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Influences on Understanding and Belief About the Origin of Species in Chinese and American Adolescents

A Dissertation submitted in partial satisfaction
of the requirements for the degree of

Doctor of Philosophy

in

Psychology

by

Erin Irene Smith

August 2011

Dissertation Committee:
- Dr. Rebekah A. Richert, Chairperson
- Dr. Mary Gauvain
- Dr. Ruth Chao
- Dr. Andrew Shtulman

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The Dissertation of Erin Irene Smith is approved:

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Committee Chairperson

University of California, Riverside

Acknowledgement of Contributions

> "All mankind is of one author, and is one volume; when one man dies, one chapter is not torn out of the book, but translated into a better language; and every chapter must be so translated...As therefore the bell that rings to a sermon, calls not upon the preacher only, but upon the congregation to come....No man is an island, entire of itself; every man is a piece of the continent, a part of the main" (Donne, 1624/1959, p.108[1]).

Although John Donne certainly did not have dissertation research in mind when he wrote this meditation, as I reflect on the process by which the study you are about to read was designed, collected, analyzed, and described within these pages, I am convinced that I am—as is the research itself—just a piece of the continent.

The roots of this research may be traced back several years, when Dr. Rebekah Richert invited me to work as a graduate research assistant on a Cognition, Religion, and Theology Grant awarded to her to study the development of concepts of the soul. It was this grant that partially funded my first data collection trip to China. Through a series of research restrictions and set-backs that limited my ability to examine Chinese children's soul concepts, a section of questions was added to this survey to examine Chinese children's beliefs about the origin of species. I had always found Kelemen's (2004) concept of intuitive theism and Evans (2001) research into origin beliefs to be interesting; Rebekah (rightly) fostered that interest in this initial study.

The results from these questions about origins (Smith & Richert, 2011b) contradicted the most often cited research and theory into the development of beliefs about origins. As my husband will attest, I am quite the contrarian, thus, the opportunity

[1] Donne, J. (1624/1959). *Devotions upon emergent occasions together with death's duel.* Ann Arbor: University of Michigan Press.

to be a contrarian in the name of science was highly appealing. However, it is not a good idea to challenge well-established research without the help of a small army of friendly faces to ask the tough questions and to promote clear, theoretically-grounded thinking before a group of less-than-friendly faces has the opportunity to catch one unawares. For this reason, I credit much of my ability to continually pursue these contradictory findings in the line of research represented in this dissertation to the unwavering support—often in the form of highly challenging questions—of Rebekah and other members of the Childhood Cognition Lab during my time in the lab: Dr. Michael Robb, Rachel Flynn, Nicholas Shaman, Dr. Jodi Fender, and Dr. Ellen Wartella. Their encouragement, questions, and willingness to critique, as well as the countless conversations we have had about a wide variety of research topics, has been essential not only to the development of my research, but also to my development as a scholar. To the Childhood Cognition "Army," and "Commander-in-Chief" Dr. Richert, I am greatly indebted.

Furthermore, the research presented in these pages is not just the result of hours of thinking and research discussion with the brilliant individuals in the Childhood Cognition lab, but also the result of stimulating discussions, class sessions, and professional conference meetings I have had the opportunity to have with the outstanding members of my dissertation committee, Drs. Mary Gauvain, Ruth Chao, and Andrew Shtulman. The opportunities I have had to interact with these individuals, as well as the specific feedback and input they provided on the proposal and outcome of this research was invaluable in this dissertation process. Additionally, I am thankful for the insight and encouragement offered by my dear friend Emily Burdett who labored through all these

pages despite her own dissertation deadlines and obligations. I look forward to the possibility of collaborating on projects to follow up on our questions of mutual interest as I have come to believe that a career in science is stimulating, but a career in science with friends is truly wonderful!

Finally, the research represented in these pages represent data collected after much labor, with the involvement of many undergraduate research assistants, translators, members of the local Riverside community, as well as members of the small community that so graciously hosted me in Southern China. Without the cooperation and participation of these students, teachers, school principals, and the dedication of my undergraduate research assistants and translators, this research would not have been possible. I am grateful that I had the opportunity to know these quality individuals. I am also thankful that as the result of the support of several funding sources I had the opportunity to give something back to these communities in exchange for their participation. The support of a Dissertation Research Grant and Dissertation Year Fellowship Program Award, both awarded by the Graduate Division at the University of California, Riverside, helped make that possible.

Acknowledgements

The dichotomy between an "acknowledgement of contributions" and a more personal "acknowledgements" section is mostly artificial. Individuals mentioned in both sections have contributed to my own development and the development of my research directly or indirectly. However, I will use this section to express my gratitude to several individuals who have dramatically shaped my overall life course, including the accomplishment of my Ph.D., from outside of the academic sphere. Since this task is considerably more daunting then it appears I will simply start from the beginning.

One of the basic principles of psychology is that from the beginning, individuals are a complex product of the interaction of their genes and their environment. Luckily for me, I am convinced my parents offered me the best of both. However, my parents did not pre-select my genes, so I won't talk about those. Instead, I'll focus on what I know best: my developmental environment that was rich in opportunities, experiences, and intellectual challenges, a credit largely owed to my parents' love and encouragement.

For as long as I can remember, my parents always encouraged me to try new things, to try my best, and to never give up. I did not realize it as a child, but thinking back I am amazed at how much my parents supported me. I think of their diligence as they drove me to, paid for, and most importantly were involved in my myriad of activities—piano lessons, youth group activities, club soccer, cross country, drama (the list goes on)—all while maintaining the truly important things, like eating dinners as a family or teaching me what it means to be a person of character. I could share any number of stories or memories to give evidence for how my parents have shaped my

development as a Christian, a thinker, a woman, a doer, a friend—and so much more. However, as this precedes one of the largest markers of my intellectual accomplishments, I will focus on two habits my parents had that I believe were highly influential to my intellectual development. I can say that these habits, no matter how minor or mundane they may seem, are evidence of the fact that my parents loved me enough to not only believe that I could achieve great things, but to meet me where I was, walking alongside me, challenging me to take steps necessary to strive higher and achieve more.

My sister and I now often tease our father about his terribly frustrating, yet typical response to our (frequent) questions during our childhoods: "what do you think?" (For me, this question was often also phrased, "how do you think it's spelled?" Dad, if I knew, I wouldn't have asked you.) But after years of asking (and not learning that he was not just going to give me the answer), I realized that this very question, and the process of thinking, debating, and researching that followed it, was largely responsible for many of the traits I have now that make me a good scientist. These conversations we had about so many things would never make an interesting novel, but in challenging me to think and to extend my knowledge beyond my assumptions, I believe my dad was largely responsible for the development of my critical thinking skills, my curiosity for knowledge, my interest in learning, and my intellectual development more generally.

With my mom I had my first exposure to research. More appropriately, I should say, I was her first test subject. I do not know how she did it, but I can think of several summers that we had "projects" that we worked on together. These projects usually involved me watching less television, reading more books, getting outside more often,

and (attempting) to keep my room clean. As an adult all of that sounds great to me, but to this day I cannot remember (or imagine) how she got me to agree that these challenges would be fun. Looking back, I saw several specific and strategic behaviors during these projects that my mom used to modify my behavior, including the use of token economies. Thus, in the comfort of my own home (in a clean room or the front yard while reading a book with the television off), my mom introduced me to psychology 101: behavior modification and token economies. I firmly believe that the behaviors she encouraged (and, ahem, modified) are largely responsible for my love of reading—and the closely related love of learning. Though these projects required more work from my mom (and stress, as was evident from The Case of the Missing Nancy Drew Book), I am forever grateful she took the time and energy required to instill in me habits of lifelong learning and healthy behaviors. Many academic and intellectual accomplishments have resulting from these habits and behaviors; these accomplishments are much to the credit of my mom.

With my love for research being traced to my mom, it is only fitting that I heard on the radio recently that "research shows that 2 girls make the most harmonious family." Luckily for my wonderful parents, that is exactly what they had…although I wonder if that is how they remember my sister and me as children. But, with the maturity that comes in adulthood, I can unequivocally say that my sister is one of my dearest friends. During times of doubt and insecurity, my sister always had kind and encouraging words to share. During less tender times, she inspires me to try things I would have otherwise skipped. I have great memories—not the least of which is capsizing our kayak in La

Jolla—full of laughter and everything a good friendship has. No one can ever decide if we are more similar or more different—but that is one of the things I love about my sister Tracy—it just does not matter. When we are together we can set aside the pressures of this world and we can both just be ourselves.

In addition to the incredible support and love of my family, I have a long history of fantastic educators that have clearly contributed to my educational success. One professor in particular, Dr. Wu at Point Loma Nazarene University, requires special mention as I credit my decision to attend graduate school at all to him. As an undergraduate student I got good grades and worked hard, but I was mostly interested in getting out. I was tired of working so hard (in and outside of school), so my plan was to work extra hard, graduate early, and "just work one job" for once. My, I remember how good that plan sounded to me. That was, until the day Dr. Wu ruined it all (for the best!). There was one particular assignment—an outline—that I had turned in to Dr. Wu as part of the requirements for his Developmental Psychology course the spring semester of my junior year. When the assignment was returned, there was a simple comment in the back: "have you thought about graduate school?" I had (and still have) great respect for Dr. Wu, so I took that comment quite seriously. In a later conversation with Dr. Wu, he told me that I had the kind of intellectual capability to succeed at high levels and that if I had not thought about graduate school I at least owed it to myself to do so. At that point the most consideration I had given to graduate school was in the form of can nots, would nots and could nots. But as I am now writing this story in the acknowledgements of my

dissertation, I would say that simple comment and follow-up conversation has made all the difference for me.

The move to Riverside for graduate school was a good one, not just because of the caliber of the program, faculty, or other graduate students, but because of what my husband and I never expected to find: Sandals Church. Sandals Church is a unique place where for the first time in a long time I was challenged to stop faking it and to start living authentically. Surrounded by the kind of community the Apostle Paul talks about in Acts, I began to feel alive in the Spirit of God's grace. I was humbled by my weakness and strengthened by the power of Christ. My husband and I have had the opportunity to know—and be known by—some incredible people at Sandals Church. There are too many to list here, but I think specifically of the Sullivan and Thompson families. If it were not for their exercise of the gifts that God has given them, I do not know if we would have made that first scary step to really commit to serving God by serving His people. Sean, Michelle, Miles, and Heidi (oh, the Meidi Hiles!) have been wonderful friends and mentors. I am so grateful for their friendship, wisdom, and continual prayers; I am so grateful to be on the journey of life with them.

There is also a small collection of individuals with whom I have had the opportunity to grow with at Sandals Church specific to the question of what it means to be a Christian scholar. I believe that God is the author of all knowledge, and I am humbled that He would permit me all the opportunities I have had to know him through not only His Scripture but also by studying His creation, His book of nature. As humankind was made in the image of God (Genesis 1:26), knowing the intricacies of

human psychology is to know something more about God himself. I mean no hyperbole when I say that without the strength, will, spirit, direction, saving grace, and redemptive power of Jesus Christ in my life, I would amount to nothing and everything I have gained and accomplished would be to my detriment. This is exactly the sentiment of the Apostle Paul in Philippians 3:8, "Indeed, I count everything as loss because of the surpassing worth of knowing Christ Jesus my Lord…" (ESV).

Before concluding this inherently insufficient acknowledgement, I will say that I feel honored to travel down this road of knowing and loving Christ. I have come to believe that God is not so simple as I once thought, nor are things as straightforward as I once believed them to be. However, I believe that God can be revealed through science, even if indirectly. In pushing the boundaries of our knowledge about the natural world, we provide the opportunity increase our knowledge of God. I think this may be, in part, the sentiment provided by Dietrich Bonhoeffer when he wrote:

> It has again brought home to me quite clearly how wrong it is to use God as a stop-gap for the incompleteness of our knowledge. If in fact the frontiers of knowledge are being pushed back (and that is bound to be the case), then God is being pushed back with them, and is therefore continually in retreat. We are to find God in what we know, not in what we don't know; God wants us to realize his presence, not in unsolved problems but in those that are solved.[2] (p. 311)

[2] Bonhoeffer, D. (1972). Letters and papers from prison, enlarged edition. New York: Macmillan.

My final acknowledgement here is by no means the least. For that reason, I struggle to even think of where to begin. My husband, Raider, is the best person I have ever met. Raider is the kind of man that is not easily described on paper; the listing of so many positive traits and incredible memories in one sentence violates all sorts of grammatical practices. People are amazed at how much he has given up and put on hold for my educational endeavors. They usually do not even know half of it. For the sake of space, I will say two specific things about Raider that I admire and that encourage me to be a better me. First, Raider is incredibly intelligent. Because of the (soon-to-be) alphabet soup behind my name, our friends often mistake me for the bright one in the family. I joke that Raider learned everything I did in graduate school (because I often reenacted lectures and conferences for him), but has the advantage of knowing everything else too. Raider inspires me to think bigger, to develop new ideas, and to evaluate how very different things may be fundamentally related. Second, and most important, Raider is a man who loves Jesus Christ, who strives to know him more, and who works everyday to lead me according to Holy Spirit. I respect him greatly and I believe that I won the cosmic grand prize that first time he asked me on a date. Since that date I have grown to love, respect, and admire Raider more than I ever dreamed possible. For us, this dissertation is a monumental achievement in the making but I know it is only one of many adventures for us. With Raider, the ultimate and only love of my life, I look forward to learning and discovering more through all our adventures still to come.

I fully recognize that a few paragraphs in an acknowledgement section will never be adequate to thank the individuals mentioned and unmentioned here for all they have

done for me and how they have shaped my life. I think of the many friends with whom I have enjoyed countless game nights and times of laughter. Perhaps these experiences are not directly related to this dissertation, but I am convinced I would not be in this place today without the kind of social support system I have. I also fully recognize that although I will be the one gaining a title after these 5 years in graduate school (and 3 years in college, and 4 years in high school….), my doctorate truly represents the work, love, support, encouragement, and challenges of a large collection of others. I feel that this accomplishment is really the work of the proverbial village; I have the work-of-a-village-Ph.D. So, to the village: thank you.

