13.6% of the respondents chose the right response, “modifications an organism acquires during its lifetime can be passed to its offspring”. This is the Lamarckian concept of evolution and clearly continues to be a major misconception held by many educators even today (Demastes et al., 1995; Jensen & Finley, 1996; Smith et al., 1995; Zuzovsky, 1994).

Relationship between Acceptance and Other factors

The data indicate that the percentage of correct responses on the multiple-choice portion of the survey was positively correlated with the score on the MATE portion of the instrument (rs = 0.153, $p < 0.05$; Figure 3-4). Although only to a minor extent, teacher knowledge/understanding of evolution is correlated to teacher acceptance of the theory. There was no association between teachers’ age and acceptance of evolution or between the percentage of CXC standards adopted by teachers and their acceptance of evolution.

There was a significant difference in acceptance and understanding of evolution between public and private schools. Teachers from public schools scored 14 points higher on the acceptance scale and 10 points higher on the knowledge scale than did teachers from private schools. Teachers from public schools with religious affiliations scored poorer than public schools without religious affiliations, but higher than teachers from private institutions (See Figure 3-5).

Although there was no significant correlation between % of CSEC Biology Syllabus incorporated by teachers and their acceptance of evolution, there is an increase in the acceptance and undertanding of evolution with increasing use of the CSEC Biology Syllabus (See Figure 3-6). This suggests that adhering to the CSEC Biology Syllabus is better than not adhering to it at all.

A majority of the high school biology teachers (i.e. 58%) feel unprepared to teach the theory of evolution. In general, teachers who feel prepared to teach evolution have higher acceptance and knowledge levels than those that feel ill prepared to teach its concepts (Figure 3-7). Although teachers who claim to be adequately prepared to teach evolution scored 10 points higher than those who feel unprepared in terms of both acceptance and knowledge levels, the differences between the groups are insignificant.

Outdated Standards and Standardized Tests

The current CXC biology syllabus (2004) is divided into five sections lettered A through E: A) Living organisms and the environment; B) Life processes; C) *Continuity and variation**; D) Disease and its impact on humans; and E) Environment and human activities. Of the five sections, only section C briefly introduces the theory of evolution (See Table 3-7). Although one of the main objectives of this section is to have students "demonstrate an understanding of the importance of genetic variation in species and how these traits can be altered," there is little mention of natural selection, mutation, migration or conservation. Having state standards that include evolution but omit questions related to the topic in local and regional examinations presents a hurdle for evolution education. In Belize, poor science standards pertaining to the theory of evolution are accompanied by a poor representation of evolution in the annual Biology CSEC examination. As seen in Table 3-8, only two questions on average (7% of the entire assessment) pertain to the theory of evolution. Although other test questions may indirectly pertain to the theory of evolution, students' poor performance on the standardized test indicate that they have yet to make the necessary transition from viewing evolution as an independent theme to viewing it is the underlying theme behind all life processes (CXC Report 2008).

The 2008 report from CXC found that 47% students have limited knowledge about fundamental concepts and principles about biological phenomena. The mean student performance on the exam was 53%. Topics that were most problematic for students included: natural and artificial selection, biological control and disease, and evolution. For example, students failed to associate the term "organism" with both plants and animals. Students also failed to understand that genetic engineering occurs at the sub-cellular level and that genes of all living organisms have a universal structure. Students are unclear about how organisms develop "immunity" and how this relates to evolutionary processes. Another common misconception among students is that antibiotics are used to treat any or every type of disease, even those causes by viruses. The presence of these misconceptions indicates that evolution is poorly addressed in high school biology courses.

Voices of Teachers

This section of the results is based on 1) discussions with teachers held after the completion of the survey and 2) responses on the open-ended questions in section IV of the survey instrument. Numerous teachers felt the need to express their personal concerns about the teaching of evolution post-survey completion. One teacher claimed that the theory “is just a theory”, and that “there is no scientific evidence to support its concepts”. Such viewpoints speak the low level of understanding shared by the teacher population. Three teachers admitted that their religious beliefs and devotions prevent them from addressing evolution in the classroom. Because less than 15% of the target population provided personal opinions post-survey completion, these three teachers represent an underestimate of the actual number of teachers who experience personal conflicts between religious beliefs and the teaching of evolution. In cases where conflicted teachers do present evolution, it is presented as one viewpoint in addition to the story of creation.

Although only four teachers attest that the content dictated by the CXC biology syllabus is the most important determinant for what they teach in the classroom, at least 81% of teachers align their instruction with this syllabus in hopes of adequately preparing their students for the CSEC biology exam (See Q.42 from survey instrument, Appendix E). Specifically, 70% biology teachers adopt at least 90% of these standards as their biology curriculum. Thus, if a topic is not included in the syllabus, there is a high probability that it will not make it into the classroom. Similar to the situation in the United States, teachers in Belize state that their primary goal is for students to do well on the externally mandated tests. Students’ performance on these tests is often viewed as a measure of teacher competency and can play a major role in the re-hiring process. As a result, curricular decisions are guided by teachers’ sense of accountability for preparing students to do well on those exams (Goldston & Kyzer, 2009).

Although most teachers adhere to the CXC syllabus, they confess that there is insufficient time to cover all its prescribed units. Of importance to this study is that the theory of evolution is only briefly covered in the CSEC biology examinations as indicated by its negligible presence in the syllabus and the vignettes offered by teachers. As a result, teachers limit evolution instruction to only what is required by the regional standards. Oftentimes, a brief introduction to the topic or a couple definitions seemed to suffice because of the test requirement. And even when evolution is required by the regional standards, there is the additional obstacle of teacher preference and conflicting beliefs. Topics that are not accepted by some teachers fail to make it into the classroom even if they are mandated by the regional standards. Still, one benefit of having great science standards pertaining to evolution is that they provide those teachers who do want to teach evolution with the guidance and justification to do so (Donnelly & Boone, 2007; Moore, 2002).

When asked, "To what extent should we care about evolution?" 51 % of teachers responded favorably, while 29% were totally against it and 20% were undecided. The variation and contradiction in teachers' responses speaks to their personal conflicts, confusion, and lack of understanding of the topic. While the majority claim that we should care to a great extent, many suggest that the topic is unimportant and irrelevant to everyday life and as such deserves less class time. Advocates for the theory of evolution claim it allows us to: 1) "be more aware of our surroundings", 2) "appreciate nature and changing environments", 3) "better understand ecology, anatomy and physiology" and 4) "allows us to obtain a deeper understanding of biology as a whole". Those against the theory of evolution state that: 1) "evolution is not true" 2) "nothing good has come out of the theory of evolution”, 3) “we should not care unless it starts to affect our daily lives, 4) “we shouldn’t care much if we believe in Creation”, and 5) “It is treated as factual in books but it is just an opinion”. The statement “ We shouldn’t care about evolution none whatsoever because there is a Creator. However, I do believe in adaptations to changing environments”, provides a perfect example of teachers’ convoluted ideas on the topic.

As evidenced by their responses in Section IV of the survey, teachers’ views on the importance of evolution vary markedly from teacher to teacher. This overall sense of uncertainty is an indication that teacher education and reeducation pertaining to the topic of evolution is necessary to achieve a comprehensive understanding of the topic.

Table 3-1. Demographic data including distribution by sex, age, school location, ethnicity/race, academic preparation and teaching experience for the fifty-nine teachers that participated in the study.

	N	%
Location of School		
Rural	17	28.1
Urban	42	71.9
Sex		
M	26	44.1
F	33	55.9
Age		
21-29	25	42.4
30-39	21	35.6
40-49	6	10.2
>50	5	8.5
N/A	2	3.4
Ethnicity/Race		
African	2	3.4
Caucasian	2	3.4
Creole	14	23.7
East Indian	1	1.7
Garifuna	3	5.1
Maya	2	3.4
Mestizo	30	50.8
Other/Mixed	5	8.5
Academic Preparation		
High School	3	5.1
Associates	8	13.5
Bachelors	40	67.8
Masters	7	11.9
N/A	1	1.7
Years of Teaching Experience		
0-2	12	20.3
3-5	15	25.4
6-10	15	25.4
11-20	11	18.6
>20	6	10.2
Years of Teaching Biology		
0-2	22	37.3
3-5	17	28.8
6-10	9	15.3
11-20	8	13.6
>20	3	5.1

Table 3-2. The mean score and standard deviation per question of the MATE responses for the entire group of respondents, the Acceptance Group and the Rejection Group. Asterisks (*) denote items that were more widely accepted. Triangles ($^{\Delta}$) represent least accepted items.

	Entire group of Respondents (n=59)		Acceptance Group (n=29)		Rejection Group (n=30)	
Item #	Mean	SD	Mean	SD	Mean	SD
1	3.44*	1.61	4.72*	0.45	2.20	1.32
2	3.00^{Δ}	1.31	3.62^{Δ}	1.24	2.40	1.10
3	2.92^{Δ}	1.56	4.03	1.05	1.83^{Δ}	1.50
4	3.17	1.32	4.07	0.80	2.30	1.12
5	3.83*	0.79	4.17	0.60	3.50*	0.82
6	2.90^{Δ}	1.14	3.45^{Δ}	0.99	3.37*	1.03
7	3.46	1.33	4.03	1.05	2.90	1.35
8	3.36	1.21	4.10	0.62	2.63	1.22
9	3.59*	1.23	4.24	0.87	2.97	1.22
10	3.08	1.32	4.07	0.92	2.13^{Δ}	0.86
11	3.05	1.09	3.55^{Δ}	0.95	2.57	1.01
12	3.32	1.14	3.86	0.88	2.80	1.13
13	3.29	1.08	3.72	0.70	2.87	1.22
14	3.10	1.43	4.10	0.77	2.13^{Δ}	1.25
15	2.90^{Δ}	1.51	3.93	1.00	1.90^{Δ}	1.21
16	3.27	1.32	4.07	0.65	2.50	1.36
17	3.64*	0.85	4.07	0.70	2.23	0.77
18	3.61*	1.25	4.48*	0.51	2.77	1.17
19	3.20	1.26	3.66	1.04	2.77	1.30
20	3.22	1.35	4.24*	0.64	2.23	1.10
Average	3.27	1.25	4.01	0.82	2.55	1.14

Table 3-3. Logit and INFIT MNSQ values for items and teachers obtained from the Rasch Model. Items or persons with INFIT MNSQ values outside the range of 0.6 to 1.4 are questionable. (**) indicate items or persons with misfitting MNSQ values that are too high. (*) indicate values that are too low.