ABSTRACT OF THE DISSERTATION

Influences on Understanding and Belief About the
Origin of Species in Chinese and American Adolescents

by

Erin Irene Smith

Doctor of Philosophy, Graduate Program in Psychology
University of California, Riverside, August 2011
Dr. Rebekah A. Richert, Chairperson

Although beliefs about origins and evolutionary knowledge have been considered independent, research has suggested that both are influenced by cognitive constraints of psychological essentialism and teleology. Most research supporting these claims has been conducted with children from Western cultures; little is known about the psychological processes underpinning beliefs and knowledge about the natural world outside Western contexts or during adolescence. Claims about the universality of beliefs, knowledge, and the possible relationship between should be made after examining samples that differ in theoretically relevant ways from a typical Western sample, such as a Chinese sample in which religious explanations are rare or an adolescent sample in which brain development promotes the coordination of conflicting information.

To examine how belief and knowledge are related in Western- and non-Western samples, as well as the factors that predict both independently, 238 Chinese (M = 15.85 years old, SD = .85 years; 36.6% male) and 277 American adolescents (M = 15.80 years, SD = 1.34 years; 51.6% male) were recruited from their high schools to participate. Adolescents completed a survey measuring beliefs about the origin of living and non-

living exemplars, evolutionary knowledge, and variables that were likely to influence belief and knowledge such as science preference, epistemology, psychological essentialism, teleological reasoning, and religious beliefs.

American adolescents were more creationist than Chinese adolescents. Chinese adolescents displayed more sophisticated evolutionary knowledge than American adolescents although overall performance was low. Finally, there was no relationship between belief and knowledge for American adolescents yet there was a small, positive relationship for Chinese adolescents such that adolescents who believed in creation also tended to demonstrate more evolutionary knowledge. Additional analyses employed mediation techniques to explain why cultural differences in creation belief and evolutionary knowledge exist. Age was unrelated to belief and to knowledge.

The discussion focuses on the aspects of cultural membership that contribute to belief and evolutionary knowledge. Additional discussion highlights the role of classroom curriculum, curriculum testing, and focusing on uncovering variables and techniques that promote evolutionary learning.

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Chapter 1—Introduction

James (1890/1983), a founding father of American psychology, argued that reality is understood and filtered through cognitive sub-worlds. For example, involvement in fiction activates a cognitive fantasy sub-world regulated by rules of fantasy; science activates a cognitive science sub-world regulated by rules of science. Similar principles operate when individuals are confronted with information from the physical senses and religious material. James argued that while engaged within one sub-world, others are ignored. Although James gave prominence to the world of sense, the world that is readily observable, much of what children and adults learn and believe about the world is not from the world of sense, but from scientific and religious constructs such as the existence of germs and invisible agents (Harris, Pasquini, Duke, Asscher, & Pons, 2006; Harris & Richert, 2008).

One of the predictions of this sub-world hypothesis is that inconsistent beliefs become possible, as long as the beliefs are in different sub-worlds. From the vantage of the sub-world hypothesis, the co-existence of conflicting beliefs—for example, beliefs that the origin of the world can be explained with both creation and evolution—are entirely possible, if not the normal result of individuals' cognitive and cultural development (Legare, Evans, Rosengren, & Harris, in press). According to this approach, even after the adolescent period, in which maturation of prefrontal connectivity promotes the development of the cognitive maturity to integrate and/or coordinate inconsistencies (Kagan, 2010), adults may still have and use both natural and supernatural explanations concurrently.

Another prediction of the sub-world framework is that one may have knowledge that is different from what one believes to be true, whether or not those beliefs can be tested. Knowledge here is defined by information learned from the empirical, testable methods of science; and belief is used in a broad, colloquial sense. An equivalent question to "do you believe" would be "do you hold to be true;" both questions allow individuals to incorporate or reject scientific knowledge in their belief stance. This distinction between knowledge and belief is meaningful as individuals' often hold to and act on beliefs they know are not empirically supported (e.g., base rate neglect, Berger, 2006).

Related to the topic of this dissertation, a third prediction from the sub-world hypothesis would be that beliefs and knowledge about the natural world may activate different sub-worlds. In this case, information learned using the methods of science will be independent from belief. Belief in creation, for instance, may be located within a religious sub-world whereas evolutionary knowledge may be founded in a scientific sub-world. James' sub-world hypothesis predicts that knowledge about evolution should be related to belief in evolution if both knowledge and belief about origins are processed within a science sub-world. If however, one believes creation is the best explanation for origins, it would be possible to maintain extensive evolutionary knowledge while believing in creation as creation belief belongs in the religious sub-world and evolutionary knowledge in the science sub-world. The current research addresses questions of this nature.

These predictions from James' sub-world hypothesis are partially supported by empirical research suggesting that beliefs about origins and evolutionary knowledge are orthogonal. Research into evolutionary misconceptions has found misconceptions are common among religious believers who reject evolution as well as individuals who accept and believe evolution to be the best explanation for origins (Bishop & Anderson, 1990; Dagher & BouJaoude, 1997; Lawson & Worsnop, 1992; Sinatra, Southerland, McConaughy, & Demastes, 2003). These findings suggest that evolutionary knowledge is equally lacking across among adherents of various religious and non-religious beliefs. However, given the prevalence of evolutionary misconceptions it is unclear if knowledge and belief may be related among individuals who do not demonstrate these evolutionary misconceptions. An analysis of the possibility that knowledge and belief are related for those with correct understanding of evolutionary theory is difficult as there is considerable evidence suggesting that across age and education levels, many people struggle to understand and correctly articulate the tenets of modern evolutionary theory.

Researchers have documented that misconceptions about modern evolution persist after general biology instruction (Banet & Ayuso, 2003; Bishop & Anderson, 1990) and specific instruction on evolution (Bizzo, 1994; Lawson & Worsnop, 1992; Sandoval & Morrison, 2003; Settlage, 1994). These misconceptions are present among high school students (Bizzo, 1994; Lawson & Worsnop, 1992; Settlage, 1994; Shtulman, 2006), undergraduate biology and non-biology majors (Bishop & Anderson, 1990; Dagher & BouJaoude, 1997; Ferrari & Chi, 1998; Larreamendy-Joerns & Ohlsson, 1995; Shtulman, 2006; Sinatra et al., 2003), medical students (Brumby, 1984), and adults who are not

current college undergraduates (Shtulman & Schulz, 2008). Of particular importance, these misconceptions have been documented among individuals with varying degrees of epistemological sophistication (Sinatra, et al., 2003) and religious belief (Bizzo, 1994; Dagher & BouJaoude, 1997; Lawson & Worsnop, 1992).

One of the goals of the current research is to examine evolutionary reasoning in a culture in which scientific explanations predominate cultural explanations for origins. If evolutionary knowledge is more pronounced in such a culture, it will be possible to extend the examination of the relationship between belief and knowledge without restricting the examination to an examination of the beliefs of those expressing misconceptions. Such an extension will also serve as a test of the prediction that beliefs and knowledge only conflict when they originate in different sub-worlds. In such a case, variables measuring science exposure may be the strongest predictors of both belief and evolutionary knowledge. However, there is some research suggesting that certain scientific beliefs may be unnatural (Bloom & Weisberg, 2007; McCauley, 2000) and that evolutionary misconceptions may result from developmental cognitive constraints regardless of science exposure and belief (Bishop & Anderson, 1990; Shtulman & Schulz, 2008).

Cognitive Constraints and Evolutionary Knowledge

Evolutionary biologist Ernst Mayr (1982) suggested common misconceptions of evolutionary theory are reminiscent of historical conceptual frameworks for origins. That is, prior to reaching an understanding of modern evolutionary theory, individuals progress through historical paradigms of origin explanation. Misconceptions include a

recapitulation of historical paradigms reflecting belief in special creation and may include evolution as progress, with man as either the central reference or the exception to evolutionary processes (e.g., Dagher & BouJaounde, 1997; Evans, 2001). Other misconceptions include Lamarkian, need-based reasoning and an inaccurate understanding of variation, need, use, mutation, and adaptation (e.g., Bishop & Anderson, 1990; Bizzo, 1994; Brumby, 1984; Larreamendy-Joerns & Ohlsson, 1995; Settlage, 1991; Shtulman, 2006).

Developmental research into the etiology of evolutionary misconceptions has focused primarily on constraints in cognition. Cognitive constraints come in many forms for young children, such as constraints in information processing (e.g., working memory, processing speed; Bjorklund, 2005; Kail & Salthouse, 1994) and natural proclivities for interacting with the world (e.g., essentialism, teleology; Kelemen, 1999a, 1999b; Gelman, 2009). Although the term constraint implies a limitation, developmental constraints on children's cognition should also be considered as a way to channel children's limited cognitive resources to process novel stimuli more efficiently (Bjorklund, 2005). However, a case can be made that in efficiency, children sacrifice some degree of accuracy, as defined by a mature adult member of society. Between childhood and adulthood, the adolescent period is a period of transition with advances in cognitive ability due to brain development increasing the cognitive resources available (Bjorklund, 2005; Crone, Wendelken, Donohue, van Leijenhorst, & Bunge, 2006; Kagan, 2010; Steinberg, 2010). This development places adolescents at a potentially interesting

intersection between reliance on cognitive constraints to promote efficiency and the culturally accurate information of adulthood under normal circumstances.

Psychological essentialism and teleological reasoning are two constraints on cognition that are believed to promote efficient categorization and understanding and have received much attention in research into the nearly ubiquitous misunderstanding of evolutionary theory. Each of these will be discussed in turn.

Psychological Essentialism

Psychological essentialism is the attribution of internal "essences" to biological kinds, such as horses and fish (e.g., Gelman, 2003). Essences are internal, non-obvious, unchanging attributes that determine the true nature of an entity; similar kinds thus share similar essences (Gelman, 2009). In saying that individuals are prone to attribute essences to biological and natural kinds from an early age, it is not assumed that children have a clear idea of what the internal, causal nature of the essence is; essences may be placeholders (Medin & Ortony, 1989). But these placeholders still inform children's understanding of the kind itself. For example, 3-year-olds consistently demonstrate knowledge of the relation between the insides and the outsides of different kinds (Gelman & Wellman, 1991). This is consistent with the belief that internal essences determine the kind. By 4-years-old children will express that an animal remains the same kind despite outward changes (Gelman & Wellman, 1991). This is consistent with the belief that the causally-determinant internal essences are stable.

Children's reasoning about essences changes as they learn more about animals. Specifically, children initially assume the essence placeholders are localized in a specific

place within an animal (Newman & Keil, 2008). With schooling and age, children begin to reason about essences as distributed equally across a biological kind. This change more closely represents how adults' reason about DNA, from an essentialist perspective (Newman & Keil, 2008). Thus, although the form of essentialist reasoning changes across development, as a fundamental cognitive system for interpreting the world, it persists through adulthood.

The tendency to attribute essences to species is theoretically incompatible with evolutionary arguments. For example, essences are by definition stable and unchanging. Evolutionary arguments for origins suggest that phenotypically selected adaptations within species over millions of years result in the evolution of fundamentally different kinds, even if related. Effectively, evolutionary arguments require individuals to set aside the notion that essences change gradually over time in favor of non-essentialist notions of within-species variation (Shtulman & Schulz, 2008).

An additional inconsistency between essentialist reasoning and evolutionary theory derives from the nature of essentialist reasoning and variation. From a psychological essentialist framework, similar kinds are similar because they share similar essences. Such a stance does not lend toward an accurate understanding of within-species variation. An appreciation and understanding of within-species variation is vital to evolutionary knowledge as within-species variation is fundamental to the process of natural selection, the mechanism of evolution.

In an empirical test of the relationship between essentialist and evolutionary reasoning, Shtulman and Schulz (2008) asked 4- to 9-year-old children and adults to

evaluate the variability of specific behavioral and biological attributes in different members of the same species. Most children and adults reasoned that intraspecies variation does not and cannot occur, consistent with the notions of psychological essentialism. That children and adults reasoned about variation in a manner consistent with psychological essentialism is consistent with previous work documenting the ubiquity of essentialist reasoning in children and adults' understanding of animates (e.g., Gelman, 2003; Gelman & Wellman, 1991; Keil, 1989; Poling & Evans, 2002).

The link between essentialist reasoning and evolution understanding was further examined as adults in Shtulman and Schulz's (2008) study were also given several questions to measure their understanding of natural selection. Measurements of evolutionary knowledge included 3 of the questions from Shtulman (2006) that were also included in the current research. These questions measured how participants understood the mechanism of natural selection. For example, an understanding of a "variational" theory of evolution entails understanding several specific underlying aspects of the process of natural selection, as outlined by Shtulman and Schulz (2008). It requires understanding that natural selection is the process by which individual differences within the same species promote or impede survival. Furthermore, it entails an understanding that individual members with survival-enhancing characteristics tend to reproduce more than those without those characteristics. This fitness advantage changes the frequency with which the underlying genotype of the selected phenotype is present in the population as a whole.

For example, if a darker color pattern was advantageous to fitness, a variational account would stress individual variation. Individuals with darker coats would enjoy a survival advantage and they would, in turn, be more likely to reproduce. This advantage would change the frequency with which the genotypes that underlie the darker coloration phenotype are represented in the population as a whole. A variational understanding would also recognize the role of genetic inheritance such that the offspring of members of a species will not necessarily be born with the darker coloration. This variational understanding is contrasted with pre-Darwinian conceptions of evolution referred to as "transformational." Transformational accounts of evolution stress cross-generational changes and transformations that occur unilaterally across all members of a species. A transformational account of evolution may describe the process by which members of the species acquired darker coloring, within or across successive generations, so that they may survive.

Shtulman and Schulz (2008) found that only adults who asserted within-species variation actually or can possibly occur scored in the top quartile in the measure of understanding of natural selection. Thus, adults who responded in a similar fashion to the children, attributing internal essences to species and denying the actual and possible variation within species, were likely to respond to questions about natural selection consistent with the evolutionary misconceptions previously described, including misconceptions about variation (e.g., Bishop & Anderson, 1990; Shtulman, 2006). However, the small number of adults who attributed actual and possible variation within

species were likely to reason about natural selection accurately from a modern evolutionary perspective (Shtulman & Schulz, 2008).