Item			Teacher								
No.	Logits	INFIT MNSQ	No.	Logits	INFIT MNSQ	No.	Logits	INFIT MNSQ	No.	Logits	INFIT MNS
1	-0.16	0.39	1	0.91	0.22	21	0.06	0.78	41	1.86	3.06**
2	0.35	1.37	2	-1.18	1.57	22	-1.18	0.48	42	-1.93	1.38
3	0.35	0.65	3	0.55	0.28	23	0.99	0.18*	43	-0.94	0.65
4	0.16	1.05	4	0.99	1.16	24	0.32	0.56	44	0.91	2.45**
5	-0.32	1.17	5	-0.04	0.26*	25	1.27	1.12	45	0.32	0.47
6	0.34	1.32	6	-1.05	1.26	26	-0.54	1.49	46	2.9	1.63
7	-0.33	1.16	7	0.16	0.55	27	-0.54	0.89	47	-0.68	1.06
8	0.02	0.86	8	2.68	1.77	28	0.16	1.16	48	-0.68	0.91
9	0.46	1.06	9	0.55	0.85	29	-2.05	0.49	49	-0.58	1.25
10	0.17	0.69	10	-0.63	0.72	30	0.26	0.34	50	-1.24	1.22
11	0.19	1.22	11	0.01	0.93	31	1.08	1.21	51	0.83	0.48
12	0.01	1.09	12	-0.04	0.89	32	2.9	1.56	52	-0.13	1.32
13	0.09	1.21	13	-1.38	2.21**	33	4.98	1.00	53	0.55	0.75
14	0.20	0.80	14	0.06	1.15	34	0.55	0.50	54	0.55	1.98
15	0.39	0.74	15	0.43	1.25	35	-1.24	2.02**	55	-0.68	0.37
16	0.03	0.91	16	0.83	1.39	36	0.76	0.64	56	0.83	0.42
17	-0.54	1.22	17	2.9	1.17	37	-0.17	0.69	57	0.06	0.71
18	-0.51	0.55	18	0.68	0.44	38	-0.94	0.32	58	1.08	0.36
19	-0.07	1.65**	19	-0.94	1.86	39	0.91	0.36	59	1.08	1.00
20	0.09	0.66	20	0.43	1.18	40	-1.24	1.11			

Table 3-4. Logit scores for teacher abilities according to location, sex, age, ethnicity, and area of specialization. None of the differences among the groups are significant at an alpha level of 0.05.

	Mean Logit Score	S.D.
Location		
Rural	-0.03	1.32
Urban	0.40	1.26
Sex		
M	0.35	0.95
F	0.20	1.66
Age		
21-29	0.00	0.94
30-39	0.41	1.17
40-49	-0.58	0.58
>50	1.06	2.32
Ethnicity		
Caucasian	-1.31	0.88
Creole	0.49	1.22
Garifuna	0.48	0.69
Maya	0.69	0.19
Mestizo	0.48	1.36
Other/Mixed	-0.61	0.96
East Indian		
African/Jamaican		
Academic Qualification		
High School	1.39	1.33
Associates	-0.46	0.99
Bachelors	0.43	1.32
Masters	-0.36	0.78
Years of Teaching Experience		
0-2	0.05	1.17
3-5	0.61	1.35
6-10	0.83	1.44
11-20	-0.31	0.91
>20	-0.41	0.83
Years of Teaching Biology		
0-2	0.23	1.39
3-5	0.86	1.40
6-10	0.12	0.80
11-20	-0.21	0.89
>20	-0.93	0.25

Table 3-5. The ranks of the multiple-choice questions testing evolutionary knowledge for the entire group, the Acceptance Group, and the Rejection Group.

Entire Group of Respondents			Acceptance Group			Rejection Group		
Rank	Item	% Correct	Rank	Item	% Correct	Rank	Item	% Correct
1	35	81.4	1	35	96.6	1	26	73.3
2	26	79.7	2	26	86.2	2	35	66.7
3	25	64.4	3	28	82.8	3	29	63.3
4	29	62.7	4	25	72.4	4	25	56.7
5	28	59.3	5	27	65.5	5	27	46.7
6	27	55.9	6	21	62.1	6	41	43.3
7	21	50.8	6	29	62.1	7	21	40.0
8	30	49.2	8	22	58.6	7	30	40.0
8	34	49.2	8	30	58.6	7	33	40.0
10	22	47.5	8	34	58.6	7	34	40.0
10	41	47.5	11	31	55.2	11	22	36.7
12	31	44.1	12	32	51.7	11	28	36.7
13	32	40.7	12	39	51.7	13	31	33.3
13	39	40.7	12	41	51.7	14	32	30.0
15	33	39.0	15	37	44.8	14	37	30.0
16	37	37.3	16	33	37.9	14	39	30.0
16	38	37.3	17	23	34.5	17	23	20.0
18	23	27.1	18	36	24.1	18	36	16.7
19	36	20.3	19	24	20.7	19	38	10.0
20	24	13.6	20	40	17.2	19	40	10.0
20	40	13.6	21	38	10.3	21	24	6.7

Table 3-6. Teacher responses to the multiple-choice items pertaining to the knowledge of evolutionary theory. (*Denotes correct response).

Question	%
23. Using radioactive dating techniques, the first life seems to have appeared on the earth about:	
a. 10 thousand years ago	5.1
b. 270 million years ago	1.7
c. 3.3 billion years ago	6.8*
d. 4.5 million years ago	20.3
e. 10 billion years ago	13.6
No Answer	32.2
24. Which of the following phrases best describes the process of evolution?	
a. The development of man from monkey-life ancestors	1.7
b. The change of simple to complex organisms	23.7
c. The development of characteristics in response to need	32.2
d. The change of populations through time	13.6*
e. The change of populations solely in response to natural selection	23.7
No Answer	5.1
36. The extinct species *Archaeopteryx* has characteristics of both birds and reptiles. This is an example of a(n):	
a. Convergent species	18.6
b. Trace fossil	5.1
c. Archetype	8.5
d. Intermediate form	20.3*
e. Polymorphic species	25.4
No Answer	22.0
38. Radiometric dating techniques rely on the fact that:	
a. The bony portions of organisms decompose at known rate	8.5
b. Organisms which lived earlier in time will tend to be found in sediments below organisms which lived more recently	11.9
c. The magnetic field of the earth has reversed its polarity at the known time intervals in geologic time	5.1
d. The earth contains elements which change into other elements at a constant rate	10.2
e. During the decomposition process organic matter is converted into radioactive elements at a known rate	37.3*
No Answer	27.1
40. Which of the following is not a part of Darwin's theory of natural selection?	
a. Individuals of a population vary	5.1
b. Organisms tend to over-reproduce themselves	55.9
c. There are limited resources for which individuals compete	8.5
d. Modifications an organism acquires during its lifetime can be passed to its offspring	13.6*
e. Variations possessed by individuals of a population are heritable	5.1
No Answer	11.9

Table 3-7. Description of the five sections that comprise the 2004 CXC biology syllabus. Numbers in brackets indicate the suggested number of weeks needed to teach each section. Note that the content in the CXC syllabus is to be covered over two academic years (11th and 12th grade). Numbers in brackets next to each section indicate the number of weeks teachers should expect to spend on each section.

Section A (5)	Section B (40)	Section C (10)	Section D (3)	Section E (7)
Living Organisms and the Environment	Life Processes	Continuity and Variation	Disease and its Impact on Humans	Environment and Human Activities
- food chain - food webs - symbiotic relationships - energy flow	- cell structure (plant and animal) - nutrition - photosynthesis - systems (respiratory, skeletal, nervous, circulatory, excretory, digestive) - sexual and asexual reproduction - pollination, germination	- mitosis - meiosis - chromosome, DNA, gene, allele, inheritance, genetic engineering	- disease types, - treatment, control - vectors, pathogens - sexually transmitted diseases - immune system - social and economic implications	- environment - population - limiting resources - recycling - pollution - human impact

Table 3-8. Test questions pertaining to the theory of evolution included in CSEC biology examinations for the years 2000-2007. Both mandatory and optional questions are presented in this table. Test questions for the year 2006 were unavailable. Test questions for the year 2008 were transcribed from the CXC 2008 report.

Year	Biology CSEC questions pertaining to the theory of evolution
2000	none
2001	1. What is meant by the term homologous? 2. Sometimes in nature there is an unexpected change in the genes or in a chromosome. What is this change called? 3. Genes on a chromosome can also be changed by genetic engineering. Suggest TWO differences between this process and natural selection. 4. People now eat food crops grown from seeds, which had their genes changed by genetic engineering. Suggest TWO unintentional outcomes of using this process in food crops.
2002	1. State TWO possible effects on the rest of the ecosystem if the birds were removed from the forest. 2. What are the causes of variation within a population? (*optional*) 3. Many organisms, such as snails and insects have colors, which are similar to the colors of their regular habitats. Explain how mutations and natural selection could have contributed to this fact. (*optional*) 4. Man seems to be losing the war against pests as new pesticides remain effective only for a short time. (i) Explain why this may be so. (ii) How has man used his knowledge of natural selection to deal with this problem? Explain your answer fully. (*optional*)
2003	1. What is the long-term effect of asexual reproduction for a species? 2. In developed countries like the United States, genetic engineering methods are being used to fight plant diseases and improve agricultural products. (i) Use your knowledge of Biology to explain TWO reasons why there is a growing emphasis on manipulating genes. (ii) Suggest TWO possible disadvantages for regions like the Caribbean, if this trend continues. (*optional*)
2004	1. In many societies, men are disappointed when they have too many female offspring and they tend to blame their partners. Use your biological knowledge to explain why this is an unreasonable position to take. (*optional*) 2. It may one day be possible to use genetic engineering methods to remove a defective gene (for example, the sickle cell gene) from a zygote or gamete and replace it with a normal gene. What might be the advantages of developing this technique instead of trying to develop better treatments for genetic diseases? (*Optional*) 3. In the future, parents may be able to select certain characteristics that they want their offspring to have and have the appropriate genes inserted into the chromosomes of the embryo. Suggest ONE advantage and ONE disadvantage of this possibility? (*optional*)
2006	1. Why is genetic variation important? 2. 'Monocropping'- planting of the same type of plants over an extensive area- is sometimes considered risky because of the lack of genetic variation. Explain why this practice may be considered risky. 3. Besides introducing new species, human activities also affect the natural environment in other ways. For example, many Caribbean coral reefs have been damaged by human activities. (i) Describe TWO ways in which human activity destroys coral reefs. (ii) Suggest the implications of the coral reef destruction described above. (*Optional*)
2007	1. Suggest TWO reasons why sugarcane farmers tend to choose a single variety for their crops. (*Optional*)
2008	1. Label the process of meiosis. 2. Define the term 'genetic engineering' and provide an advantages and a disadvantage of GMOs. 3. Explain how the body defends itself against disease. State two biological and two social implications or the misuse of antibiotics.