Research suggests that psychological essentialism is evident in the first several years of children's lives across diverse populations (for a summary, see Gelman, 2009). Thus, the argument that psychological essentialism constrains individuals' ability to learn evolutionary concepts should not be culture-specific. Rather, if psychological essentialism is a universal cognitive constraint then evolutionary reasoning across diverse cultures should be equally constrained by proclivities toward psychological essentialism. However, Gelman (2003) pointed out that "cues in the environment are undoubtedly critical" (p. 158), as evidence suggests that children's attribution of essences varies across and within cultural contexts (Gelman, 2009). For example, within a sample of Israeli school-aged children, the attribution of essences to social categories was more common among children who attended an orthodox school than children who attended a secular school (Diesendruck & Haber, 2009). However, the attribution of essences to animates was common for both orthodox and secular Israeli children (Diesendruck & Haber, 2009). On the other hand, the Zafimaniry in Madagascar rarely attributed essences to social categories although the tendency to attribute essences to nonhuman animates was common (Bloch, Solomon, & Carey, 2001, as cited in Gelman, 2009).

Explanations for these within- and between-culture differences have focused on explicit and implicit cues in language and the cultural environment (Gelman, 2009). This research suggests that children's proclivity to attribute essences is shaped by the cultural environment in which essentialist reasoning is expressed. Although the cultural

environment influences essentialist reasoning it is unclear if and how cultural variation influence how psychological essentialism constrains evolutionary reasoning. One method to examine this question is by measuring essentialist and evolutionary reasoning across diverse cultural contexts. The current research provides an important step in that direction.

Teleological Reasoning

In addition to psychological essentialism, teleological reasoning is pervasive in how children reason about natural kinds and how children and adults reason about biological kinds. Similar to psychological essentialism, teleological reasoning is also inconsistent with evolutionary reasoning. Misconceptions of evolution as progress, improvement, and the willful efforts of evolving species are common (e.g., Brumby, 1984; Dagher & BouJaoude, 1997); and Lamarkian explanations that invoke intention, will, and purpose are prevalent in evolutionary reasoning (Bizzo, 1994; Shtulman, 2006). These misconceptions may be rooted in teleology, beliefs that result in the frequent reference to purpose and design in their explanations of the natural world.

Researchers have explored teleological reasoning about the natural world in children and adults primarily from Western societies (e.g., Kelemen, 1999a, 1999b, 2003; Kelemen & Rosset, 2008; Kelemen, Widdowson, Posner, Brown, & Casler, 2003; Poling & Evans, 2002). In one early study, Kelemen (1999b, Study 1) showed 7-, 8-, and 10-year-old American children and adults an unfamiliar prehistoric animal (e.g., a Cryptoclidus) and the environment in which that animal lived (e.g., pointy rocks). Participants were asked to choose between two explanations for a biological property of

the animal (e.g., "Why do you think Cryptoclidus had such long necks?"), a behavioral property of the animal (e.g., "Why do you think Cryptoclidus' neck swayed from side to side?"), and a physical property of the environment (e.g., "Why do you think the rocks were so pointy?"). The explanations were either physical/natural (e.g., "Their necks swayed because of the way the bones fit together on their bodies") or teleological. The teleological responses reflected a self-serving, mechanistic teleology (e.g., "Their necks swayed so they could move quickly through the water") or a social teleology (e.g., "Their necks swayed so that they could soothe their children to sleep").

Kelemen (1999b) found that adults accepted self-serving teleological explanations for animates' biological and behavioral properties. Children's responses, however, indicated a preference for any type of teleological explanation for animals and for natural kinds. Similar to adults, children preferred teleological explanations for biological and behavioral properties. However, children's reliance on teleology was robust, extending to the social teleological explanations most frequently rejected by adults and to explanations for the natural kinds in the environment. Kelemen (1999b) termed this overextension *promiscuous teleology*. The change in use of teleology between children and adults makes adolescence an interesting transitory period; adolescents' use of teleology is likely to be somewhere between the over attribution of teleology of childhood and the selective attribution of teleology in adulthood.

In a second study, Kelemen (1999b, Study 2) attempted to reduce children's preference for teleological explanations by including training trials explaining how scientists think about the issues children would be asked about. Although these

explanations avoided teleological language, the training did little to reduce children's preference for the teleological explanations.

Using a similar methodology, Kelemen (1999a) found similar results with 4- and 5-year-old American children and adults. Consistent with the results with older children (Kelemen, 1999b), preschool-aged children were less discriminating in their use of and preference for teleological explanations than adults. These differences in teleological preference between children and adults cannot be explained by heightened sensitivity to artifact and biological part function in adults. The children and adults in this study demonstrated an understanding of the distinction between what something is for and what it does (Kelemen, 1999b, Study 3).

The pervasive influence of teleological reasoning is not necessarily the result of children's inability to reason about nature from a biological, physical/natural perspective. Evidence suggests that children's ability to reason about biological properties in adult-like patterns begins in the preschool and kindergarten years (Atran, Medin, & Ross, 2004; Inagaki & Hatano, 2004; Keil, 1994; Wellman & Gelman, 1998). This is especially compelling given the success of training studies looking at the development of biological reasoning (e.g., Samarapungavan, Mantzicopoulou, & Patrick, 2008) and the failure of Kelemen's (1999a) non-teleological reliance training study.

An alternate view to the hypothesized promiscuous teleology is *selective teleology*. The perspective of selective teleology suggests that children are adult-like in the restriction of teleological explanations to biological traits and man-made artifacts from early in development (e.g., Atran, 1995; Keil, 1992, 1995). Although evidence

suggests that children prefer teleological explanations over natural, mechanistic explanations for artifacts and biological kinds, consistent with a selective teleology view (Keil, 1994; Kelemen, et al., 2003), preference for teleology does not appear to be limited to biological kinds. Rather, consistent with the promiscuous teleology view, children extend teleological explanations to non-biological exemplars (Diesendruck & Haber, 2009; Kelemen, 1999a, 1999b, 2003).

Even once adults restrict their use of teleology to artifacts and biological parts, teleological reasoning is still evident under conditions of cognitive stress (Kelemen & Rosset, 2008). According to research by Kelemen and Rosset, when undergraduate students were given no time limitations, they correctly identified scientifically unjustified, or improper, teleological explanations (e.g., "Earthworms tunnel underground to aerate the soil"), proper teleological explanations (e.g., "Children wear gloves to keep their hands warm"), improper physical explanations (e.g., "Clouds form because bits of cotton collect together"), and proper physical explanations (e.g., "Bread rises because it contains yeast"). The rate at which unjustified teleological explanations were identified as correct increased under time pressure in fast and moderately speeded conditions. This was especially true with the teleological explanations for biological phenomena. The students in the speeded conditions performed equally well compared to the students in the unspeeded conditions on control questions (e.g., improper physical explanations). Thus, even once teleological explanations are rejected after scientific training and conscious thought, there is still trace evidence of earlier teleological constraints in interpretations of the world.

There is some evidence that the restriction of the use of teleology through development may arise from family interactions. Over a two-week period, parents of preschool children were interviewed about the types of questions their preschool children asked and the nature of the parents' responses (Kelemen, Callanan, Casler, & Pérez-Granados, 2005). Children asked about biological and social phenomena more often than other possible topics, such as artifacts and natural kinds; and according to parents' reports, children's questions were often vague as to if they were looking for teleological, purpose-driven explanations or causal explanations to understand the mechanism. Parents reported more often answering questions about biological and social phenomena with causal explanations suggesting that young children's preference for teleological explanations is not a direct result of modeled explanations by parents (Kelemen, et al., 2005). Although children's early teleological preference cannot be credited to cultural modeling, cultural modeling may be responsible for the later restriction of the use of teleology.

This evidence suggests that teleology may constrain cognition in a way that is at least partially responsible for the near ubiquitous misconceptions of purpose and will in evolution. However, it is unclear if evolutionary misconceptions are the universal outcome of teleology. Said another way, this conclusion does not address the possibility that teleology may be expressed in culturally-specific ways that do not automatically result in evolutionary misconceptions.

Kelemen's (2003) research examining teleological preference in American and British children found that both groups were inclined toward teleology. However, the

cultural differences examined in this research may not be marked enough to distinguish variation in teleological preference. Despite low church attendance among a typical British sample (Rogers, 2009), some estimates indicate that nearly three-quarters of the population claims Christianity as their religious affiliation (Office for National Statistics, 2003). Christian theology is associated with belief in a divine creator, a teleological belief. Thus, although there are differences between a typical British and American sample, these differences may not be marked enough to capture effects related to early religious reasoning and concepts invoking teleology. This is one of the primary motivations for the population selection of the current study, a point discussed later in this chapter. The aim of the current research is to better understand if evolutionary misconceptions and creation beliefs are expressed as the result of teleological reasoning across diverse cultural contexts.

Together, the research into psychological essentialism and teleological reasoning suggests that both constrain cognition in a way that may interfere with evolutionary knowledge. Although these constraints are most marked in childhood, they are still operative in adulthood. If these constraints are fundamental to cognition, they may influence thinking about the natural world across multiple sub-worlds. Thus, the following section examines how cognitive constraints may influence the religious sub-world, specifically the development of creation belief.

Cognitive Constraints and Creation Belief

Similar to the development of evolutionary (mis)understanding, there is a strong theoretical link between beliefs about essences, teleology, and the expression of creation

belief. Diesendruck and Haber (2009) define creationism as the "belief that every creature has a God-given *essence* and *purpose*" (p. 100, emphasis added). This definition draws out the conceptual overlap between psychological essentialism, teleology and creation belief; recent research has examined this conceptual overlap between cognition and creation belief.

One study examined the link between teleology and beliefs about the origin of the natural and biological world in 6- and 7-year-old and 9- and 10-year-old British children (Kelemen & DiYanni, 2005). In this study, children were asked about their conception of the origins of natural events (e.g., thunderstorms), nonliving natural objects (e.g., mountains), animates (e.g., birds), and artifacts (e.g., hats). Children first answered open-ended questions about origins (e.g., "Why did the first ever bird exist?), followed by closed-ended questions asking children to choose between a physical response (e.g., "The first ever bird existed because an animal that lived on the ground began to develop wings and fly") and a teleological response (e.g., "The first ever bird existed to eat worms and insects so there wouldn't be too many of them"). Finally, children were asked about the possible intelligent design of the previous events, objects, animates, or artifacts (e.g., "Did someone or something make the first every bird exist or did it just happen?"). Children's preference for teleological explanations was related to their belief that the natural world was created by God (Kelemen & DiYanni, 2005), supporting the conceptual overlap between teleology and belief in a divine creation.

An earlier study examined the possibility that differences in cultural religiosity may alter the use of teleology due to the salience of teleological explanations in religion

(Kelemen, 2003). This study examined the possibility that teleological explanations may be particularly salient for young American children because they are socialized within a culture of religiosity (Kelemen, 2003). In a typical American sample, over 90% of adults claim to believe in some higher power or spirit, and over three-quarters specifically claim to believe "in God" (Newport, 2008). Theologically-speaking, belief in the Christian God is tied directly to the belief in a creator and supernatural designer. Inherent in this belief is teleology.

To examine if previous findings were an artifact of cultural religiosity, preference for teleological explanations in American children (from Kelemen, 1999b) was compared to teleological preference for a sample of 7- to 10-year-old British children (Kelemen, 2003). In many ways, cultural differences between these two samples are minimal. However, British children are socialized in a culture considered to be one of the least religious in the world (De Graaf & Need, 2000; Kelley & De Graaf, 1997, as cited in Kelemen, 2003). Just over one-third of British citizens believe in a God or spirit/life force, and about one-fifth claim not to believe in any supernatural power (European Commission, 2005). The comparison of these two samples held many possible confounding variables (e.g., education, modernization) constant while varying the degree of cultural religiosity (for more on the logic of this type of population variation, see Rutter, 1989).

Like similarly-aged American children, British children were promiscuously teleological in their explanation preferences (Kelemen, 2003). Additionally, like the American children, this strong inclination toward teleological explanations persisted even

when children were told that adults endorse physical explanations for living and non-living natural kinds in training pre-trials (Kelemen, 2003, Study 1). This finding contributes to an understanding of the scope of teleology, at least in early childhood. Considered with other research, this suggests that although the use of teleology becomes refined and reduced with increased scientific education and training, it is not eradicated (Kelemen & Rosset, 2008). However, these results do not address the influences of an American culture of religiosity on teleological reasoning beyond childhood, specifically whether teleological use throughout adolescence and adulthood continues to be related to creation belief.

An additional study examined the relation between teleology, psychological essentialism and creation belief with slightly older children (Diesendruck & Haber, 2009). In this study, 7- and 11-year-old Israeli children from secular and orthodox schools were given tasks to measure (a) beliefs about the origin of categories, (b) preference for teleological explanations for categories, and (c) preference for essentialist explanations for categories. The categories tested included animates, artifacts, and social categories. Diesendruck and Haber were interested in if and how the relation between essentialist and teleological beliefs varied between the two groups of children who differed in their endorsement of a divine creator.

The results indicated that essentialist beliefs about animates did not vary between the secular and the orthodox samples although essentialist beliefs about social categories did (Diesendruck & Haber, 2009). Essentialist beliefs about animates appeared to be independent of religious beliefs whereas the attribution of stable, intrinsic essences to

social categories was positively related to belief in a divine creator. The children from the orthodox school endorsed claims about social categories that were consistent with the belief that certain social categories were imbued with significance in the act of divine creation (e.g., Israeli vs. Arab).

The application of teleology across these different groups also differed by domain category (Diesendruck & Haber, 2009). Although children from both religious backgrounds used teleological explanations for artifacts, the orthodox children who believed in a divine creator were more likely to extend teleological explanations to the animate and social categories. One interpretation of these findings is that beliefs about essences and teleology may promote the expression of belief in creation. An alternate interpretation is that belief in a divine creator influences the expression of psychological essentialism and teleology. These findings are correlational and there is no causal support for either interpretation; yet, they suggest that statements about the role of cognition in the development of beliefs requires an examination of cultures that differ along lines of cultural—and even nominal—religiosity.

Although there is conceptual overlap between belief in creation and psychological essentialism and teleology, creation belief itself may be an extension of intentional reasoning, which may be a highly salient bias in adults (Rosset, 2008). Psychological essentialism, teleological, and intentional reasoning all constrain cognition, although across development the salience of these different reasoning systems change (Poling & Evans, 2002). In a test of 6- to 12-year-old children's and adults' preference for these three methods of reasoning about why various biological kinds "stay together,"

participants considered intentional (e.g., "Because they *like* each other"), teleological (e.g., "Because they will be *safe* from danger"), and essentialist (e.g., "Because each of them has the same things *inside*") explanations (Poling & Evans, 2002). Both adults and children were flexible in their use of all three styles of reasoning and endorsed different styles of reasoning depending on the behavioral context. However, intentional reasoning was the most common among the youngest children. Between 6 and 12 years of age, intentional reasoning generally decreased and essentialist reasoning increased. Essentialist reasoning was more common in adults than explicit teleological or intentional reasoning about biological kinds (Poling & Evans, 2002). These findings suggest that even if constraints on cognition influence early creation belief, by adolescence and adulthood, the move away from intentional reasoning toward more essentialist reasoning may reduce the influence of cognitive constraints on creation belief.

The role of cognitive constraints in the development of creation belief is only one aspect of this line of theory and research. Kelemen (2004) suggested that from a young age children can be considered intuitive theists, "predisposed to construe natural objects as though they are nonhuman artifacts, the products of nonhuman design" (p. 295). This claim is defended by evidence that children demonstrate three cognitive prerequisites for such a design stance: (1) the ability to represent invisible agents, (2) the ability to attribute special qualities to invisible agents, and (3) an understanding of design intentions. Furthermore, the claim that children are intuitive theists is consistent with evidence suggesting that until early adolescence individuals from Western societies tend

to favor creationist explanations for origins, regardless of their own or their family's religious beliefs.

The Development of Creation Belief

In an early study, Evans (2000) asked children from a mid-Western American town to explain how "the first" of three animates (human, dinosaur, and mammal) got to be on earth. Seven-year-olds generally gave two types of responses: a creation response or a spontaneous generation response. Spontaneous generation responses reflected natural yet non-evolutionary responses such as "it just appeared" or "it came out of the ground." Nine-year-old children nearly exclusively expressed creationist responses to explain the origins of these animates in their open-ended responses, such as "God made them." Eleven-year-olds predominately responded consistent with an evolutionary understanding of speciation, such as "People evolved from mammals, which evolved from dinosaurs." The expression of evolutionary or creation beliefs in older children was influenced by the beliefs of children's parents (Evans, 2000, Study 2). The 11-year-old children who had parents who were highly consistent in the endorsement of evolution or creation were likely to express similar beliefs about origins.

Furthermore, parents' origin beliefs influenced children's natural history knowledge, which positively predicted the endorsement of evolution beliefs in children (Evans, 2000). Among the 11-year-old age group, with had parents who consistently endorsed evolution were likely to have the highest levels of natural history knowledge. Alternatively, children whose parents consistently endorsed creation were likely to have the lowest levels of natural history knowledge. These findings suggested that parents'

beliefs about evolution influenced children's exposure to and knowledge about the natural world, and consequently children's beliefs about the natural world and are consistent with research suggesting that parents structure their children's activities consistent with parents' cultural belief systems (e.g., Gauvain, 2001; Greenfield, Keller, Fuligni, & Mayard, 2003). Of note, however, is the shift in the 9-year-olds to exclusively use creation explanations to explain animate origins regardless of parents' beliefs (Evans, 2000).

Evans (2001) conducted a follow-up experiment to further examine the relationship between children's explanations and parental belief. One addition to this study was that parents reported what types of beliefs they would endorse to children of various ages. This was a significant inclusion as it is possible that parents use explanations with children that are inconsistent with parents' own beliefs. In this investigation, 6- to 12-year-old children and their parents from fundamentalist families who interpreted the Bible literally and non-fundamentalist families who did not adhere to a literal Biblical interpretation were asked to explain the origins of animate (e.g., a living, biological agent such as a sun bear), inanimate (e.g., a non-living natural kind such as a rock), and artifact (e.g., a man-made item such as a chair) exemplars. Children answered open-ended questions about "how the very first [exemplar]" got here on earth and then indicated how much they agreed with several possible closed-ended answers to the same question. The closed-ended options reflected a creation stance ("God made it and put it on earth"), an artificialist stance ("A person made it and put it on earth"), an evolutionary stance ("It changed from a different kind of animal that used to live on earth"), and one of

two different spontaneous generation stances ("It just appeared/It came out of the ground"). Parents responded to these same measures as well as a measure of their likelihood of using creationist, evolutionary, and spontaneous generationist responses to answer questions posed by their children at different ages.

Across all ages, children from the fundamentalist homes consistently endorsed creationist explanations for the origin of animates in both the open- and closed-ended questions (Evans, 2001). Among the non-fundamentalists, 6- to 10-year-old children favored creation for the closed-ended responses. The open-ended responses, which preceded the closed-ended responses, revealed a slightly different pattern. In the open-ended questions, 6- and 7-year-old non-fundamentalist children were equally likely to provide responses consistent with spontaneous generation or creation. Eight- to 10-year-old non-fundamentalist children, however, more frequently expressed creation beliefs than spontaneous generation or evolution in their open-ended responses. Between the ages of 10 and 12 years, children from the non-fundamentalist homes began to provide some evolutionary responses in open-ended questions and stopped ubiquitously favoring creationist responses in the closed-ended questions. It was between 10 and 12 years that children from the non-fundamentalist homes demonstrated a shift in their reasoning about origins and began to respond to questions in a fashion similar to that of their parents (Evans, 2001).

As expected, parents' beliefs were consistent with their religious views (Evans, 2001). Fundamentalist parents strongly endorsed creationist explanations for the origin of animates. These parents were also likely to endorse creationist explanations about the

origin of humans and dinosaurs to children of all ages. Conversely, non-fundamentalist parents were more likely to endorse evolutionary, natural explanations for the origin of animates. However, there is some evidence that parents from the non-fundamentalist community were more willing to be somewhat inconsistent in their endorsement of their own beliefs to their younger children (Evans, 2001). Although parents from the non-fundamentalist communities were more likely to endorse evolution overall, they were likely to claim they would explain the origin of humans to their children using creationist reasoning. This was especially true for how parents would explain the origin of humans to the youngest children, aged 6 and 8 years (Evans, 2001). Although these findings support claims for intuitive theism in child development (e.g., Kelemen, 2004), they leave open the possibility that the early endorsement of creation is a by-product of specific contextual factors (e.g., parental endorsement; Evans, 2001) and broader cultural factors (e.g., American religiosity; Kelemen, 2003).

At least two studies in different cultural contexts have provided additional support for Evans' (2001) general pattern of findings. In these studies the origin beliefs of children from British and Dutch populations were examined; both of these cultures are somewhat agnostic compared to a typical American sample (European Commission, 2005; Kelemen, 2003). As previously discussed, a typical British sample is, at best, nominally religious (European Commission, 2005; Kelemen, 2003; Office for National Statistics, 2003; Rogers, 2009). Dutch samples may be similar as no more than one-third of the population believes in a God and about an equal portion of the population believes that there is no God (European Commission, 2005). If Evans' (2001) findings can

generalize across cultures, the pattern of responses for British and Dutch children should be similar to similarly-aged non-fundamentalist children who still ubiquitously endorsed creation as the best explanation for origins between 8- and 10-years of age.

In one study, 3- to 5-year-old British children were questioned about their beliefs about the origins of natural kinds, such as rocks, plant life, and the sky (Petrovich, 1997). These young British children, like their adult counterparts, expressed two types of responses. Their responses either indicated their belief that God was responsible for the origin of natural kinds, a creation response, or that no one knew who/what power was responsible for the origin of natural kinds, an agnostic response (Petrovich, 1997). These young British children, raised in a nominally religious culture, responded consistent with the similarly-aged non-fundamentalist American children (Evans, 2001). In both cases, children raised in generally non-religious homes were likely to choose equally between a religious response and an agnostic/spontaneous generation response (a non-evolutionary, non-supernatural response) in explaining origins.

In a different study, 9- and 12-year-old Dutch children were asked to explain the origin of species (Samarapungavan & Wiers, 1997). The vast majority of the children used non-Darwinian explanations, with very few of the children using a creationist framework (10.7%). That the older Dutch children used primarily natural explanations for origins, even if non-Darwinian, is consistent with the age-related shifts from early reliance on creationist explanations toward evolutionary explanations in the non-fundamentalist children (Evans, 2000, 2001). With age comes increased exposure to scientific instruction and natural history knowledge. This knowledge would be mostly

consistent with the dominant beliefs of the culture, beliefs that may override the hypothesized naturalness of creation beliefs.

Together, these results suggest that creation may be generally favored by children in middle childhood, regardless of cultural beliefs (Evans, 2001). However, of particular interest to the current research is the shift toward evolutionary belief that exists in cultural contexts that support evolutionary beliefs, as evidenced by the non-fundamentalists (Evans, 2001) and the non-religious European cultures (Petrovich, 1997; Samarapungavan & Wiers, 1997).

These findings have considerably shaped researchers' understanding of the development of beliefs about origins. One of the next questions from this line of research concerns the trajectory of beliefs in adolescence. For example, Evans (2001) found that parents' beliefs independently influenced children's beliefs between the ages of 10- and 12-years of age. However, adolescence is a period of rapid social changes in which brain reorganization makes adolescents particularly sensitive to environmental input; especially input relevant to executive function and social cognition, such as the processing of emotions (Blakemore & Choudhury, 2006). This neurological sensitive period (Blakemore & Choudhury, 2006) corresponds with a period of development that is associated with increased social demands (Brown & Larson, 2002). These demands are increasingly associated with social demands outside the family unit as the adolescent period starts with parents in the center of the personal network and ends with peers displacing parents as the primary socializing agents (Meeus & Deković, 1995). The increased influence of the peer group during adolescence coincides with increased

autonomy given to adolescents by their parents, especially in Western societies (Brown & Larson, 2002). Thus, Evans' (2001) findings that parents' beliefs influence their children's beliefs about creation during late childhood may be substantially different from adolescence, with the beliefs of peer groups being more predictive of adolescents' own beliefs.

Epistemology. Sinatra et al. (2003) explored another factor contributing to creation belief: epistemological beliefs. Broadly speaking, epistemology is the study of knowledge; the study of the nature of what is known. Thus, epistemological reasoning concerns the process by which individuals coordinate subjective and objective aspects of knowledge. Sinatra et al. (2003) measured the epistemological beliefs of American college undergraduates by examining participants' beliefs about the certainty of knowledge, dependence on authority, seeking single answers, and other similar scales. Epistemological beliefs were not related to the acceptance of evolution generally, but were negatively associated with the acceptance of human evolution (Sinatra et al., 2003). Although these results do not directly address belief in creation, they warrant further discussion.

Kuhn, Cheney, and Weinstock (2000) explored the development of epistemological reasoning by examining epistemological stances across age and occupation. Kuhn and colleagues discussed three stances toward epistemology: absolutist, multiplist, and evaluativist. Each of these stances represents specific views about reality, knowledge, the legitimacy of assertions about knowledge, and the value of critical thinking. Each will be reviewed in turn.

As outlined by Kuhn et al. (2000), at the absolutist level, one can know what reality is directly because knowledge is derived from some external, certain, definitive source. In this sense, an assertion about the true reality of a thing is a fact that is either true—a reflection of the external reality—or false—an incorrect representation of reality. Finally, such a stance renders critical thinking necessary only for the comparison of facts to determine if they are correct or incorrect reflections of the external, objective knowledge in reality (Kuhn et al., 2000).

The multiplist level reflects an understanding of knowledge as generated by humans (Kuhn et al., 2000). Knowledge is inherently uncertain, which renders reality unknowable. In this way, assertions about reality reflect opinions. These opinions are relevant only to their holders making critical thinking about them irrelevant (Kuhn et al., 2000).

Finally, Kuhn et al. (2000) suggest that individuals at the evaluativist level hold similar views of the nature of knowledge as human-generated and uncertain, lending to the view of reality as not directly knowable. The vital difference between a multiplist and an evaluativist stance is that the latter deems assertions about reality to be judgments. The difference between an opinion and a judgment is that the latter can be evaluated with evidence according to the criteria of the argument (e.g., scientific judgments are to be evaluated with scientific evidence). In an evaluativist stance, critical thinking serves a valuable purpose in promoting the sound evaluation of judgments and arguments that promote and facilitate understanding (Kuhn et al., 2000).

Kuhn and colleagues (2000) measured these stances by providing participants from different age groups (2^{nd}, 3^{rd}, 5^{th}, 8^{th}, and 12^{th} grades, and adults) and different educational experiences (community college, 4-year undergraduate university, professional degree program, and philosophy Ph.D. candidates) with conflicting assertions in various domains (e.g., aesthetics, the social world, the physical world). After reading the arguments, participants were asked to consider the arguments in general (Kuhn et al., 2000). A response consistent with the absolutist level of epistemology was such that "only one is right." If participants agreed that both assertions could have some rightness, an individual reasoning from a multiplist stance would endorse the statement that "one could not be more right than the other" whereas an individual reasoning at the evaluativist level would agree that "one could be more right." Epistemological reasoning is thought to be highly dependent on experience, especially educational experience (Kuhn et al., 2000).

Epistemological stances/levels are referred to throughout this paper by a variety of names: epistemological stances, levels, reasoning, and sophistication. The latter name, epistemological sophistication, requires a brief explanation. These levels, absolutist, multiplist, and evaluativist, reflect increasingly mature stances toward the nature of knowledge when considered within the domain of science. As this research is intimately concerned with the nature of adolescents' evaluation of scientific knowledge about origins, it is appropriate to consider these levels as representing an increasingly sophisticated, scientific epistemology. Thus, although it may not be appropriate to reason

from an evaluativist stance in all domains (e.g., aesthetics); this is the ideal, sophisticated stance from which one should engage with scientific material.

The major finding of note from Kuhn et al.'s (2000) research is that across age, education, and experience, by adulthood most individuals were likely to transition from an absolutist to a multiplist stance. By adolescence, the multiplist stance was increasingly common. This is consistent with research into adolescent brain development; the adolescent period is associated with advances in the connectivity in the prefrontal cortex associated with relational reasoning (Crone et al., 2006). Compared to adults between 18 and 25 years old, 8- to 12-year-old preadolescents were much less successful at reasoning tasks that required the integration of multiple relations (Crone, et al., 2006). This suggests that the maturation of prefrontal connectivity occurs sometime after age 12 (Kagan, 2010), and continues into the young adult years (Bjorklund, 2005). During the adolescent years, especially between 12 and 18, connectivity may promote the recognition of multiple views of knowledge (multiplist) without the brain maturation and experience to evaluate these views (evaluativist). Although many individuals never advance to the evaluativist stance, individuals may hold various stances toward knowledge as a function of the domain of that knowledge (Kuhn et al., 2000).