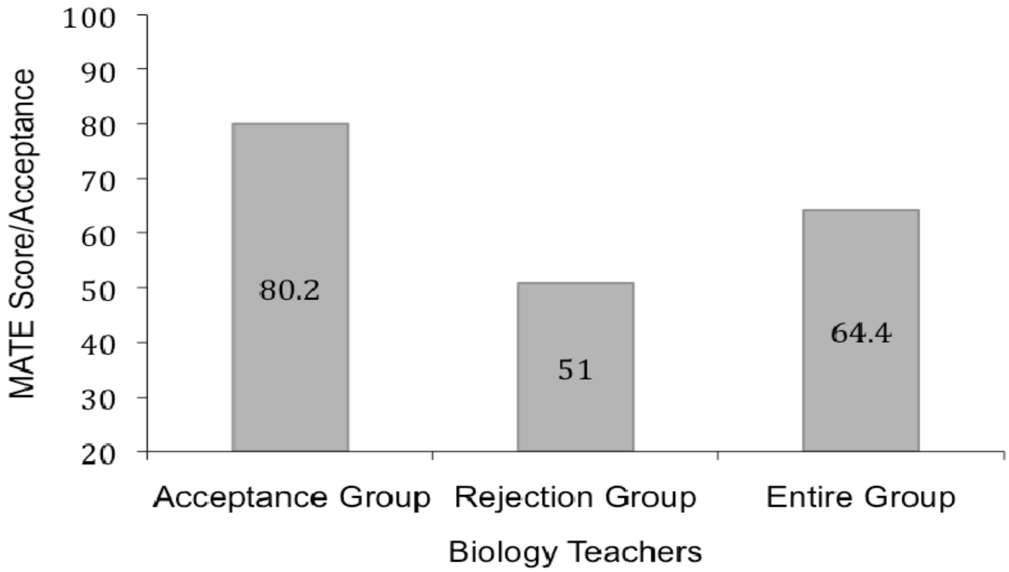

Figure 3-1. Mean acceptance scores for the Acceptance, Rejection and Entire group of respondents based on the sum of scores on the MATE instrument.

```
                 Persons - MAP - Items
                       <more>|<rare>
 5                          33  +
                                |
                                |
                                |
                                |
                                |
 4                              +
                                |
                                |
                                |
                                |
                                |
 3                              +
                   17,32.46 T|
                          08   |
                               |
                               |
                               |
                               |
 2                             +
                          41  |
                              |
                             S|
                              |
                          25  |
                    31,58,59 |
 1                   04,23  +
       01,16,39,44,51,56 |
                      18,36  |
         03,09,34,53,54  |T
                      15,20  |      Item15
               24,30,45 M|S    Item2   Item3   Item6
                      07,28  |      Item10  Item11  Item13  Item14  Item20  Item4
 0   05,11,12,14,21,57  +M   Item12  Item16  Item8
                      37,52  |      Item1   Item19
                             |S     Item5   Item7
                             |      Item9
             10,26,27,49  |T     Item17  Item18
                  47,48,55  |
                             |
-1          06,19,38,43 S+
                      02,22  |
                  35,40,50  |
                          13  |
                              |
                              |
                              |
-2                   29,42  +
                       <less>|<frequ>
```

Figure 3-2. Person/Item Case Map for the Rasch Analysis of MATE Scores.

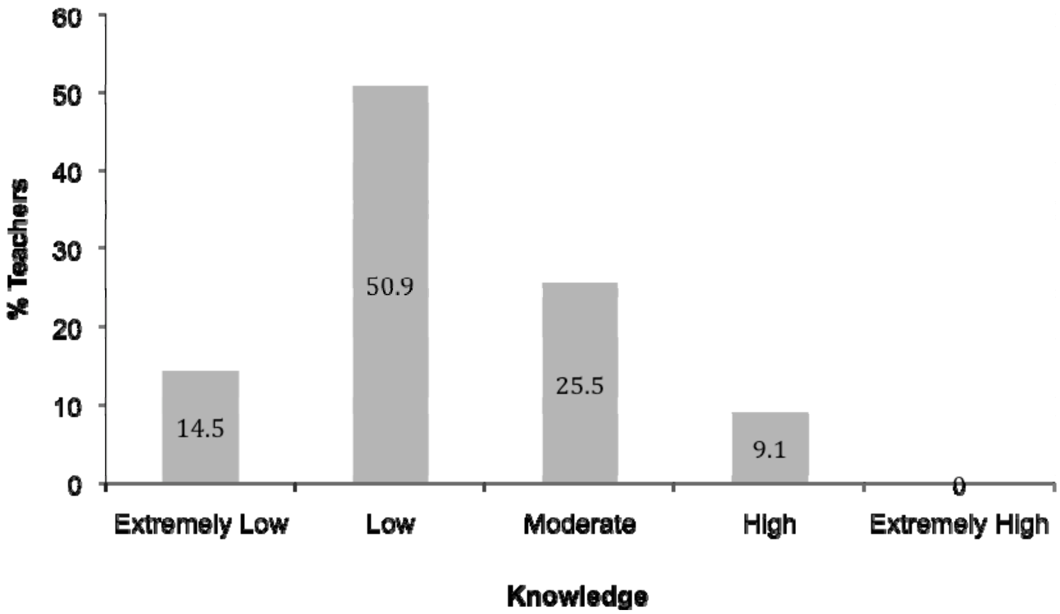

Figure 3-3. Teacher knowledge on evolution based on scores on the 21-multiple choice items in Section III of the survey instrument. Total N=55. Scores range between 0 and 100 percent. Extremely Low (<30%); Low (30-49%); Moderate knowledge (50-69%); High (70-84%), Extremely High (>85%).

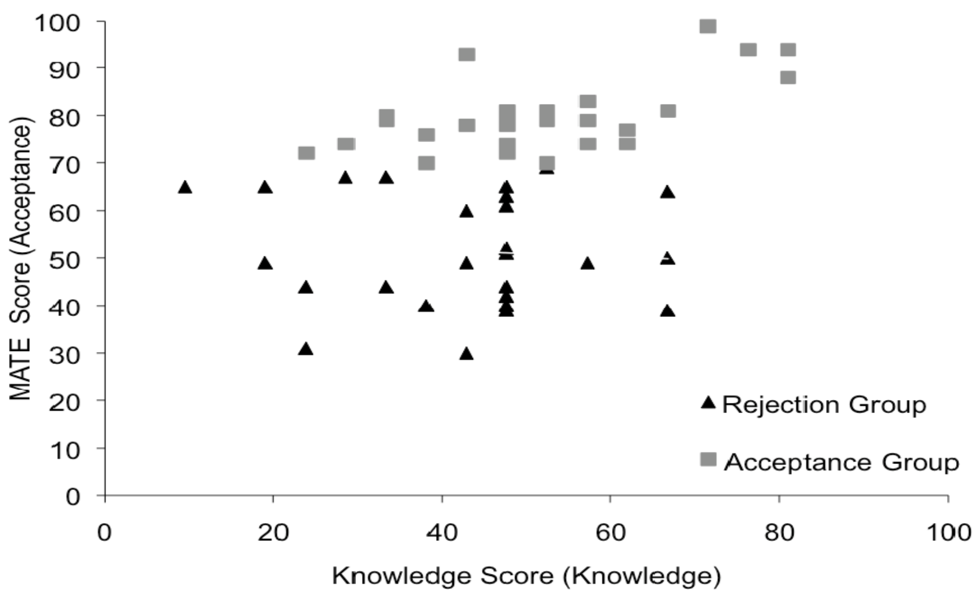

Figure 3-4. A comparison of biology teachers' scores Knowledge Scores plotted against MATE/Acceptance Scores.

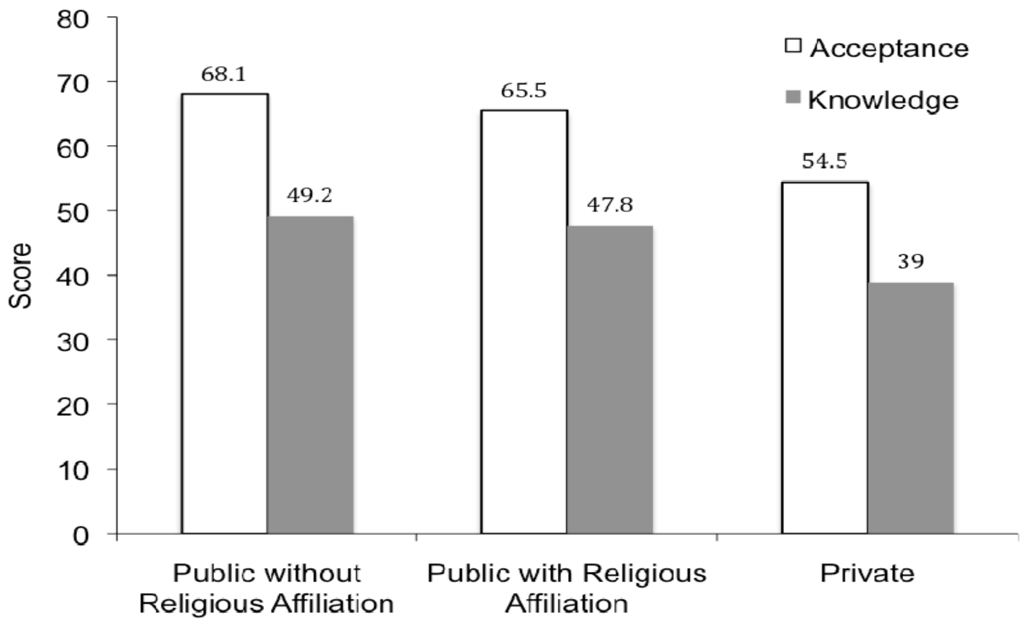

Figure 3-5. A comparison of biology teachers' Acceptance and Knowledge Scores for Public and Private high schools.

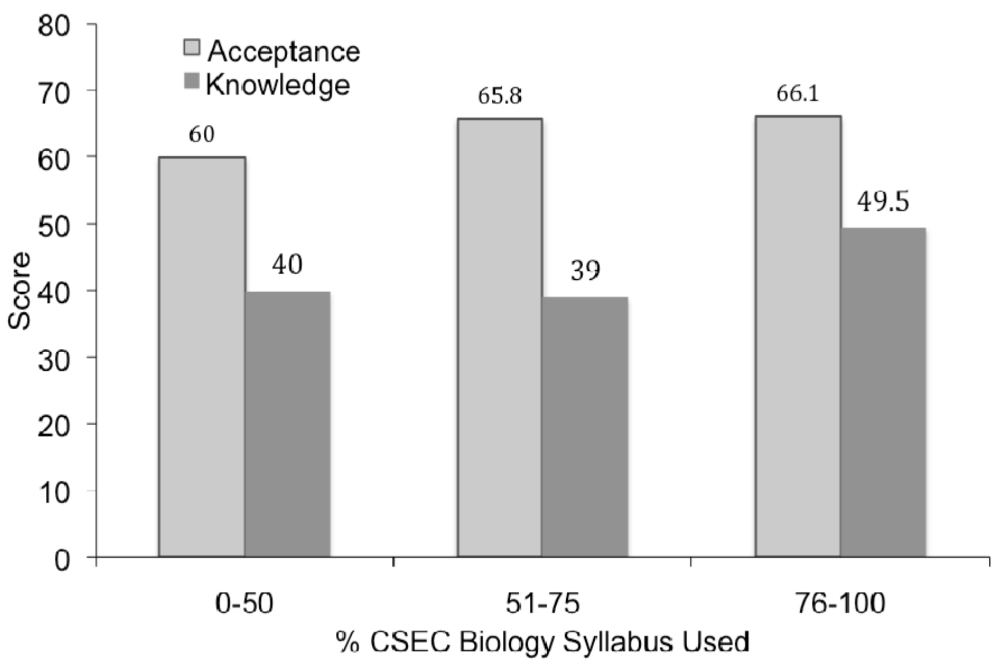

Figure 3-6. A comparison of biology teachers' Acceptance and Knowledge Scores plotted against the % of CSEC Biology Syllabus used by teachers.

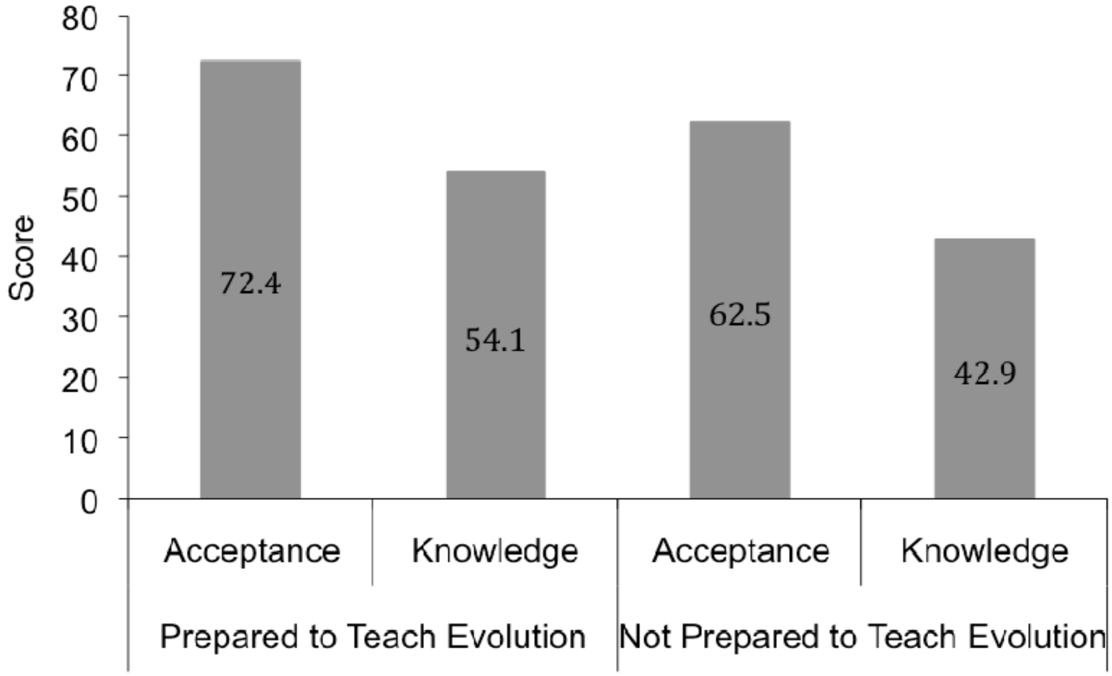

Figure 3-7. Mean Acceptance/MATE Score and Knowledge Score for teachers who feel prepared to teach evolution (N=23) and teachers who do not feel prepared (N=32).

CHAPTER 4
SUMMARY AND CONCLUSIONS

This study investigated the current level of acceptance and understanding of the theory of evolution among high school biology teachers in Belize. It was hypothesized that the majority of respondents would have extremely low levels of both acceptance and understanding. Based on the literature and similar studies in the United States (See Troost, 1966; Shankar & Skoog, 1993; Aguillard, 1999), it was predicted that teachers with higher levels of education, particularly in larger urban, public schools, would exhibit greater levels of acceptance and knowledge of evolutionary theory.

The results indicate that even though less than 49% of teachers in Belize accept the theory of evolution, the entire population exhibits a poor understanding of the theory and its related concepts. Teachers mean acceptance level was 64.4 out of 100 points. Because a majority of the teachers either reject or are undecided about evolution there is room for improvement. Tackling teachers' misconceptions is imperative, especially when most teachers admit to teaching for content purposes, and have little time to instill deeper understandings and connections between the subject matter and everyday life.

There is a complex relationship between acceptance and understanding of evolution. While some studies have suggested a positive correlation between the two (Fahrenwald, 1999; Rutledge & Warden, 2000; Deniz et al., 2008), others have found no relationship (e.g. Brem et al., 2003). In this study, there was a significant correlation between the acceptance and understanding of evolutionary theory held by high school biology teachers in Belize. The correlation test, however, accounts for only 15% of the association suggesting that the factors that contribute to the acceptance of evolutionary theory are complex and cannot be attributed to a single factor such as knowledge of evolutionary theory. The generalized assumption that an increase in understanding of evolution leads to an increase in acceptance of the theory is a gross oversimplification. Although this relationship has been supported in some studies, there are numerous extraneous variables that can influence acceptance of the theory of evolution and these may vary across countries, and cultures.

It was expected that because developing countries have different content requirements than the United States, teachers with only high school or associate level degrees would have extremely high levels of non-acceptance. Previous studies have shown that teachers who take more courses on evolution (i.e. higher academic preparation) spend more time teaching the subject and doing a better job at teaching (Aguillar, 1999; Rutledge & Mitchell, 2002). Contrary to expectations, the variations in teacher preparation and qualifications in Belize did not influence the acceptance of evolution, i.e. teachers with Masters degrees do not accept the theory of evolution any more than teachers who have only a high school diploma or an associate’s degree. I speculate that in addition to teacher preparation, culture, religious beliefs, and/or parents’ educational background contribute to teachers’ acceptance of the theory of evolution. Future studies should investigate whether these socio-cultural factors influence teacher acceptance and understanding of the theory of evolution across social, political and cultural barriers.

Interestingly, teachers of indigenous backgrounds like Maya had higher acceptance towards evolution than the remaining ethnic groups particularly Caucasians and East Indians. Among the entire group of respondents, the most controversial and rejected items were: 1) the ambiguity of the data supporting the theory of evolution, 2) the testable nature of evolution, and 3) human evolution. Providing evidence to support the testable nature of evolution will be much easier than addressing the issues of human evolution. Although some studies advocate the use of human evolution as the central theme behind the teaching evolution (Besterman & Baggott la Velle, 2007), the results of this study suggest that most biology teachers have strong issues against human evolution. Although evolution could be addressed using human evolution as the primary evidence, there is a huge risk of offending and alienating various teachers before we get our message across.

Because teachers had higher ability levels compared to item difficulties it was expected that they perform well on the acceptance test. This was not the case as teachers' acceptance level of evolution was weak across the entire population regardless of sex, academic preparation or whether or not evolution was taught. In addition, teachers who claim to teach evolution did not have higher levels of acceptance compared to those teachers who do not accept the theory. This unsettling result suggests that claiming to teach evolution is not enough. It is the concepts that are taught and how they are taught in relationship to other areas in biology that is important. Previous studies have found that the teaching of evolution is influenced by a complex set of factors including: textbooks, tests, curricula, religious beliefs, and acceptance or rejection of evolution (Lerner, 2000; Moore, 2002). In this study, school affiliations played a role in teacher acceptance with teachers from public schools have higher acceptance than those from public schools with religious affiliations and private schools.

One of the two factors that contributed to an increase in acceptance among high school teachers in Belize was teaching experience in biology. Teachers with ten years of more of teaching experience in biology have significantly higher levels of acceptance than those who recently entered the classroom. Such correlation has huge implications for the future of evolution instruction in Belize and in other countries where teachers are hired on a year-by-year basis and whose job depends on student performance on standardized tests. If our goal is to prepare students for life, then we need to allow teachers the time and flexibility to engage in research and other experiences that promote a deeper understanding of the content they are responsible for teaching. In addition, teachers should be encouraged to familiarize themselves with the nature of science if they are to fully comprehend the complexity of scientific processes. Future research on teachers' epistemological views of science may help clarify if teachers genuinely have low acceptance levels of evolution or simply have an inadequate understanding of the nature of science, as has been suggested in other studies (See Abd-El Kahlick & Lederman, 2000a).

This study concludes that, in general, teachers have inadequate levels of knowledge about the theory of evolution. Specifically, teachers have a poor grasp of "deep time". By failing to appreciate the importance of geological processes, the fossil record and macroevolution, teachers limit their understanding of historical biology and its relevance to the modern world (Catley & Novick, 2009). With teachers scoring as low as 9% on the knowledge test, there is room for much improvement. Most surprisingly, teachers were unable to correctly define the theory of evolution and to distinguish among the processes that contribute to natural selection. There results are noteworthy because teachers cannot teach the theory of evolution effectively if they lack a basic understanding of its concepts including natural selection, the driving force behind evolution. Along with mutation, gene flow, genetic drift, and macroevolution, natural selection is one of the most important concepts required for a comprehensive understanding of the theory of evolution. The results of this study reveal the many hurdles in evolution education in Belize. As such, they provide significant support for the proper education of pre-service teachers and the reeducation of in-service teachers.

As predicted, evolution plays only a minor role in the regional science standards and standardized tests in the Caribbean. Compared to the United States, where nationwide, state standards for teaching evolution average a grade of C, or satisfactory, (Lerner, 2000), Belize's science standards as it pertains to evolution average a D at best. Because most teachers in Belize subscribe to the mandated biology curriculum by CXC, evolution instruction is often limited to a brief introduction of the topic. Teachers' personal views and preconceptions as well as their low levels of acceptance and understanding of the concepts they are responsible for teaching further diminish the role of evolution as a unifying theme in the classroom. Although non-significant, there is an increase in the acceptance and undertanding of the theory of evolution with increasing use of the CSEC Biology syllabus (See Figure 3-6). This is even more reason for science educators and officials in the region to re-evaluate the goals of the CSEC biology standards so they pertain to evolutionary concepts as they relate to the many fields of science. If we are to improve the status of evolution education, we need to continue to emphasize to teachers that biology cannot be taught effectively without the inclusion of its unifying theme: the theory of evolution.