Using a method derived from Kuhn et al. (2000), Smith and Richert (2011a) investigated American adolescents' epistemological sophistication and their belief in evolution. Participants read a scenario about two potentially conflicting opinions about the origin of species and were asked to comment on the disagreement in general (only one could be right, both have good points and it is impossible to choose, both have good

points but one is better than the other). Smith and Richert (2011a) found that adolescents reasoning at the absolutist level were more likely to endorse a belief in creation than those reasoning at the multiplist level. However, this trend was somewhat parabolic; adolescents reasoning at the evaluativist level were also more likely to endorse creation beliefs than those reasoning at the multiplist level. Thus, in an American context, in which creation beliefs are among the most dominant explanations for origins, both an absolutist stance and a stance that integrates multiple perspectives may be associated with creation beliefs whereas the uncertainty in a multiplist stance may be related to more naturalistic beliefs.

This pattern is partially inconsistent with Sinatra et al.'s (2003) findings and requires replication. Additionally, the degree of cultural specificity for this pattern is also unknown. Cultural patterns are likely as creation is not the dominant explanation for origins across different cultural settings. The relation between epistemological sophistication, cultural support for creation, and individuals' own creation belief and evolutionary knowledge is an open question explored in the current research.

Summary. Although past research suggests that some factors, like parents' beliefs and endorsement (Evans, 2001), cultural and familial religiosity (Dagher & BouJaoude, 1997; Diesendruck & Haber, 2009; Petrovich, 1997; Samarapungavan & Wiers, 1997), natural history knowledge (Evans, 2000, 2001), and epistemological sophistication (Sinatra et al., 2003), may influence an individual's shift to and away from creation beliefs across development, these explanations need further elaboration across childhood, adolescence, and adulthood. Understanding the factors that contribute to how

beliefs about the origin of species change is crucial not only to this specific line of research but also to understanding the development of beliefs more generally. In addition to requiring elaboration across developmental periods, the research reviewed above suggests divergent patterns by culture, but fails to systematically examine theoretically-selected samples. For example, although evolutionary knowledge is generally conceptualized as distinct from beliefs about origins, this research has been conducted primarily within Western samples. Thus, the current research focuses on the adolescent period in two cultural samples that differ in strategic and theoretically important ways.

Culture

Culture, in a general sense, is the "patterns of behavior that are passed from one generation to the next through extrasomatic means" (Cole, 2005, p. 49) and includes "social interaction between individuals, the values and practices of the culture that appear in the routines, rituals, and customs in which people engage, and the tools and signs, most importantly language, that people use to support and extend thinking" (Gauvain, 2008, p. 406). However, culture is not an all-or-nothing phenomenon. In the same way individuals considered extraverted are not all equally extraverted, individuals within a particular culture do not necessarily share all values and practices associated with that culture (D'Andrade, 1965). Cultural variability is not simply a between-culture description; cultural variation occurs between cultures as well as within cultures. The current research aims to consider between- and within-culture differences in evolutionary knowledge and creation belief in two theoretically-selected samples. Understanding culture and cultural variation in this way will provide a more theoretically-grounded

explanation of the specific factors that may explain evolutionary understanding and beliefs about the origin of species.

Rationale for a cultural approach to understanding the development of beliefs about the origin of species, and possibly evolutionary understanding, is found in several lines of research. First, developmentalists who have seriously considered the role of culture have found that cultural processes have influenced even some of the aspects of development considered to be highly biologically-driven, such as motor and muscular development (e.g., Adolph, Karasik, & Tamis-Lemonda, 2010; Super, 1976). If aspects of development believed to be primarily biological are influenced by culture, the influence of culture on highly psychological aspects of development such as spatial reasoning (e.g., Mishra, Singh, & Dasen, 2009), self and personality development (e.g., Thompson & Virmani, 2010), cognitive development more generally (e.g., Cole & Cagigas, 2010), and the specific aspects of cognitive development investigated in the current research is likely to be large.

This question was, in part, the motivating framework for the preliminary research to the current research. Most research into evolutionary knowledge and creation beliefs have been with participants from Western samples. A dissatisfaction with the diversity of cultural samples from which claims about the universal trajectory of creation beliefs have been derived (e.g., Kelemen, 2004) and initial evidence that creation belief may vary by cultural input (e.g., Diesendruck & Haber, 2009) led to preliminary research examining Chinese children's beliefs about the origin of species (Smith & Richert, 2011b; a more

detailed rationale for examining questions of origins in a Chinese sample is provided below).

Smith and Richert (2011b) asked 8- to 13-year-old Chinese children to select the best response for how the "very first" of different animate and natural kinds got here on earth. Children chose between evolutionary ("It changed over a very long period of time from a different kind of animal/thing that used to live on earth"), reincarnation ("It was something that was reborn as a [exemplar]"), spontaneous generationist ("It just appeared and It came out of the ground"), artificialist ("A person made it and put it here on earth"), and a creation response ("It was made a put on earth, but not by a person"). Finally, children also were given an open-ended response that allowed them to write their own response if they did not prefer any of the provided responses. These responses were selected to cover a variety of non-religious and religious responses, including a Buddhist religious response of reincarnation which may have more readily appealed to Chinese children than a creation response.

As young as 8-years-old, Chinese children preferred evolutionary explanations for the origin of animates such as fish, dog, and human being (Smith & Richert, 2011b). Furthermore, children's responses for a tree and a rock also suggested a preference for the endorsement of non-religious frameworks as spontaneous generationist responses were the most common. These results suggest that intuitive theism (Kelemen, 2004) may not adequately explain the development of children's origin beliefs; creation beliefs may not be the universal expression of cognitive constraints such as psychological essentialism and teleology.

This interpretation echoes Diesendruck and Haber's (2009) interpretation of the variation in essentialism and teleology in the school-aged Israeli children from orthodox and secular schools. Diesendruck and Haber argued that cultural support for creation belief may be responsible for the modification of cognition (essentialist and teleology reasoning), not the other way around. Together, these lines of evidence provide a theoretical foundation for the current research, which examines the aspects of cultural and individual variability that influence creation belief and evolutionary knowledge in Chinese and American cultural samples.

Several additional caveats on culture and cultural variability bear mentioning. First, cultural variability does not unequivocally conflict with notions of universals in development. For example, beliefs about essences and teleology may be universal. However, these potentially universal cognitive constraints may not be expressed in universal ways (e.g., in creation beliefs). This is consistent with research in cultural psychology indicating that cognitive universals may take a variety of cultural forms (Greenfield, 1997). Higher-order psychological processing that may be universal across cultures will not necessarily look the same or take the same form. Additionally, even if the end point (e.g., creation belief) is the same across cultures, the path by which that point was reached may be different or have different meanings (Gauvain, Beebe, & Zhao, 2011).

Second, culture is not an independent variable (Gauvain, et al., 2011). Independent variables, by definition, are manipulated and randomly assigned. Culture like many variables used as explanatory variables such as gender, age, and religious

affiliation, can be neither manipulated nor randomly assigned. This is important to mention as the models examined in the current research do use culture as an explanatory variable. The inclusion of culture as an explanatory variable in these models represents a statistical measure of Whiting's (1975) conception of culture: as a variable that represents a package of other unmeasured variables. One of the primary goals in the current research is to unpack cultural membership by measuring the specific variables that create the "cultural package" influencing creation belief and evolutionary knowledge (e.g., religious belief, epistemological stance, scientific preference). The rationale for the inclusion of a culture variable is to provide a statistical measure of how successful the measured variables were at explaining variation otherwise attributed to "culture."

Specifically, the extent to which an omnibus culture variable contributes significantly to a model with other variables serves as a measure of the successfulness of the other variables in unpacking cultural membership. Keeping with this theoretical understanding, the models that examine the effectiveness of the measured variables in understanding how culture influences beliefs and knowledge are examined between cultures by including an omnibus, packaged culture variable to examine the overall success of these variables in explaining the psychological experiences that contribute to cultural membership. The current research also examines models within cultures to explore if the variables function similarly within each cultural sample.

One final caveat is that no one research study can fully explore or explain the complex relationship between cognition and culture (Gauvain, et al., 2011). The current study is no exception; however, restricting the scope of the current research question does

not imply that no worthwhile information can be gained. Although this research will be unable to fully explain how culture influences creation belief and evolution understanding, the variables measured in the current research were selected for their likelihood of influence, derived from the research discussed throughout this chapter (see Chapter 2).

Despite these caveats, most working definitions of culture including the one given here acknowledge that cultural processes influence patterns of communication, learning, and beliefs. The development of beliefs and scientific knowledge about the origin of species is not exempt (e.g., Smith & Richert, 2009). Thus, the current research includes measures of the types of communicative and learning process likely to influence the formation of these beliefs. This research also includes measures of cultural variation noted by previous research as foundational in the selected research populations, such as measures of perceived expectations and cultural values associated with interdependence (Kagitcibasi, 2005; Kim, Atkinson, & Yang, 1999). Additionally, individual measures that are likely influenced by cultural factors are included in the current research investigating explanations for beliefs about origins and evolution understanding. These measures include epistemological sophistication, liking of scientific instruction and stereotypes. The rationale for measures of epistemology and scientific instruction has already been discussed; however, a brief discussion of the foundations for the inclusion of stereotype measures in the current research is warranted.

Stereotypes. Social psychology has a long history of research into stereotypes, in-group preference/out-group discrimination, and the formation/regulation of social

groups more generally. Although a complete review of this research is unnecessary for the purposes of the current research, one of the major findings in this field is particularly relevant. Although salient cues, such as gender and race, establish in-group favoritism and out-group discrimination, a minimal group bias, such as shirt color, is also sufficient to establish a similar pattern of behavior (Brewer, 1979; Frank & Gilovich, 1988; Tajfel, 1970, 1982). In-group favoritism includes conforming to norms, patterns, opinions and beliefs of the larger group; discrimination entails rejecting, withholding resources from, and systematically marginalizing members of the out-group. The establishment of whether one identifies with a particular in-group (or out-group) may yield predictions about the types of opinions, behaviors, and beliefs of the individual; this is likely to be especially true during adolescence when identity formation is a primary developmental concern (Boyes & Chandler, 1992; Meeus & Deković, 1995; Tajfel, 1982).

The current research aimed to examine the extent to which adolescents favored individuals who used scientific explanations or religious explanations; whether the use of scientific or religious explanations would be sufficient to establish a group bias. Specifically, the current research measures the extent to which adolescents believed individuals who relied on scientific or religious explanations for the origin of the natural world possessed a high number of positive or negative traits. These measures will serve as an indication of whether adolescents perceive individuals who use scientific or religious explanations to be part of their in-group or part of an out-group. The rationale for this interpretation is that in-group members are perceived more positively than out-

group members. Given the differential focus on religion and science in an American and a Chinese population, this is a particularly relevant point of investigation.

Cultural Selection

Adolescents from the People's Republic of China and the United States of American were recruited to participate in this research. Although there are many differences between these cultural samples, of primary interest to the current research is how these cultural samples differ in their approach to and focus on religion and education, particularly science education. These differences will be discussed in turn.

Religion

Comparing evolutionary knowledge and creation belief between an American and Chinese sample is particularly relevant because China lacks the cultural religiosity, even nominal, of most Western nations (e.g., Kelemen, 2003). It is not simply that China provides a non-religious sample equivalent to the non-fundamentalists in Evans (2001); rather a Chinese sample is one that has been recruited in the midst of a specific and tense sociopolitical climate surrounding religious issues.

The Chinese government has five state-regulated religions: Buddhism, Daoism, Islam, Catholicism, and Protestantism (Embassy of the People's Republic of China in the United States of America, 1997). However, the official stance of the government promotes atheism (Central Intelligence Agency, 2009). Moreover, the government claims to promote religious freedom, yet religious conflict persists (e.g., Borenstein, 2001; UN Commission on Human Rights, 2006) despite the assertion that "religious disputes are unknown in China" (Embassy of the People's Republic of China in the

United States of America, 1997, ¶12). Officially, religious involvement is neither encouraged nor discouraged; however, the official stance also suggests that religion needs to conform to the requirements for advancement of the State (Embassy of the People's Republic of China in the United States of America, 1997). This is consistent with reports of persecution for religious activists.

Given the political sensitivity of religious topics, accurate numbers of religious believers are difficult to determine, though some estimates put this number between 5% and 10% (Central Intelligence Agency, 2009). There is some evidence that the regulation of religion by the Chinese Communist Party has caused some forms of religious activities to increase compared to non-regulated religious practices in much of the Western world, however these religious activities are often indigenous, informal religious practices and beliefs (Yang, 2006). As suggested above, these low numbers of religious involvement are in stark contrast to the typical Western cultural environment in which most of the research on origin belief and evolutionary knowledge has been conducted. The religious climate in China is at best religion-neutral, with many individuals only exposed to a context that is almost completely devoid of explicit religious content.

Education

The non-religiosity of the Chinese culture is reinforced by educational contexts that endorse scientific explanations from a very early age (Bao, Cai, Koenig, Fang, Han, Wang et al., 2009). Projected numbers suggest that China will soon surpass the US and the European Union in terms of high school and college graduates, of which a higher proportion are expected to pursue education and careers in science (Schleicher & Stewart,

2008). This is consistent with Stevenson and Lee's (1996) claim that students of Chinese decent are overrepresented in science competitions, although this research compared Chinese-Americans to European-Americans and should take into consideration the unique characteristics and pressures of immigrants relative to the samples included in this research.

For the Chinese, education is not only about learning information; it is also moral imperative (Ministry of Education of the People's Republic of China, n.d.). Education has traditionally been considered the "most effective avenue to social and economic advancement and for the improvement of the person" (Stevenson & Lee, 1996, p. 133), and being a scholar is a position of high regard. Furthermore, educational advancement is very competitive (Schrock, 2002a). From an early age Chinese students spend much of their time pursuing academic endeavors (Brown & Larson, 2002; Stevenson & Lee, 1996).

This evidence is consistent with increases in parental expectations about academic achievement (Patrikakou, 2004). However, although parental expectations and academic demands increase during adolescence, there are differences across cultures (Chen & Lan, 1998). For example, although American and Chinese tenth-graders expressed a high willingness to fulfill parental academic expectations, Chinese adolescents have demonstrated more obedience to parents, more willingness to accept parents' advice, and more concern about parents' expectations than American adolescents (Chen & Lan, 1998). This finding is consistent with research into Chinese cultural values of interdependence. It is worth noting here that changes in academic expectations during

adolescence do not just come from parents, but are also reflected in changes of societal expectations as adolescence is associated with a more complex school structure (Patrikakou, 2004).

The rise of parental and societal expectations during adolescence occurs during a time in which there is an increase in the influence of the peer group relative to the family, at least in Western societies. However, there is considerably less research into the structure and role of peer groups for Chinese adolescents (Stevenson & Zusho, 2002). One explanation is that the developmental tasks of adolescence, including socioemotional and school adjustment, are highly interconnected in a Chinese sample where the focus is often on academic achievement or difficulties (Chen, Chen, Kaspar, & Noh, 2000). This is consistent with the research tradition focusing on the cultural values of collectivism and interdependence associated with Eastern cultures (e.g., Kagitcibasi, 2005; Markus & Kitayama, 1991). In a culture that values interdependence and harmony, the success of the adolescent is not solely the result of individual achievement, but rather is representative of the achievement of the family (Kim et al., 1999). Academic achievement, for example, reflects the success or failure of the entire family unit, not just the individual child, as is the case in independent cultures, such as is generally the case in the United States.

One note about how cultural orientation shapes social and academic expectations for Chinese adolescents is warranted. Many researchers have suggested that the rapid social and economic change in China is influencing cultural development in currently unknown ways, as published research lags behind these cultural trends (Stevenson &

Zusho, 2002). One example of the larger socio-political structures associated with cultural change influencing development is the adoption of the one-child policy in China. This policy has spurred questions about whether the next generation of Chinese adolescents and young adults are members of the "me generation" (Elegant, 2007; Stevenson & Zusho, 2002). Although the empirical data may lag behind the rapid pace of cultural change in China, this interpretation has some anecdotal support. Many teachers and community members in the Chinese community where the Chinese adolescents in the current study were recruited commented that American Chinese were more traditional than "actual" Chinese, given the rapid state of change in Mainland China. From an empirical perspective it is too early to determine precisely if and how these changes may alter cultural models of interdependence. Yet, historical and modern trends seem to suggest that for Chinese adolescent development peer influence, in addition to family influence, are both salient.

Regardless of the role of cultural interdependence in the increasing complexity of school structures, the adolescent period is one of increased expectations about school achievement and content mastery in both American and Chinese adolescents. For Chinese and American adolescents, the high school years are years of increasing focus on science education and explicit instruction about evolution (Asia Society, 2006; California State Board of Education, 1998/2003). However, the method in which Chinese and American educational institutions focus on content mastery varies dramatically between the two cultures. For example, the specific school from which the Chinese adolescents in the current study were recruited had students in class for a minimum of 11.5 hours a day

participating in active instruction or teacher-guided study hall. This schedule was maintained for six days a week; on the seventh day, students were in class from 6 to 11.5 hours depending on their age. This is contrasted with a six-hour school day, five days a week for a typical American high school.

This increased time in school, relative to a typical American adolescent, is largely filled with education in the STEM fields. According to Schrock (2002a), China has a stronger focus on science coursework compared to the United States. Unlike the elective process of science education in the United States beyond basic biology, the Chinese national curriculum requires extensive training in biology, chemistry, and physics (Asia Society, 2006). Schrock (2002a) argued that this unilateral educational focus on science has important consequences for the working scientific knowledge of the general public and for the process of science education which peaks in the high school years to prepare students for the *gau kao* exit examinations necessary for college entrance.

One of the consequences of this focus is that an increased science background better prepares primary school teachers to teach foundational scientific concepts in biology, chemistry, and physics. Furthermore, teachers at the secondary level receive their training not in education, but in the specific subject they intend to teach. This approximates the university model in both the US and in China. For example, high school biology teachers studied biology within a biology department at a university for future teachers. Schrock (2002a) suggested this teacher training model increases the depth of knowledge and resources available to teachers and conversely to students, but he

is careful to note that the traditional model of these departments focuses on factual knowledge, not on methods and inquiry.

Anecdotal evidence is consistent with this overview of the Chinese focus on science education. A conversation with a graduate student in the Evolution, Ecology, and Organismal Biology program at a large university in Southern California who was educated in China indicated that basic evolutionary principles, including descent from a common ancestor, are taught as early as primary school (L. Zeng, personal communication, April 29, 2009). Additionally, religious material was taught in history as superstitions (L. Zeng, personal communication, April 29, 2009). Similar anecdotes from Chinese nationals about their educational experiences echo these sentiments. Thus, although previous research has suggested no link between science education and evolutionary understanding, previous research has been conducted primarily in cultures with mixed support for evolutionary explanations in the general public. The cultural support for scientific explanations in a Chinese sample (Bao et al., 2009; J. R. Schrock, personal communication, March 19, 2011) may work toward not only the development of evolutionary beliefs (Smith & Richert, 2011b) but also evolutionary knowledge.

One final note about the science education goals in People's Republic of China bears mention. Classroom education is clearly defined at the national level; teachers participate in frequent professionalization activities and guidelines for instruction aimed at preparing students for the *gau kao* exit examination are clearly outlined for instructors (Asia Society, 2006; DeHart Hurd, 1981; Ministry of Education of the People's Republic of China, n.d.; Schleicher & Stewart, 2008; Schrock, 2002a). The early outline of

biology curriculum (DeHart Hurd, 1981) has been supplemented with more stringent standards prompting a variety of sources to point to ways in which the US can learn from China's educational approach to the STEM fields (e.g., Asia Society, 2006; Schleicher & Stewart, 2008; Shukman, 2011).

Although the traditional Chinese model has historically focused on repetition and rote memorization of facts, the advent of the National Standards in China in 2000 by the Chinese government has pushed science and math education toward a model of inquiry-based education (Asia Society, 2010; Dinghua, 2010; Liu, 2010; Schrock, 2002b). These National Standards focus on students learning how to ask the "Big Questions" about science, rather than simply repeating fact-based knowledge (Liu, 2009). It is worthwhile to note that the data collected from the Chinese sample in the current study took place at the 10-year marker of the adoption of the National Standards and at the completion of the first 10-year plan for implementation. However, Chinese science educators still struggle implementing a inquiry-based approach to learning, in part because professional development and modeling of such an approach is limited (Liu, 2009; Schrock, 2002b). Moreover, teachers are inclined to teach as they themselves have been taught which is primarily fact- and memorization-based (Liu, 2009; Schrock, 2002b). This is consistent with anecdotal evidence gained while working with Chinese educators during the data collection process.

Current trends in Chinese education are shifting from memorization to inquiry learning. Several science educators and media outlets with ties to China's policies and implementation of science education have commented that China's historic focus on fact

memorization and teaching to standardized test achievement is one of the explanations for why no Chinese-trained national has yet to be awarded a Nobel Prize in science (Friedman, 2010; J. R. Schrock, personal communication, March 19, 2011; Zhang, 2010). Interestingly, the very system that has been suggested as promoting memorization rather than inquiry—the system China is making national efforts to leave behind in favor of a system of innovative, inquiry-driven thinking and teaching—is the system recent American trends are approaching. Specifically, the American system seems to be moving toward a system where content is taught and mastered according to specific national test content (e.g., No Child Left Behind, the Common Core), increasingly replacing the traditional inquiry-driven learning model of American science education.

The inquiry-based model of learning is likely largely responsible for the historical influence of the United States as a leader in the global science community. Relative to biology, that the United States is—or has been—a global leader in science is reflected in the official standards of several states, including the state of California, where the American sample in the current research was recruited. California state standards describe the high school period as one of educational synthesis, at least for the biological sciences (California State Board of Education, 1998/2003). Throughout elementary and junior high school, the instruction of the biological sciences focuses on various foundational elements of modern evolutionary theory, the theory considered to be the unifying theory of modern biology (Mayr, 1982).

In the second grade, children learn that individuals within a population vary (California State Board of Education, 1998/2003). This is one of the most fundamental,

yet most misunderstood aspects of evolution (e.g., Bishop & Anderson, 1990; Bizzo, 1994; Brumby, 1984; Larreamendy-Joerns & Ohlsson, 1995; Settlage, 1991; Shtulman, 2006). During the high school years, an understanding of variation within species becomes central to understanding the mechanism of evolution, specifically how the process of natural selection capitalizes on naturally occurring variation within species such that individuals with a fitness advantage survive. In the third grade, around 8 years of age, children begin to learn that some phenotypes and behavioral patterns are adaptive and promote survival (California State Board of Education, 1998/2003). Like the integration of inter-species variation into evolutionary instruction in high school, an understanding of phenotype selection promoting survival is vital to understanding how variation is the driving mechanism of natural selection.

Despite these official standards (which do not differ substantially from China's standards as described by Liu, 2009), there is evidence that American students are not achieving this level of understanding. The 2009 tests of the California State Standards in biology indicated that more than half of all high school students tested in the state of California performed at levels of limited proficiency or below (California Department of Education, 2010). Nationwide, America has dropped in educational status relative to other modernized countries in the past several decades. One such measure compares scores in reading, mathematics, and science across 30 countries that participate in the Organisation for the Economic Co-operation and Development (OCED). Results from the Program of International Service Assessment (PISA) for these 30 countries indicated

that America ranks 21st for student achievement in the sciences with scores well below the OCED average (Schleicher & Stewart, 2008).

One explanation for this finding is that the appropriate scientific coursework and content is a topic of frequent debate in the United States. Polls suggest that nearly the same number of Americans believe only creationism should be taught in schools as believe only evolution should be taught in schools (People for the American Way, 2000). The most common opinion, about 30% of Americans, is that evolution should be taught in schools, with creationism discussed as a specific form of belief about the origin of species (People for the American Way, 2000). This is consistent with the recent finding that many American science instructors teach creation alongside evolution, what Berkman and Plutzer (2011) call a "systematic undermining of science" (p. 404). One of the most common explanations for teaching creation and evolution in a science classroom is that American science educators often report being afraid of negative backlash from students, parents, school boards, and the general public. This consistent with observations that evolution in America has a socio-political facet surrounding issues of origins that does not exist in most other countries (Miller, Scott, & Okamoto, 2006).

In short, differences between typical American and Chinese samples in religiosity, tolerance of religious ideas within and outside of academic situations, science education, and cultural differences in evolutionary acceptance make examining the cultural variation between these two groups particularly relevant for understanding influences on creation belief and evolutionary knowledge. Furthermore, the early reliance on evolutionary explanations in a Chinese sample (Smith & Richert, 2011b) provides a unique point from

which to examine the possibility that evolutionary understanding is influenced by cultural belief and acceptance. In the current research, the inclusion of several cultural variables that may have reasonable within-culture variation, such as talk about religious and explanations with parents, will allow for an examination of the extent to which variation is attributable to broad-level, between-culture factors compared to within-culture variability.

Chapter Summary

William James (1890/1983) argued over 100 years ago that individuals approach the world generally through the specific lens of various sub-worlds. Although these claims can be tested in a variety of domains, research into the sub-worlds about scientific and religious explanations for origins has suggested that the two are unrelated (Bishop & Anderson, 1990; Dagher & BouJaoude, 1997; Lawson & Worsnop, 1992; Sinatra et al., 2003). Despite the independence of these variables, there are at least two cognitive constraints that have been suggested as influencing the development of evolutionary knowledge: psychological essentialism and teleology. Research into evolution understanding has generally suggested that regardless of religious beliefs, practices, and education, most individuals fail to develop an accurate understanding of modern evolutionary theory (Banet & Ayuso, 2003; Bishop & Anderson, 1990; Bizzo, 1994; Brumby, 1984; Dagher & BouJaoude, 1997; Ferrari & Chi, 1998; Larreamendy-Joerns & Ohlsson, 1995; Lawson & Worsnop, 1992; Sandoval & Morrison, 2003; Settlage, 1994; Sinatra, et al., 2003; Shtulman, 2006; Shtulman & Schulz, 2008). This inaccurate understanding about evolution reflects constraints promoting psychological essentialism

and teleology. Furthermore, research suggests that creation belief is a default in child development (Kelemen, 2004), in part as a result of these same cognitive constraints (Diesendruck & Haber, 2009; Kelemen & DiYanni, 2005).

These claims have been substantiated by research conducted primarily within Western cultures. However, cultural variation in recurrent patterns of behavior, values, and beliefs across generations exists within and across cultures and can influence development of even the most fundamental biological processes (Cole, 2005; Gauvain, 2008). Although claims that evolutionary knowledge and beliefs about origins are believed to be independent (Evans & Lane, in press; Sinatra et al., 2003), the research supporting this claim has been conducted primarily in cultural samples where support for scientific explanations for origins are mixed, at best (e.g., Miller et al., 2006). It remains an open question whether cultural support for scientific explanations may influence the formation of accurate evolutionary knowledge. Furthermore, research has suggested that cultural variation, especially in religious beliefs and practices (Diesendruck & Haber, 2009; Evans, 2001; Smith & Richert, 2009; Smith & Richert, 2011a, 2011b), influences children and adolescents' beliefs about origins. Another open question, however, is what aspects of cultural variation are particularly influential in the formation of beliefs about origins.

To build from and extend previous research into these topics, three primary research questions will be examined in a sample of Chinese and American adolescents.

Research Question 1: Are there between-culture differences in creation belief and evolutionary knowledge?

The first research question concerns cultural differences in origin beliefs and evolutionary understanding. The first hypothesis is that American adolescents will express creation belief at higher rates than Chinese adolescents (Hypothesis 1.1). Conversely, it is hypothesized that Chinese adolescents will demonstrate more sophisticated evolutionary knowledge than American adolescents (Hypothesis 1.2). The other two hypotheses address the nature of the relationship between creation beliefs and evolutionary knowledge. Specifically it is hypothesized that there will not be a relationship between creation belief and evolutionary knowledge in the American adolescents (Hypothesis 1.3). Alternatively, it is predicted that there will be a negative relationship between creation belief and evolutionary knowledge in the Chinese adolescents (Hypothesis 1.4). These hypothesized differences lead to the next two research questions that examine explanations for these hypothesized differences.

Research Question 2: What are the factors that influence creation belief?