CHAPTER 5
IMPLICATIONS AND RECOMMENDATIONS

The findings of this study have implications for policy, practice and research. The results of this study suggest that there is an urgent need for the re-education of in-service teachers in Belize as it pertains to the theory of evolution. From a regional standpoint, these findings can help officials determine what resources teachers in the region, particularly those who subscribe to CXC standards, need in order to effectively teach the theory of evolution at the high school level. It is recommended that regional examination boards and science departments set adequate standards for the teaching of evolution in the classroom. By including evolution as an integral part of the regional examinations, they ensure that a majority of the teachers will cover the content matter even though they may reject the theory. Instead of revising the CSEC standards every five years, the Caribbean Examination Council should consider integrating evolution in all areas of the CSEC Biology Syllabus. This would be more effective than modifying the standards or the format of the exam more frequently. The goals, content, and test material should be modified to incorporate evolution in a form that is relevant to both teachers and students so they are able to make connections among topics. Currently, the sections in the CSEC biology syllabus are disjointed and need to be taught from an interrelated standpoint. Evolution is more than a micro-level process. Although evolution is key for the explanation of DNA, cell division, and genetic engineering, it also has a place in the explanation of food webs, energy flow, cell structure, photosynthesis, reproduction, pollination, disease transmission, and the impact of humans on the environment (Sections A-E in the CSEC Syllabus). Thus, evolution indirectly forms part of all five sections of the CSEC biology syllabus, and should not be restricted to only

Section C: Continuity and Variation (See Table 3-7). The isolation of the topic fosters more misconceptions by failing to make connections to the rest of the topics in biology. Because evolution is central to the understanding of biology, I advocate that its concepts be embedded within other topics such as ecology, genetics and conservation. Without an appreciation of evolution as an overarching theme in biology, lessons are limited to content with little relevance to everyday life. We need to bridge that gap between scientists, and the teaching community.

Although 68% of the teachers feel satisfied with the treatment of evolution in their biology textbooks, 58% of high school biology teachers in Belize feel unprepared to teach the theory of evolution. This presents a meaningful opportunity for professional development programs and workshops that will address teachers' misconceptions about the topic. Understanding what teachers need to be more comfortable and confident about teaching its concepts can have positive implications for future effective teachers. These professional development programs should include a "misconception profile" that includes all the poorly answered questions from the survey instrument used in this study. These topics can be used to develop effective teaching strategies that will foster a deeper understanding of the topic among teachers. These professional development programs should seek to include multiple teaching strategies, including discussion, historical underpinnings (Clark & Brown, 1996) and problem solving in addition to content presentation to target teachers' low acceptance and understanding of evolutionary content. The goal of these workshops should be to 1) clarify misconceptions, particularly those pertaining to macroevolutionary processes and 2) help teachers master how to think critically and scientifically about the nature of science.

To fully comprehend the centrality of evolution teachers need to understand numerous fields including paleontology, biogeography, molecular biology, genetics, and developmental biology (Mayr 2002, pp 12-39).

Given that acceptance and understanding increase as the teachers' years of experience in the biology classroom increase, it is recommended that teachers make use of reliable outside resources such as books, journals, and websites intended to increase their knowledge of the theory of evolution. Griffith & Brem, (2004) showed that the teachers who taught the theory of evolution more effectively were the ones who possessed the most up to date information. However, this endeavor is difficult to ask of teachers who are already swamped with so many job responsibilities. In addition, leaving the research and self-training up to teachers may prove problematic if their preconceptions or beliefs are strongly against the teaching of evolution. Regional officials and science department heads should spearhead and encourage research and the use of reliable support documents. As continuous learners, it is important that teachers build on their knowledge of factual information pertaining to evolution so they provide unbiased accounts of the topic. Failure to do so results in limited conceptions of what it means to be a teacher (Anderson, 2007).

APPENDIX A
DEFINITION OF TERMS

- CARIBBEAN EXAMINATION COUNCIL (CXC). An educational governing body that was established in 1972 by several participating governments across the Caribbean to conduct examinations and set regional standards, with the purpose of making curriculum more relevant to the needs of the Caribbean rather than those imposed by the British Education, GCE. The standardized tests from CXC are designed to test students' knowledge in specific subject areas at the secondary and tertiary levels of education (www.cxc.org).

- CARIBBEAN SECONDARY EXAMINATION CERTIFICATE (CSEC). An examination offered by CXC, which recognizes a level of proficiency in various subjects historically bench-marked with secondary level education. The examination is taken at the end of 12th grade and is used to evaluate student knowledge against peers across the region (www.cxc.org).

- CSEC BIOLOGY EXAMINATION. Although not mandatory, this 12th grade examination is very popular among high school students planning to pursue higher education in Belize and/or the Caribbean. The exam is spilt into four sections. Paper 01 is a multiple-choice, Paper 02 is comprised of structured questions, and Paper 03 contains essay questions. A laboratory component known as the standard based assessment (SBA) also contributes to the overall score on the examination. As of 2008, the format of the exam was changed resulting in the merging of Paper 02 and Paper 03. Unlike previous years, all questions in the exam are now mandatory (www.cxc.org).

- THEORY OF EVOLUTION. This term refers to biological evolution. Biological evolution is defined as the change of alleles or trait frequency in a population due to natural selection, mutation, gene flow, or genetic drift (Futuyama, 1998). The National Academy of Sciences [NAS] defines evolution as "Change in the hereditary characteristics of groups of organisms. (Darwin referred to it as 'descent with modification')" (p.13).

- NATURAL SELECTION. A key process of the theory of evolution, along with mutation, gene flow and genetic drift in which organisms with heritable traits that are better suited to their environments have greater reproductive success, therefore increasing the frequency of favorable traits in a population (Futuyama, 1998; WGBH Educational Foundation, 2001).

- SCIENCE. "A way of knowing about the natural world based on observations and experiments that can be confirmed or disproved by other scientists using scientifically accepted techniques" (WGBH Educational Foundation, 2001).

- *THEORY*- In vernacular English, the definition of a theory is often something that is unproven or assumed. However, in science, a theory is defined as "a well sustained explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses” (NAS, 198, p.5).

- HIGH SCHOOL. Grades 9-12. In Belize these are referred to as Form I-IV.

APPENDIX B
UF-IRB SUBMISSION

UFIRB 02 – Social & Behavioral Research Protocol Submission	
Title of Protocol: Small Country, Big Implications: The Role of Teacher Acceptance and Understanding in Shaping Evolution Instruction in Belize. **UFIRB #2009-U-0097**	
Principal Investigator: Elvis Nunez	**UFID #: 7531 6400**
Degree / Title: Masters in Zoology with a minor in Education **Department:Zoology/Vertebrate Paleontology**	**Mailing Address:** 218 Dickinson Hall, Museum Road & Newell Drive, Gainesville, FL 32611 **Email Address & Telephone Number:** enunezbz@ufl.edu, 808 854 5436
Co-Investigator(s): None	**UFID #:**
Supervisor: Dr. Bruce MacFadden	**UFID #: 1730-0400**
Degree / Title: Ph.D./Curator of FLMNH **Department: Professor of Zoology and Geological Sciences**	**Mailing Address:** 218 DICKINSON HALL GAINESVILLE FL US 32611-7800 **Email Address & Telephone Number:** bmacfadd@flmnh.ufl.edu, **352 273 1937**
Date of Proposed Research: March, 2009	
Source of Funding *(A copy of the grant proposal must be submitted with this protocol if funding is involved):* Personal Funding	
Scientific Purpose of the Study: 1) To investigate the current level of acceptance and understanding of evolutionary theory among high school biology teachers in Belize? 2) To investigate the level of evolutionary content depicted in the local (classroom) and regional (Caribbean) high school science standards?	

Describe the Research Methodology in Non-Technical Language: ***(****Explain what will be done with or to the research participant.****)***

Official letters announcing the study will be sent by both email and regular mail to all high school principals in Belize. *Please note that all official documents, including consent forms and survey instruments will be written in English, the official language of Belize. This is appropriate since English is the only language used for instruction at the high school level*. Once all institutions have received this notification, principals will be contacted via phone to verify their willingness to participate in the study. Instead of mailing consent forms and survey instruments,

I will personally fly to Belize and drive to all participating high schools to provide both principals and biology teachers with consent forms (transportation has been arranged). Both consent forms will indicate the study's objectives, procedures, potential risks and anticipated benefits in addition to a statement providing the opportunity to withdraw from the study at any time. Because complete disclosure of the research content may allow teachers to prepare for the surveys in advance (i.e. reading text books or even altering course outlines), I ask that IRB grant me permission to disclose only a limited degree of information about the research topic to each subject. I will however, debrief subjects once course outlines have been collected and surveys have been completed and sealed in privacy envelopes. During this time, teachers will be given the opportunity to both ask questions and make comments.

Only schools whose principals have agreed to participate in the study will be visited. *Upon arrival at the school but prior to interacting with teachers, the researcher will first meet with the respective principal and have him/her sign the "Principal Consent Form". Once this has been successfully accomplished, teachers of participating high schools will be briefed on the project and asked to read and sign the " Teacher Consent Form" if they wish to participate in the study.*

Surveys will be conducted at the teacher's discretion, either during free class periods or at the end of the school day so as not to disrupt regular class time. Teacher(s) will be directed to an unoccupied classroom/laboratory and asked to complete the survey to the best of their abilities. *For schools that have more than 1 biology teacher, teachers will be asked to complete the surveys in separate rooms. If this is not possible, teachers will be asked to sit far away from each other and to refrain from communicating with one another. Teachers will then be provided with a copy of the survey (identifiable only by a survey number), and a "privacy envelope" to place their completed surveys (these will not be opened until the data compilation phase).* All teachers will be given specific instructions on how to complete the surveys in addition to being briefed on the anonymity of the study, the importance of an honest response, and their ability to withdraw from the study at any particular time.

The researcher will then leave the room but remain close by in case there are any questions as the teachers complete the surveys. *Following the completion of the surveys, teachers will be asked to drop their sealed envelopes in an box.* Once all surveys have been submitted, the researcher will be open for questions and feedback on the study.

In addition to implementing the surveys, 11^{th} and 12^{th} grade biology course outlines (syllabi) will be collected from each of the participating schools (this will be done prior to implementing the surveys).

Describe Potential Benefits and Anticipated Risks: (*If risk of physical, psychological or economic harm may be involved, describe the steps taken to protect participant.)*

Potential Benefits.

1) Participants will be challenged to think critically during the survey. They will be exposed to a topic, which remains controversial in most regions of the world.

2) Findings from this research will contribute to the strengthening of the biology curriculum in Belize and possibly the rest of the Caribbean.

Anticipated Risks

This study presents no more than minimal risks to the subjects. No physical, economic, or psychological harm is anticipated. Due to the nature of the evolutionary content in the study, some participants may be uncomfortable responding to some of the survey questions. To ensure that there is as little discomfort as possible, participants will be briefed on confidentiality, anonymity of responses, and on their ability to withdraw from the study at any time. In addition, all surveys will be completed in the absence of the researcher and will be submitted in sealed envelopes.