The focus of the second research question is on the factors that influence creation belief. The first hypothesis is that of the variables examined (e.g., epistemology, science exposure, religious/science stereotypes), religious belief will be the strongest positive predictor of creation belief regardless of cultural membership (Hypothesis 2.1). The second hypothesis tested is that American adolescents will have higher religious belief compared to Chinese adolescents, which will account for the largest amount of the

between-culture variation in creation beliefs (Hypothesis 2.2). Finally, age is not predicted to be a significant predictor of creation belief (Hypothesis 2.3).

Research Question 3: What are the factors that influence evolutionary knowledge?

The focus of the third research question is on the factors that influence evolutionary knowledge. The first hypothesis is that of the variables examined (e.g., epistemology, science exposure, religious/science stereotypes), science exposure will be the strongest positive predictor of evolutionary knowledge regardless of cultural membership (Hypothesis 3.1). Hypothesis 3.1 is keenly interested in the positive predictors; negative predictors, such as measures of psychological essentialism and teleology will also be examined. The second hypothesis is that the Chinese adolescents have higher rates of science exposure compared to American adolescents, which is expected to account for the most variation in the cultural differences (Hypothesis 3.2). The third hypothesis is that age will be a positive predictor of science exposure, and thus, evolutionary knowledge (Hypothesis 3.3).

Chapter 2—Method

The current research examines how between- and within-cultural variation influences evolutionary knowledge and creation belief in Chinese and American adolescents. Variables examining these influences were measured in six basic categories: (1) religious beliefs, (2) beliefs of others (which also included adolescents' own beliefs)/stereotypes toward religion and science, (3) science exposure/preference, (4) epistemological reasoning, (5) cognitive tendencies toward psychological essentialism and teleological reasoning, and (6) cultural orientation. Variables from all six of these categories will be tested against religious belief and science exposure in an examination of Hypotheses 2.1 and 3.1 respectively.

Participants

Adolescents were recruited from high schools in two locations: Southern China and the Southwest United States. Information about participants' age, gender, and ethnicity are discussed separately for each of these cultural samples; cultural differences, including religious differences, are discussed in Chapter 3. Cultural differences were always examined with the Chinese adolescents as the reference category (0) and the American adolescents as the +1 category. Thus, when *cultural membership* has a positive score, this should be interpreted as American adolescents scoring higher on the variable of interest. A negative score should be interpreted as the Chinese adolescents scoring higher on the variable of interest.

Chinese. 238 Chinese adolescents (M = 15.85 years old, SD = .85 years; *range* = 14.04 to 18.81 years) were recruited to participate in the current survey from the top high

school in a small rural village in Southern China. There were 87 males and 149 females. This village has a population of about 100,000 people and the school has a population of 5,000 students, the majority of whom lived in dormitories full-time on campus. The village itself is described by the locals as very poor and disadvantaged economically, especially compared to other cities and regions in China. Many of the students who attended this school were from the smaller villages surrounding the rural village in which the school was located. The teachers at this school described the majority of the students in this study as coming from disadvantaged and low socioeconomic status families. Of the participants, 53.4% (*n* =127) identified as part of the Han majority ethnic group, 45.4% (*n* =108) identified as one of the 52 ethnic minority groups, and 1.3% (*n* = 3) declined to respond to this question. This region in China has a high population of ethnic minorities; thus, that about half of the participants were from a minority group reflected the general population of this region.

American. 277 American adolescents (*M* = 15.80 years, *SD* = 1.34 years; *range* = 14.02 to 19.75 years) were recruited to participate in the current survey from a high school of about 2,500 students in a relatively large city of about 300,000 in the Southwestern United States. There were 143 males and 126 females. Reflecting the general population of this region, the majority of participants described themselves as Hispanic (82.7%, *n* =229), with 4.0% (*n* = 11) describing themselves as Caucasian, 2.2% (*n* = 6) as African American, 1.4% (*n* = 4) as Asian American, and 7.6% (*n* = 21) describing themselves as having a mixed or other ethnic background. 2.2% (*n* = 6) declined to answer this question. Furthermore, 9.7% (*n* = 27) reported being a first

generation American, with both they and their parents having been born outside the United States. Just over half of the participants (51.3%, *n* = 142) reported being a second generation American with both of their parents having been born outside of the United States but the adolescent having been born in the United States. An additional 21.3% (*n* = 59) reported being at least a third generation American, with adolescents and their parents having been born in the United States. The remaining 17.7% (*n* = 49) declined to respond to these questions or provided incomplete information to determine their generational status. Ethnic differences within the two cultural samples will not be considered beyond this description.

Measures

The data were collected in the form of a written survey, lasting the duration of one class period, about 45 minutes. American adolescents completed the survey in English; Chinese adolescents completed the survey in Chinese, simplified characters. The surveys were identical in content with one exception in Section 1, noted below. Following, translation techniques are discussed, after which an explanation of the survey content and variable coding is provided.

Survey translation. The survey was originally written in English and later translated into Chinese using a method of collaborative back-translation with careful consideration of cultural equivalence in the design and structure of the translated questions and instructions (Peña, 2007). Five qualified undergraduates were selected based on (a) their ability to translate materials used in previous study (Smith & Richert, 2011b) from English to Chinese and vice versa and (b) their previous educational

experiences. Two of the five translators were educated though the high school years in the People's Republic of China (in Shanghai and Beijing regions); the remaining three were either educated in Taiwan or had extensive training in a Chinese school in the United States from an early age.

Initial translation was completed by a team of three of these translators. These translators spent several hours a week independently reviewing the progress of the previous translator, specifying where they would translate a word/phrase differently, and making progress on translating the next section of the survey. Once the entire survey had been completed, multiple meetings with all three translators and the author were conducted to reconcile all of the changes and comments made by the three translators. The author's presence at and involvement in these meetings allowed for input in these discussions to make sure that words were not simply being directly translated, but that the intended meaning of the words was being successfully communicated in the translation. Special attention was given to key phrases such as "higher power" (非人类力) and "Darwin's theory of evolution" (解的达尔文的进化). These meetings resulted in a single translated document that was satisfactory to all three translators and the author.

This single translated document was then given to the remaining two translators, who had not seen the original English document. This document was translated in a similar fashion as described above from Chinese back into English. At the conclusion of this translation, several meetings were held with the two translators and the author to reconcile back-translation discrepancies. The author was only involved in these meetings to facilitate their efficiency; no comments or directive influences were given on the

proper equivalent English wording. Where the translators believed several possible translations existed, both were included in the document.

Once a final back-translated document was established, all five translators participated in a final series of meetings to discuss discrepancies between the original English document and the back-translated English document, based on the Chinese translation. This process fine-tuned the Chinese translation, such that all five translators agreed the Chinese and the English surveys asked equivalent questions, provided equivalent responses, and offered equivalent instructions. Translators agreed that the final product was such that questions did not have several possible meanings, but that the purpose and intent of each question was clear and direct at similar levels as the original English survey. This conclusion was confirmed by the author's examination of an independent translation of this final, resolved survey by the primary translator of previous research (Smith & Richert, 2011a, 2011b).

Translation of open-ended survey responses for the Chinese participants was conducted by one of the initial translators. The closed-ended responses of the Chinese participants were also entered by this translator. Accurate entry of the closed-ended responses for the Chinese participants was double-checked by an independent research assistant using transparent coding sheets created to display the accurate numerical code over the circled response. This same research assistant also checked the accuracy of entry of the American participants' responses, which was conducted by three different undergraduate research assistants.

Survey content. The survey was organized into seven sections, each described in turn. Although composite variables generally were formed from questions in the same section, one measure of psychological essentialism described under the Cognition Section was actually presented to participants in the Origin Belief section. This is noted below. Variable names are mentioned in italics in this and future chapters for consistency. Although attempts were made to maintain variable names, they are occasionally altered for grammatical purposes, but are still presented in italics. These variable names, what survey questions they were derived from, how they were coded and created, as well as what previous research they were adapted from are summarized in Appendix A; Appendix B provides the full survey text, as given to American adolescents.

Section 1: Demographics, cultural orientation, and science exposure. This section was comprised of 24 questions for the American participants and 21 questions for the Chinese participants. Initial questions asked participants to report basic demographic information, including date of birth from which *age* was calculated based on the date of survey administration to examine Hypothesis 2.3 and 3.3. Participants also reported their *gender*, which was always coded with males as the reference category (0) and females as the +1 category. Information about participants' ethnicities was collected slightly differently for the two cultural samples. Chinese participants were asked about their ethnicities and given two options, Han or Other. American participants were given seven options, including African American, American Indian, Asian, Caucasian, Hispanic, Native Hawaiian, or other. Other responses in both cultural samples requested an open-ended follow-up response. American participants were given three additional questions

that asked participants to report if they, their mother, and their father, were born in the United States. These questions were used to examine the generational status of American participants and were not included in the survey for the Chinese participants.

Additional questions in this section asked about participants' living situation. At the time this survey was constructed, the author did not know that the Chinese participants lived in school dormitories. Thus, this question was uninterruptable for the Chinese participants—some responded that they lived in dormitories; some reported their out-of-school, vacation living situation.

The final questions in this section were used to measure two additional types of information: science exposure/preference and cultural interdependence. Science exposure was to be primarily measured by participants' responses to the question "how many biology classes have you taken?" This question further asked participants to "list the total number of classes and approximate length of each class (in months)." An examination of these responses indicated that participants varied widely in their understanding of this question; some listed an approximate number of class sessions (e.g., 108 to represent a class that meets 3 times a week for 9 months or 3 to represent 1 class a year for 3 years). The variety of these answers, and the inherent assumptions as to what they represent, which participants did not always specify, left these responses uninterruptable and therefore, unable to be coded. Thus, science preference will be used as an imprecise proxy variable for science exposure in the examination of Hypotheses 3.1-3.3. A discussion of the implications of using the proxy variable for interpreting the findings is included in Chapter 5.

Science preference was measured by three variables: *favorite science, least favorite science,* and *liking of biology.* The first two variables were derived from the coding of participants' open-ended responses to two questions, "what is your favorite/least favorite school subject?" To derive the *favorite science* and *least favorite science* variables, the listing of a science subject (e.g., biology) or the listing of a generic category (e.g., "science") was given a +1; the listing of a non-science subject (e.g., "geometry") or generic category (e.g., "math") was given a +0. When participants listed multiple subjects, the author examined the subjects listed; if a science subject or a generic science category was listed as one of the favorite or least favorite subjects, this was coded a +1. Listing multiple subjects without including a science subject or a generic science category was coded as a non-science (0).

The final measure of science preference examined participants' *liking of biology*, in which participants endorsed a closed-ended response for how much they liked the subject of biology, compared to all other subjects. Responses were scored on a 5-point scale ranging from *less than all other subjects* (-2), to *about the same as most other subjects* (0), to *more than all other subjects* (+2). The three variables measuring science preference, *favorite science, least favorite science,* and *liking of biology,* will be compared against the other variables described in this survey in an examination of the relative strength of science preference in predicting evolutionary knowledge (Hypotheses 3.1-3.3).

The final variables measured in this section examined participants' cultural orientation. *Cultural interdependence* was measured by 6 questions derived from the

Asian Values Scale (Kim, et al., 1999). The 6 questions from the Asian Values Scale were chosen because they were the highest loading questions from each of the original six sub-scales (*conformity to norms, family recognition through achievement, emotional self-control, collectivism, humility*, and *filial piety*). Each of the six questions used to create an average *cultural interdependence* variable represented each of these six sub-scales from the original measure. The second question, *family recognition through achievement,* was reverse-scored. Wording of the questions varied slightly from the original research, reflecting a simplification of wording to facilitate comprehension with a younger sample than used in the original research (see Table 2-1).

Table 2-1
Cultural interdependence questions

Statement	Sub-scale
It is important to follow family and societal expectations.	Conformity to norms
My family would not be ashamed of me if I failed at my occupation.	Family recognition through achievement
The ability to control one's emotions is a sign of strength.	Emotional self-control
Parental love should be understood and not openly expressed.	Collectivism
The needs of others in my group should be put before my needs.	Humility
My family should be my main source of trust and dependence.	Filial Piety

Note. Participants ranked each of these questions on a 5-point scale, from strongly disagree to strongly agree, with participants' responses to the question measuring *family recognition through achievement* being reverse-coded.

Consistent with Kim et al. (1999), each question was scored on a 5-point scale of agreement ranging from *strongly disagree* (-2) to *strongly agree* (+2). The composite

score was created by summing the individual questions and dividing by 6. Higher scores reflect a more interdependent cultural orientation; lower scores a more independent cultural orientation. Individual questions were examined for cultural differences; however, all correlational and inferential analyses were conducted with the averaged *cultural interdependence* variable.

Two supplemental variables to cultural interdependence asked adolescents to reflect on how they perceived their *academic* and *social choices* were made. Participants endorsed one of three closed-ended responses: that their parents made these choices (-1), that they made these choices together with their parents (0), or that they made these choices independent of their parents (+1). The -1 and 0 codes are conceptually consistent with a culturally interdependent orientation which places elders—specifically parents—in the place of authority for most choices; a +1 is conceptually consistent with a culturally independent orientation which places the individual in the place of decision authority.

Section 2: Origin beliefs. The questions in this section were designed to measure participants' beliefs about the origin of species. Participants were asked to consider where the "very first" of 9 different kinds (exemplars) on earth came from: fish, chair, tree, plankton, ape, rock, dog, Neandertal (cave man), and human being. With the exception of the man-made artifact (chair), these exemplars reflect a variety of living and natural kinds. Participants ranked 5 explanations from best to worst for where these exemplars "came from." These explanations were the same for the 9 exemplars and reflected evolutionary (*it emerged over a very long time from a different kind of thing on earth*), reincarnation (*it was something that was reborn as a [exemplar]*), spontaneous

generationist (*it just appeared*), artificialist (*a person made it and put it here on earth*) and creationist (*it was made by a higher power*) responses. These response options are similar to those used in previous research (e.g., Evans, 2001; Smith & Richert, 2011b), although the method of ranking these responses is unique to this research. Ranking responses was selected in order to gather more descriptive information than the single endorsement of a "best" response (Smith & Richert, 2011b), although only the "best" responses were examined statistically, without the time burden of the rating of the value of each of the 5 explanations for the 9 exemplars (Evans, 2001).