Describe How Participant(s) Will Be Recruited, the Number and AGE of the Participants, and Proposed Compensation:

My initial research indicates that there are a total of 71 high school biology teachers in Belize. These teachers are distributed among the 47 high schools in the country. Because this sample pool is so small, all 71 teachers will be asked to participate in the study. Prior to implementing the surveys, all 47 high school principals in Belize will be contacted and asked to participate in the study. Once the respective principal has agreed and signed the consent form, I will request the participation of their biology teachers.

There will be no compensation for participating in the study.

Describe the Informed Consent Process. Include a Copy of the Informed Consent Document:

Each participating high school principal and biology teacher will be provided with informed consent documents. The survey will not be implemented unless both principals and teacher(s) along with a witness have signed the consent forms.

Informed Consent Documents are attached: YES

Principal Investigator(s) Signature *Elvis E. Nunez*	**Supervisor Signature:**
Department Chair/Center Director **Signature:**	**Date:**

APPENDIX C
PRINCIPAL CONSENT LETTER

High School Principal Consent Letter

Dear Sir or Madam:

My name is Elvis Nunez. I am a graduate student from Belize enrolled in the Department of Zoology at the University of Florida. Under the supervision of Dr. Bruce MacFadden, I am currently conducting research pertaining to biology content and curricula in Belize.

The results of the study may help administrators and education officials better understand the importance of teaching concepts like evolutionary biology, genetics, and conservation as an integral part of the high school biology curricula, leading to improved curricula and instructional practices. These results may not directly help your institution today, but may benefit future students seeking a more comprehensive science education. Today, I would like to ask that you give permission for your school to participate in the study. Specifically, the study will require that your biology teachers complete a survey regarding biology curriculum and their perspectives on various topics units taught in the discipline. Even after you agree to participate in the study, each individual teacher's consent will be sought. I assure you that your institution's participation will be greatly appreciated and will be the first step towards enhancing science education in Belize, and possibly the rest of the Caribbean.

Due to the small number of high schools and biology teachers in the Belize, all high schools in the country will be asked to form part of this study. Specifically, all 11th and 12th grade (3rd and 4th Form) biology teachers around the country will be asked to complete the questionnaire. Please be advised that teachers will not have to answer any question they do not wish to answer. In addition, they will not be asked to write their names on the questionnaires so that their responses are anonymous. Their identity will be kept confidential to the extent provided by law. Results will only be reported in the form of collective data. And, schools will not be penalized for not participating in the research study.

Even after signing this form, your school will have the right to withdraw from the study at any time without any consequence. This study presents no known risks or immediate benefits to the participants. Group results of this study will be available late in the fall 2009 semester. If you have any questions about this research protocol, please contact me at 1-808-854-5436 or my faculty supervisor, Dr. Bruce MacFadden, at 1-352-273-1937. Questions or concerns regarding your participation in this research project may be directed to the IRB02 office, University of Florida, Box 112250, Gainesville, FL 32611, (352) 392-0433.

Sincerely, Elvis Nunez

I have read the procedure described above. I ______________________ voluntarily give consent for my institution, ________________________, to participate in Elvis Nunez's study regarding high school teachers' perceptions about biology content. I have received a copy of this project's description.

_____________________________ ___________ Principal's Signature, Date
_____________________________ ___________ Witness, Date

APPENDIX D
BIOLOGY TEACHER CONSENT LETTER

Dear Sir or Madam:

My name is Elvis Nunez. I am a graduate student from Belize enrolled in the Department of Zoology at the University of Florida. Under the supervision of Dr. Bruce MacFadden, I am currently conducting research pertaining to biology content and curricula in Belize.

The results of the study may help administrators and education officials better understand the importance of teaching concepts like evolutionary biology, genetics, and conservation as an integral part of the high school biology curricula, leading to improved curricula and instructional practices. These results may not directly help your institution today, but may benefit future students seeking a more comprehensive science education. Today, I would like to ask that you participate in this research by completing a survey regarding your biology curriculum and your perspectives on various units taught in your discipline**.** Your participation will be greatly appreciated and will be the first step towards enhancing science education in Belize and possibly the rest of the Caribbean.

Due to the small number of biology teachers in Belize, all 11th and 12th grade (3rd and 4th form) biology teachers around the country will be asked to complete this questionnaire. Please be advised that you will not have to answer any question you do not wish to answer. In addition, you will not be asked to write your name on the questionnaire so that your responses are anonymous. Moreover, your completed survey will be placed inside a "Privacy Envelope" and not opened until the data compilation phase. I assure you that your identity will be kept confidential to the extent provided by law. Results will only be reported in the form of collective data. Schools will not be penalized for not participating in the research study.

Even after signing this form, you will have the right to withdraw from the study at any time without any consequence. This study presents no known risks or immediate benefits to its participants. Group results of this study will be available late in the fall 2009 semester. If you have any questions about this research protocol, please contact me at 1-808-854-5436 or my faculty supervisor, Dr. Bruce MacFadden, at 1-352-273-1937. Questions or concerns regarding your participation in this research project may be directed to the IRB02 office, University of Florida, Box 112250, Gainesville, FL 32611, (352) 392-0433.

Sincerely,

Elvis Nunez

I have read the procedure described above. I ______________________ voluntarily give my consent to participate in Elvis Nunez's study regarding high school teachers' perceptions about biology content. I have received a copy of this project's description.

_____________________________ ___________ Biology Teacher's Signature, Date
_____________________________ ___________ Witness, Date

APPENDIX E
SURVEY INSTRUMENT

Biology Teacher Survey

Date: ___________________________

Time: ___________________________

Age: ___________________________

Sex: (M) (F)

Ethnicity: (A) Mestizo (B) Creole (C) Maya (D) Garifuna (E) Taiwanese (F) Caucasian (G) Mixed

(G) Other: ___________

Area of Specialization:

____

Section I: Please respond to the following questions as honestly as possible.

1. What is your level of academic teacher preparation?
   1) High School
   2) A.S. / A.A.
   3) B.S. / B.A.
   4) M.S./ M.A.

2. Number of years teaching?
   1) 0-2
   2) 3-5
   3) 6-10
   4) 11-20
   5) >20

3. Number of years teaching ***Biology***?
   6. 0-2
   7. 3-5
   8. 6-10
   9. 11-20
   10. >20

4. What Form level do you teach?
   A. 3rd Form (11th Grade)
   B. 4th Form (12th Grade)
   C. Both 3rd and 4th Form

Section II: For the following items, please indicate your agreement/disagreement with the given statements using the scale below.

A	B	C	D	E
Strongly Agree	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**

____1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.

____2. The theory of evolution is incapable of being scientifically tested.

____3. Modern humans are the product of evolutionary processes, which have occurred over millions of years.

____4. The theory of evolution is based on speculation and not valid scientific observation and testing.

____5. Most scientists accept evolutionary theory to be a scientifically valid theory.

____6. The available data is ambiguous as to whether evolution actually occurs.

____7. The age of the Earth is less than 20,000 years.

____8. There is a significant body of data that supports evolutionary theory.

____9. Organisms exist today in essentially the same form in which they always have.

____10. Evolution is not a scientifically valid theory.

____11. The age of the Earth is at least 4 billion years.

____12. Current evolutionary theory is the result of sound scientific research and methodology.

____13. Evolutionary theory generates testable predictions with respect to the characteristics of life.

____14. The theory of evolution cannot be correct, since it disagrees with the Biblical account of creation.

____15. Humans exist today in essentially the same form they always have.

____16. Evolutionary theory is supported by factual, historical, and laboratory data.

____17. Much of the scientific community doubts if evolution occurs.

____18. The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms.

____19. With few exceptions, organisms on Earth came into existence at about the same time.

____20. Evolution is a scientifically valid theory.

Section III: For the following items, please circle the letter that corresponds to the BEST answer.

21. The evolutionary theory proposed by Charles Darwin was:
   a. Change in populations through time as a result of mutations
   b. The spontaneous generation of new organisms
   c. The passing on of genes form one generation to the next
   d. Change in populations through time as a response to environmental change
   e. The development of characteristics by organisms in response to need

22. The wing of a bat and the fore-limb of a dog are said to be homologous structures. This indicates that:
   a. They have the same function
   b. Bats evolved from a lineage of dogs
   c. They are structures which are similar due to common ancestry
   d. The limb bones of each are anatomically identical
   e. They have a different ancestry but a common function

23. Using radioactive dating techniques, the first life seems to have appeared on the earth about:
   a. 10 thousand years ago
   b. 270 million years ago
   c. 3.3 billion years ago
   d. 4.5 million years ago
   e. 10 billion years ago

24. Which of the following phrases best describes the process of evolution?
   a. The development of man from monkey-life ancestors
   b. The change of simple to complex organisms
   c. The development of characteristics in response to need
   d. The change of populations through time
   e. The change of populations solely in response to natural selection

25. Marine mammals have many structural characteristics in common with fishes. The explanation that evolutionary theory would give for this similarity is:
   a. Fish and mammals are closely related
   b. Fish evolved structures similar to those already existing in mammals
   c. Marine mammals evolved directly from the fishes
   d. Marine mammals never developed use of limbs
   e. Marine mammals adapted to an environment similar to that of the fishes

26. An alternation in the arrangement of nucleotides in a chromosome, possibly resulting in either a structural or physiological change in the organism, is called:
   a. Genetic drift
   b. Gene flow
   c. A mutation
   d. Natural selection
   e. A recessive gene

27. It is thought that there was a rapid evolutionary rate once animal life invaded land from the oceans. The explanation given for this rapid evolution is:
   a. There were many potential habitats for new forms to fill
   b. The land was a perfect haven for life
   c. There were many climatic changes occurring at the time
   d. Radiation from the sun caused mutations
   e. The ocean was too stable and limited to allow for evolution to occur

28. The first animals to settle on land probably had which one of the following characteristics?
    a. They were quite mobile to escape from predators
    b. They were partially dependent upon water for survival
    c. They were capable of completely adapting to the terrestrial environment in their life span
    d. They had wings for flight from one habitat to another
    e. They were quite adept at feeding on specific terrestrial plants

29. Two islands are found in the middle of the Pacific Ocean, isolated from any other land mass. These two islands were at one time connected by a land bridge and are of recent origin. They have identical plant and animal life and are separated by 50 miles of ocean. Assuming different selection pressures, which of these island populations would be most likely to be reproductively isolated, possibly allowing for species divergence?
    a. Dandelions, with airborne seeds
    b. Coconuts with floating seeds
    c. Birds
    d. Butterflies
    e. Mice

30. The population of Florida panthers has been drastically reduced by the actions of man. Which of the following most likely threatens their ability to continue to evolve in response to the pressures of their environment:
    a. There is no longer the prospect of over-reproduction
    b. There is no longer the prospect of a struggle for limited resources
    c. There is a lack of genetic variation for selection to act upon
    d. There is no longer the prospect of a trait conferring a reproductive advantage
    e. There is no longer the prospect of genetic drift occurring

31. A sudden major climatic change would most likely result in:
    a. A rapid increase in adaptive radiation
    b. A rapid increase in extinction rates
    c. A sharp increase in numbers of species
    d. An increase in mutation rates
    e. Plants and animals developing new characteristics in order to cope with environmental changes

32. The most compelling evidence for large-scale evolutionary change or macroevolution is:
    a. Kettlewell's release-recapture experiment with peppered moths
    b. The fossil record
    c. The occurrence of mass extinctions
    d. Domestication of plants and animals
    e. The observed increase of mutation rates across all species

33. When first proposed, Darwin's theory of natural selection did not fully explain how evolution could occur. This was due to:
    a. Darwin's failure to recognize the tendency of organisms to over-reproduce
    b. Darwin's initial overemphasis of the significance of genetic drift
    c. The fact that accurate mechanisms explaining genetic inheritance were not widely known
    d. The absence of accurate description of the embryological development of most plants and animals
    e. The absence of biochemical techniques to determine the genetic similarities between species

34. The presence of tropical rainforest fossil forms in Canada can best be explained by:
    a. A shifting of environmental requirements by these types of species
    b. A major climatic shift of the Earth
    c. A drifting of continents in a northward direction
    d. An uplifting of lowland areas
    e. A long-term constance of climate

35. Individuals within a species tend to be genetically different. The primary mechanism generating this individual variability is:
    a. Meiosis
    b. Mitosis
    c. Polyploidy
    d. Duplications
    e. Asexual reproduction

36. The extinct species *Archaeopteryx* has characteristics of both birds and reptiles. This is an example of a(n):
    a. Convergent species
    b. Trace fossil
    c. Archetype
    d. Intermediate form
    e. Polymorphic species

37. The earliest fossils found in the geologic record are:
    a. Fungi
    b. Bacteria
    c. Small photosynthesizing plants
    d. Seed plants
    e. Protozoa

38. Radiometric dating techniques rely on the fact that:
    a. The bony portions of organisms decompose at known rate
    b. Organisms which lived earlier in time will tend to be found in sediments below organisms which lived more recently
    c. The magnetic field of the earth has reversed its polarity at the known time intervals in geologic time
    d. The earth contains elements which change into other elements at a constant rate
    e. During the decomposition process organic matter is converted into radioactive elements at a known rate

39. Which of the following best represents Lamarck's ideas of evolutionary process?
    a. Survival of the fittest
    b. Inheritance of acquired characteristics
    c. Neutral drift
    d. Punctuated equilibrium
    e. Assortive mating

40. Which of the following is not a part of Darwin's theory of natural selection?
    a. Individuals of a population vary
    b. Organisms tend to over-reproduce themselves
    c. There are limited resources for which individuals compete
    d. Modifications an organism acquire*s* during its lifetime can be passed to its offspring
    e. Variations possessed by individuals of a population are heritable

41. The life histories of five birds of the same species are listed below. The most evolutionally successful bird is the one that:
    a. Lives 5 years, lays 12 eggs in a lifetime, 4 hatch
    b. Lives 2 years, lays 8 eggs in a lifetime, 5 hatch
    c. Lives 6 years, lays 2 eggs in a lifetime, 2 hatch
    d. Lives 4 years, lays 7 eggs in a lifetime, 6 hatch
    e. Lives 5 years, lays 4 eggs in a lifetime, 3 hatch

Section IV: Please respond to the following questions as honestly as possible.

5. What percentage of the content in your biology syllabus is taken from the CSEC biology syllabus?

____

6. Do you currently teach evolution in your biology classroom? Yes No
   If so, do you teach it as a *unit* or *overarching theme*?

____

7. What biology textbook do you use?

____

8. Are you satisfied with the treatment of evolution in your course textbook? Yes No
   If No, why not?

____

9. Do you feel well prepared to teach concepts in evolution? Yes No
   If No, what would help you be better prepared?

____

10. To what extent should we care about the theory of evolution?

____

THANK YOU FOR YOUR TIME AND SUPPORT

LIST OF REFERENCES

Abd-El Khalick, F., & Lederman, N.G., (2000a). Improving science teachers' conceptions of the nature of science. A critical review of the literature. *International Journal of Science Education*, 22, 665-701.

Abell, S.K., (2007). Research on Science Teacher Knowledge. In S. K. Abell & N.G. Lederman (eds.) *Handbook of research on science education*. (pp 1105-1149). Manhwah, NJ: Lawrence Erlbaum Associates.

Aguillard, D. (1999). Evolution education in Louisiana public schools: a decade following Edwards v. Aguillard. *American Biology Teacher*, 61, 182-188.

Aleixandre, M.P.J., (1994). Teaching evolution and natural selection: A look at textbooks and teachers. *Journal of Research in Science Teaching*, 31, 519-535.

Allmon, W.D., (2006). Evolution, Creation, and Intelligent Design: A Natural History Museum's Experience. ASTC Dimensions.

American Association for the Advancement of Science. (1993). Benchmarks for Science Literacy. New York: Oxford University Press.

American Association for the Advancement of Science, (2002). AAAS resolution: Opposition to teaching creation accounts in science class. Retrieved, November 21, 2009, from http://archives.aaas.org/docs/resolutions.php?doc_id=292.

Anderson, R.D., (2007). Teaching the theory of evolution in Social, Intellectual and Pedagogical context. *Science Education*, 91, 664-677.

Bandoli, J.H., (2008). Do State Standards Matter? Comparing Student Perceptions of the Coverage of Evolution in Indiana & Ohio Public High Schools. *The American Biology Teacher*, 70, 212-216.

Belize Protected Areas Conservation Trust (PACT) http://www.pactbelize.org Accessed, July, 2009.

Besterman, H., & Baggot la Velle, L., (2007). Using human evolution to teach evolutionary theory. Journal of Biological Evolution 42, 76-81.

Bransford, J.D., A.L., Brown, & R.R. Cocking, eds. (2000). How people learn. National Academy Press, Washington, D.C.

Brem, S.K., Ranney M., Schindel, J. (2003). Perceived consequences of evolution: College students perceived negative personal and social impact on evolutionary theory. *Science Education*, 87, 181-206.

Brumby, M.N., (1984). Misconceptions about the concept of natural selection by medical biology students. *Science Education*, 68, 493-502.

Bybee, R.W., (2002). We should teach about biological evolution. *Bioscience,* 52, 616-618.

Caribbean Examinations Council (CXC) www.cxc.org. Accessed January, 10, 2009.

Carlesen, S.W., (1991). Effects of new biology teachers' subject-matter knowledge on curricular planning. Science Education, 75, 6631-6647.

Catley, K.M., (2006). Darwin's Missing Link—A novel paradigm for evolution education. *Science Education*, 90, 767-783.

Catley, K.M., & Novick, L.R., (2009). Digging Deep: Exploring College Students' Knowledge of Macroevolutionary Time. *Journal or Research in Science Teaching*, 46, 311-332.

Chuang, H.C., (2003). Teaching evolution: Attitudes and strategies of educators in Utah. *American Biology Teacher*, 65, 669-674.

Clark A.M., & Brown, J., (1996). Teach Evolution with a Historic Perspective. *The American Biology Teacher*, 58, 326-327.

Cobern, W., (1994) Point: Belief, Understanding and the teaching of evolution. *Journal of Research in Science Teaching*, 31, 583-590.

Crawford, B.A., Zembal-Saul C., Munsford, D., Friedrichsen, P., (2005). Confronting Prospective Teachers Ideas of Evolution and Scientific Inquiry using Technology and Inquiry-Based Tasks. *Journal of Research in Science Teaching*, 42, 613-637.

Cummins, L.C., Demastes, S.S., & Hafner, M.S., (1994). Evolution: biological evolution's under researched unifying theme. *Journal of Research in Science Teaching*, 31, 445-448.

D'Adamo, P.J., & Whitney, C., (1997). Eat right for your type: The individual diet solution to staying healthy, living longer, and achieving your ideal weight. New York. Puntam Publishing.

Dean, C. (2005). Evolution takes a back seat in U.S. Classes. The New York Times February 1, Section F, p.1.

Demastes, S.S., Good, R.G., Cummins, C.L., (1992). Resource paper on evolution education research. In: R. G. Good, J. E. Trowbridge, S.S., Demastes, J.H. Wandersee, M.S. Hafner, & C.L. Cummins (Eds), Proceedings of the 1992 Evolution Education Research Conference (pp. 42-71). Baton Rouge, LA: Lousiana State Univeristy. (ERIC Document Reproduction Service No. ED 361183).

Demastes, S.S., Settlage, J. Jr., & Good, R.G. (1995). Students' conceptions of natural selection and its role in evolution: Cases of replication and comparison. *Journal of Research in Science Teaching*, 21, 535-550.

Deniz, H., Donnelly, L.A., Yilmaz, I. (2008). Exploring the factors related to acceptance of evolutionary theory among Turkish preservice biology teachers: Toward a more informative conceptual ecology for biological evolution. *Journal of Research in Science Teaching*, 45, 420-443.

Dobzhansky, T., (1973). Nothing in biology makes sense except in the light of evolution. *The American Biology Teacher*, 35, 125-129.

Doddick, J., & Orion, N. (2003). Cognitive factors affecting student understanding of geologic time. *Journal of Research in Science Teaching*, 40, 415-442.

Donnelly, L.A., & Boone, W.J. (2007). Biology Teachers' Attitudes Toward and Use of Indiana's Evolution Standards. *Journal of Research in Science Teaching*, 44, 236-257.

Donnelly, L.A., Kazempour, M., Amirshokoohi, A., (2008). High school students' perceptions of evolution Instruction: Acceptance and Evolution Learning Experiences. *Research in Science Education.* DOI 10.1007/s11165-008-9097-6.

Downie, J.R., & Barron, N.J., (2000). Evolution and religion: Attitudes of Scottish first year biology and medical students to the teaching of evolutionary biology. *Journal of Biological Education*, 34, 139-146.

Eve, R.A., & Dunn, D., (1990). Psychic powers, astrology & creationism in the classroom? *American Biology Teacher*, 52, 10-20.

Fahrenwald, C.R., (1999). Biology teachers acceptance and understanding of evolution and the nature of science. *Dissertation Abstracts International*, 60, 2434.

Futuyama, D.J. (1998). Evolutionary Biology (3rd ed). Sunderland, MA: Sinauer Associates, Inc.

Goldston, M.J. "Dee" & Kyzer P. (2009). Teaching Evolution: Narratives with a view from Three Southern Biology Teachers in the USA. *Journal of Research in Science Teaching*, 46, 762-790.

Greene, E.D., (1990). The logic of university student' misunderstanding of natural selection. *Journal of Research in Science Teaching*, 27, 875-885.

Griffith, J.A., & Brem, S.K., (2004). Teaching evolutionary biology: Pressures, stress and coping. *Journal of Research in Science Teaching*, 41, 791-809.

Gross, P.R., (2005). The State of State Science Standards. Washington: The Thomas B. Fordham Foundation.

Hameed, S., (2008). Bracing for Islamic Creationism. *Science*, 332, 1637-1538.

Hamer, D.H., & Copeland, P., (1998). Living with our genes: Why they matter more than you think. Garden city, NY: Doubleday.

Hermann, R.S., (2005). The Interaction of belief and understanding of controversial science concepts: toward a grounded theory of cognitive apartheid. Paper presented at the annual meeting of National Association for Research in Science Teaching, Dallas, Texas.

Hermann, R.S., (2008). Evolution as a controversial issue; a review of instructional approaches. *Science and Education*, 17, 1011- 1032.

Hokayem, H., & BouJaoude, S., (2008). College Students' Perceptions of the Theory of Evolution. *Journal or Research in Science Teaching*, 45, 395 - 419.

Jensen, M.S., & Finley, F.N., (1996). Changes in Students' Understanding of Evolution Resulting from Different Curricular and Instructional Strategies. *Journal of Research in Science Teaching*, 33, 879-900.

Johnson, R.L., (1986). The acceptance of evolutionary theory by biology majors in colleges of the West North Central states. (Doctoral Dissertation, University of Northern Colorado, 1095). Dissertation Abstracts International, 46, 1893a.

Johnson, R.L., & Peebles, E.E. (1987). The role of scientific understanding in college: Student acceptance of evolution. *The American Biology Teacher*, 49, 93-98.

Kampourakis, K., & Zogza, V., (2008). Preliminary Evolutionary Explanations: A Basic Framework for Conceptual Change and Explanatory coherence in Evolution. *Science and Education*,18, 1313-1340.

Korte, S.E., (2003). The Acceptance and Understanding of Evolutionary Theory among Ohio Secondary Life Science Teachers. Unpublished Masters Thesis. Ohio University.

Lawson, A.E., & Thompson, L.D., (1988). Formal reasoning ability and misconceptions concerning genetics and natural selection. *Journal of Research in Science Teaching*, 25, 733-746.

Lawson, A.E., & Weser, J., (1990). The rejection of nonscientific beliefs about life: Effects of instruction and reasoning skills. *Journal of Research in Science Teaching*, 27, 589-606.

Lawson, A.E., & Worsnop, W.A., (1992). Learning about evolution and rejecting a belief in special creation. Effects of reflective reasoning skill, prior knowledge, prior belief and religious commitment. *Journal of Research in Science Teaching*, 29, 143-166.

Lee, Y.J., & Yeoh, O.C., (1998). Biological Evolution: A Tough Nut for Biology Teachers in Singapore? *Popular Measurement*,1, 69-72.

Lerner, L. S., (2000). Good Science, Bad Science: Teaching Evolution in the States. Washington: The Thomas B. Fordham Foundation.

Mayr, E., (2002). What evolution is. Weidenfeld and Nicholson, London.

Meadows, L., Doster, E., Jackson, D.F., (2000). Managing the conflict between evolution and religion. The *American Biology Teacher*, 62, 102-107.

Miller, J.D., Scott, E.C., Okamoto S., (2006). Public Acceptance of Evolution. *Science*, 313, 765-766.

Moore, R., (2000). The revival of creationism in the United States. *Journal of Biological Education*, 35, 17-21.

Moore, R., (2002). Teaching evolution: Do state standards matter? *BioScience*, 52, 378-381.

Moore, R., & Kraemer, K., (2005). The teaching of evolution and creationism in Minnesota. *The American Biology Teacher*, 67, 457-466.

Moore, R. , Mitchell, G., Bally, R., Inglis, M., Day, J., & Jacobs, D., (2002). Undergraduates' understanding of evolution. Ascriptions of agency as a problem for student learning. *Journal of Biological Education*, 36, 65-71.

Moore, R., (2004). How well do biology teachers understand the legal issues associated with the teaching of evolution? *BioScience*, 54, 860-865.

Nehm, R.H., & Schonfeld, I.S., (2007) Does Increasing Biology Teacher Knowledge of Evolution and the Nature of Science Lead to Greater Preference for the Teaching of Evolution in Schools? *Journal of Science Teacher Education*, 18, 699-723.

National Academy of Science. (1998). Teaching about evolution and the nature of science. Washington, DC: National Academy Press.

National Academy of Sciences. (1999). Science and creationism: A view from the National Academy of Science. Washington DC: National Academy Press.

National Academy of Sciences (NAS). Science, evolution and creationism. Washington D. C. National Academies; 2008a. Available at http://www.nap.edu/catalog.php?record_id=11876 (accessed Oct 26, 2009).

National Association of Biology Teachers, (2000). Statement on teaching evolution. Retrieved November 21, 2009, from http://www.nabt.org/sub/position_statements/evolution.asp.

National Research Council. (1996). National Science Education Standards. Washington, DC: NRC.

National Science Teachers Association, (1997) NSTA position statement: The teaching of evolution. Retrieved November 21, 2009, from &http://www.nsta.org/159&psid=10.

National Science Teachers Association (NSTA). (2005). Survey indicates science teachers feel pressure to teach nonscientific alternatives to evolution. Available online at www.nsta.org/pressroom&newsstoryID=50377.

Osif, B.A., (1997). Evolution and religious beliefs: A survey of Pennsylvania high school teachers. *The American Biology Teacher*, 59, 552-556.

Prinou, L., Halkia, L., Skordoulis, C., (2005) Teaching the Theory of Evolution: Secondary Teachers' Attitudes, Views and Difficulties. Available at: http://www.ihpst2005.leeds.ac.uk/papers/Prinou_Halkia_Skordoulis.pdf

Raizen, S.A., (1998). Standards for science education. *Teachers College Record*, 100, 66-121.

Rutledge, M.L., & Warden, M.A., (1999). "The development and validation of the measure of acceptance of the theory of evolution instrument." *School Science and Mathematics,* 99, 13-18.

Rutledge, M.L., & Mitchell, M.A., (2000). Knowledge structure, acceptance and teaching of evolution. *The American Biology Teacher*, 64, 21-28.

Rutledge, M.L., & Mitchell, M.A., (2002). High School Biology Teachers' Knowledge Structures, Acceptance and Teaching of Evolution, *The American Biology Teacher,* 64, 21-28.

Rutledge, M.L. & Warden M.A., (2000). Evolutionary Theory, the Nature of Science & High School Biology Teachers: Critical Relationships. *The American Biology Teacher*, 62, 23-31.

Scharmann, L.C. (1990). Enhancing an understanding of the premises of evolutionary theory: The influence of diversified instructional strategy. *School Science and Mathematics*, 90, 91-100.

Scharmann, L.C., (2005). A proactive strategy for teaching evolution. *American Biology Teacher*, 67, 12-16.

Scharmann, L.C., & Harris, W.M., (1992). Teaching evolution: Understanding and applying the nature of science. *Journal of Research in Science Teaching*, 29, 375-388.

Settlage, J. Jr., & Meadows, L. (2002). Standards-based reform and its unintended consequences: Implications for science education with America's urban schools. *Journal of Research in Science Teaching*, 29, 114-127.

Shankar, G., (1990). Factors influencing the teaching of evolution and creationism in Texas public high school biology classes. (Doctoral dissertation, Texas Tech University, 1989). Dissertation Abstracts International , 51 (03), 773A.

Shankar, G., & Skoog, G., (1993). Emphasis given to evolution and creationism by Texas high school biology teachers. *Science Education*, 77, 221-233.

Sinatra, G. M., Southerland, S.A., McConaughy, F., & Demastes, J.W., (2003). Intentions and beliefs in students' understanding and acceptance of biological evolution. *Journal of Research in Science Teaching*, 40, 510-528.

Skoog, G., & Gilica, K., (2002). The emphasis given to evolution in state standards: A lever for change in evolution education? *Science Education*, 86, 445-462.

Smith, M.U., Seigel, H., McInerney, J.D., (1995). Foundational issues in evolution education. *Science and Education*, 4, 23-46.

Tatina, R., (1989). South Dakota high school biology teachers and the teaching of evolution and creationism. *The American Biology Teacher*, 51, 275-280.

Tobin, K., Kahle, J., Fraser, B. (1990). Windows into science classrooms: Problems associated with higher-level cognitive learning. London: Falmer Press.

Trend, R. D., (2001). Deep time framework: A preliminary study of U.K. primary teachers' conceptions of geologic time and perceptions of geoscience. *Journal of Research in Science Teaching*, 38, 191-221.

Troost, C.J., (1966). An analysis of factors influencing the teaching of evolution in the secondary schools of Indiana. Unpublished doctoral dissertation. Indiana University, Bloomington.

Van Koevering, T.E., & Stiehl, R.B. (1989). Evolution, creation, and Wisconsin biology teachers. *The American Biology Teacher*, 51-200-202.

Weld, J., & McNew, J.C., (1999). Attitudes towards evolution. *Science Teacher*, 66, 27-31.

WGBH Educational Foundation (2001). Evolution Teacher's Guide. Boston, MA: Author.

Wood, T., (1988). State-mandated accountability as a constraint on teaching and learning science. *Journal of Research in Science Teaching*, 25, 631-641.

Woods, C.S., & Sharamann, L.C., (2001). High school students' perceptions of evolutionary theory. *Electronic Journal of Science Education*, 6 (2). Retrieved December 12, 2001 from http://unr.edu/homepage/crowther/ejse/woodsetal.html.

Wright, B.D., & Masters, G.N., (1982). Rating scale analysis. Chicago: Mesa Press.

Zimmerman, M., (1987). The evolution-creation controversy: Opinions of Ohio high school biology teachers. Ohio Journal of Science, 87, 115-125.

Zuzovsky, R., (1994). Conceptualizing a teaching experience on the development of the idea of evolution. An epistemological approach to the education of science teachers. *Journal of Research in Science Teaching*, 31, 557-574.

BIOGRAPHICAL SKETCH

Elvis Nunez was born in Belize in 1985. His undergraduate education was completed both in Belize and at the University of Hawaii at Hilo where he obtained a B.A. in Marine Science and AAs in biology, chemistry and mathematics. During his science career, Mr. Nunez’s portfolio has grown to include working on adrenal cancer; hermaphrodite nematodes; marine reserves both in Belize and in Hawaii, and excavating pre-historic mammals in Florida. He is currently pursuing a degree in biology with a minor in science Education, in hopes of working in curriculum reform and environmental policy in the near future.