One of the primary differences in these response options to those of previous research was in the presentation of the creation explanation. The creation response differed in that it did not directly reference "God" due to translation concerns. Specifically, several of the primary translations for "God" in Chinese carry specific references to state-regulated religions. For example, 上帝 (shàngdì) and 神 (shèn) both mean "God" but are generally used to refer to the Christian God of the Bible. To avoid this specific implication, responses were instead translated to reference a more general "higher power" (非人类力, fēi rénlèi lì). Literally translated, this phrase referenced a non-human force that included, but was not limited to, the Judeo-Christian God. The exemplars and the explanations were given to all participants in the same order.

Participants' ranked responses were re-coded into the selection of creation as the best explanation (+1) and the selection of another response as the best explanation (0). Participants who did not rank all responses from best to worst but still endorsed a "best" response were able to be included in the analyses. Mean differences in the preference for

creation belief were examined for each individual exemplar on a 0/1 scale. However, participants varied in their responses across the questions; not all participants answered all 8 questions (the artifact exemplar, chair, was not included in the creation belief analysis). Thus, in order to retain the maximum amount of data, and to create an overall measure of creation belief which was of primary interest to the current research, participants' responses were used to create a *creation belief proportion* (generally referred to simply as *creation belief*).

Creation belief proportions represent the proportion of questions that the participant responded to with a creation response as the "best" explanation and will be used to examine hypotheses concerning mean levels of creation belief (1.1, 1.3, 1.4, 2.1, and 2.3). All numbers reported for an average *creation belief* are proportions of the total number of origin belief questions answered (out of 8). For example, if participants answered 6 of the 8 questions, the number of questions for which they selected creation as the best response was divided by 6. The average number of questions used to calculate the creation proportion for the Chinese adolescents was 7.49 (SD = 1.39, n = 233); the average number of questions used to calculate the creation proportion for the American adolescents was 6.63 (SD = 2.38, n = 217). This mean difference was significant, t (448) = 4.73, $p < .001$. There was no difference in the average number of questions included in the proportions by *gender*, and *age* was not a significant predictor of the number of questions included in the proportions.

Section 3: Epistemology. Epistemological stance was measured using a method derived from Kuhn et al. (2000). Participants read two scenarios that presented a

disagreement between two individuals about the origin of the *universe* and the origin of *species*. Participants were asked to rate their agreement with each argument, consider if the divergent opinions could be reconciled, and provide an overall assessment of the arguments in general. The two scenarios provided religious and scientific arguments for the origin of the universe and the origin of species. Measurements of agreement include *religious agreement* (also referred to as *religious perspective*) and *scientific agreement* (also referred to as *scientific perspective*), one for the *universe* and one for the *species* scenario. Agreement was scored on a 5-point scale ranging from *I am certain [debater's name] is wrong* to *I am certain [debater's name] is right*. Additionally there are two measurements of *reconciliation*, one for each scenario, based on if participants endorsed that the divergent opinions could both be right (+1) or not (+0).

Finally, participants were presented with a single question within each scenario to measure *epistemological stance*, measured by participants' response to a consideration of the "arguments in general." As outlined by Kuhn et al. (2000), participants could endorse an absolutist (*only one opinion is correct*), a multiplist (*each opinion has some good points, and it is impossible to choose between them*), or an evaluativist (*each opinion has some good points, but one has better arguments than the other*) response. These stances represent different categories of epistemology, but also represent an underlying scale of increasing sophistication. Absolutist responses were scored +1, multiplist responses +2, and evaluativist responses +3; higher scores reflect more sophisticated stances toward the nature of knowledge. Because epistemology is domain-specific (Buehl & Alexander, 2001; Hofer 2000), participants received two scores: one for *universe epistemological*

stance and one for *species epistemological stance* to examine the possibility that these scenarios represent different domains.

Section 4: Evolutionary knowledge. Evolutionary knowledge was measured by six questions adapted from previous research (Shtulman, 2006). These questions measured understanding of five different concepts in evolutionary theory: inheritance, adaptation, variation, speciation, and extinction. Participants were instructed to answer the questions according to what they knew of Darwin's theory of evolution. Two questions measured speciation, thus variables derived from these questions are labeled after the primary subject of the question: *woodpecker* (inheritance), *basketball* (adaptation), *moth* (variation), *common ancestor* (speciation), *chimpanzees* (speciation), and *bacteria* (extinction).

Consistent with Shtulman (2006), participants were coded on a scale of -1 to +1 based on the selection of a multiple choice response and their open-ended justification. Responses consistent with sophisticated evolutionary knowledge—responses that reflected knowledge of within-species variation as key to evolutionary change—were coded as variational responses and given a score of +1. Transformational responses that reflected pre-Darwinian concepts of evolution, including will, intention, and a lack of understanding of within-species variation as the mechanism of evolution, were given a score of -1. Ambiguous responses were given a score of +0. Ambiguous codes were given for two basic types of responses. The first type of ambiguous response was given for open-ended justifications that reflected aspects of a variational as well as a transformational framework. The second type of ambiguous response was given when

either a transformational or variational code could not be given based off the participants' response. This included uninterruptable open-ended responses and the selection of a multiple choice response with no open-ended justification. Full texts of these questions, a more detailed coding explanation, and examples of the types of answers that received specific codes are provided in Appendix C.

Initial analyses for each individual question were conducted based on the mean score according to the -1 to +1 codes. Coding was completed independently by the author and a recent college graduate for all participant responses to 5 of the 6 questions: *woodpecker, basketball, moth, chimpanzees,* and *bacteria.* Codes for *common ancestor* were based solely on the recoding of closed ended responses. Although codes for *basketball* were primarily determined by the selection of the closed-ended analogies, both coders examined the open-ended justifications for participants who selected the correct "selection analogy." An examination of these open-ended responses resulted in the recoding of some of these responses initially coded as +1 into ambiguous (0) or transformational (-1) codes (e.g., the endorsement of the selection analogy with an open-ended response that described the value of practice in improvement). When participants endorsed the evolutionarily correct selection analogy but failed to provide an open-ended justification, this was coded as ambiguous.

Rater reliability for these questions was sufficiently high; Chronbach's alpha ranged from .80 to .99. The codes given by the author were the ones used in all analyses and for the creation of the *evolutionary knowledge* variable. Rater reliability for the five questions that were coded can be found in Table 2-2.

Table 2-2
Rater reliability for the evolutionary knowledge questions

Question	Evolutionary Concept	α
Woodpecker	Inheritance	.86
Basketball	Adaptation	.99
Moth	Variation	.83
Chimpanzees	Speciation	.80
Bacteria	Extinction	.84

As with the origin belief questions, participants varied in the number of evolutionary knowledge questions they answered. Similar to *creation belief*, a proportion was created as a measure of *evolutionary knowledge.* The *evolutionary knowledge* proportion is the variable used to examine Hypotheses 1.2, 1.3, 1.4, 3.1, and 3.3. Mean reported proportions reflect the average proportion of questions answered that were coded with a variational (+1) code. Measuring *evolutionary knowledge* with the proportion of variational responses allows for a more direct examination of the hypotheses about the learning and demonstration of evolutionary knowledge and understanding (1.2, 1.3, 1.4, 3.1, and 3.3). Variational reasoning reflects sophisticated evolutionary knowledge; non-variational responses (ambiguous or transformational) reflect less sophisticated, pre-Darwinian evolutionary understanding. Although differences in the nature and form of less sophisticated patterns of evolutionary reasoning is an interesting question, it is outside the scope of the current research which was keenly interested in correct, sophisticated *evolutionary knowledge*.

Chinese adolescents answered an average of 5.57 questions (SD = .90) of the 6 questions to measure evolutionary knowledge. The American adolescents answered significantly less questions with an average of 4.34 questions (SD = 1.43, t (448) = 11.09,

$p < .001$). There were no mean differences by *gender*, and *age* was not a significant predictor of number of questions used to calculate the *evolutionary knowledge* proportion.

Section 5: Cognition. The questions in this section served primarily to measure variation in cognitive reasoning about teleology and essences. Participants read two scenarios about prehistoric animals (two of the scenarios presented to children in Kelemen, 1999b). Each scenario asked participants six questions, half of which were also drawn from Kelemen's (1999b) research into teleological reasoning. Of the remaining 3 questions in each scenario, 2 were adapted from other research to measure psychological essentialism (Shtulman & Schulz, 2008) and 1 served as a measure of preference for explanatory methods (Poling & Evans, 2002). The pattern of questions across each scenario was identical.

In the first scenario, participants were told about prehistoric aquatic reptiles that spent a lot of time in the water, had very long necks, and lived in herds. Participants were also told that near where this reptile lived there were lots of very pointy rocks. The second scenario told participants about a prehistoric terrestrial birds that had soft feathers that puffed out when they sat, lived together in large nests, and that near where these birds lived there was rough, grainy sand. Following each description, participants were asked to choose the best explanation for why one of the biological parts was as it was previously described (why the reptiles had long necks/why the birds had such soft feathers), replicating Kelemen's (1999b) research. Participants were given three types of responses to choose from as the best explanation: teleological mechanistic responses (e.g., *they had long necks so that they could grab at fish and feed on them*), teleological

social responses (e.g., *they had long necks so that they could hold up their friends when they got tired swimming*), and natural responses (e.g., *they had long necks because the stuff inside got all stretched out and curved*). Participants were also provided with an *other* option where they could write in their own explanation.

After the first teleological question about a biological part in each scenario, participants were asked two questions: one to measure *actual variation* and one to measure *possible variation* (Shtulman & Schulz, 2008). Questions to measure *actual variation* asked participants if all of the reptiles/all of the birds had long necks/soft feathers. Questions to measure *possible variation* asked participants if a reptile/bird could be born with a short neck/feathers that were not soft. Both of these questions asked about the biological part mentioned in the initial teleology question. Each of the variation questions were answered with a closed-ended yes or no response.

Responses reflecting that within-species variation could not/does not occur were scored as a +1, consistent with an essentialist framework as within-species variation is inconsistent with an essentialist framework. Each composite (*possible variation* and *actual variation*) had a maximum possible score of +2 (fully essentialist) and a minimum score of 0 (fully non-essentialist) by summing across the two scenarios, with a score of +1 reflecting a partial essentialist framework.

Following the *actual* and *possible variation* questions, participants were given two additional questions to examine teleological reasoning in each scenario (Kelemen, 1999b). These questions asked participants to consider the nature of an additional biological part (why the reptiles' necks swayed side to side/why the birds' feathers puffed

out when they sat) and why the nearby natural kinds were as described (why the rocks were so pointy/why the sand was so rough and grainy). These additional teleology questions required the selection of a closed-ended response (teleological mechanistic, teleological social, or natural), or the selection of other with an explanation.

The other responses in all 6 of the teleological reasoning questions (3 in each scenario) were re-coded into one of the three categories (teleological social, teleological mechanistic, or natural) by two independent raters for 85.4% (n = 440) of the responses (Table 2-3). Because rater reliability was sufficiently high for each of these questions, the codes given by the first rater were used and this same rater coded the responses of the remaining 75 participants. Responses that referenced a purpose were re-coded as a teleological response. If the purpose served a social or relational function, it was scored as a teleological social. If the purpose served a survival or practical non-social function, it was scored as teleological mechanistic. Responses that referenced no purpose, but described a natural cause (e.g., evolution, environmental pressures) were coded as natural. Responses that reflected no conceptual framework were counted as missing data.

Table 2-3
Reliability for teleological preference question coding

Category	Question	α
Biological Kinds	Why long reptiles have long necks	.99
	Why necks sway when they move	.99
	Why feathers are soft	1.00
	Why feathers puff out when the birds sit	1.00
Natural Kinds	Why rocks are pointy	1.00
	Why sand is rough and grainy	.82

Using participants' responses to the teleological reasoning questions in both of the scenarios, two types of composites were created: *teleological preference* and *teleological*

comparison. One composite was created for questions about *biological kinds* and one for questions about *natural kinds.* Biological and natural kinds were considered independently as teleological explanations about biological kinds, common in many adults, may not interfere with evolutionary knowledge as much as teleological reasoning about natural kinds, which is relatively uncommon in adults in modernized societies.

Coding for *teleological preference-biological* and *natural kind* composites occurred in similar ways. These variables were coded to facilitate a comparison of participants' endorsement of teleological and natural explanations. Each teleological response was given a score of +1, whether it was teleological mechanistic or social. Natural responses were given a score of 0. For the *teleological preference-biological kind,* a maximum score of +4 represents an exclusive endorsement of teleological explanations across the two scenarios and a minimum score of 0 represents an exclusive endorsement of natural explanations. For the *teleological preference-natural kind,* a maximum score of +2 represents an exclusive endorsement of teleological explanations across the two scenarios and a minimum score of 0 represents an exclusive endorsement of natural explanations.

Additional coding was conducted to examine the nature of teleological responses for participants who were exclusively teleological in their responding. Teleological mechanistic endorsements were given a score of 0, whereas social teleological codes were given a score of +1. For the *teleological comparison-biological kinds,* a maximum score of +4 represents exclusive endorsement of social teleological responses, with a minimum score of 0 representing exclusive endorsement of teleological mechanistic

responses. For the *teleological comparison-natural kinds*, a maximum score of +2 represents an exclusive endorsement of social teleological responses and a minimum score of 0 represents an exclusive endorsement of teleological mechanistic responses. This two-step coding scheme allows for an individual comparison of preference for teleological and natural responses, as well as the type of teleological response participants preferred.

The final question in each scenario was adapted from Poling and Evans' (2002) research examining individuals' preferences toward teleological, essentialist, or intentional reasoning. Participants were asked to select between intentional (*they stay together because they like each other*), teleological (*they stay together because being together can ensure their safety*) and essentialist (*they stay together because they have the same things inside their bodies*) responses for the best (scenario 1) and worst (scenario 2) explanations for why these animals "stayed together."

At the conclusion of this section, participants were asked two questions from Newman and Keil (2008) examining the nature of participants' essentialist frameworks. Participants were told about a group of scientists who discovered a glacier with a large animal frozen inside and planned to take pea-sized samples from inside the animal to determine what kind of animal it was. The questions examined participants' perceptions about the scientists' planned method. Participants were asked to rate how much they agreed with a *distributed view of essences* ("it doesn't matter where they take the samples from, any sample will be able to tell them what kind of animal it is") and how much they agreed with a *localized view of essences* ("there is only one special sample that will tell

them what kind of animal it is"). Finally, because these questions were asked in a different context from the original research, an additional question was included to measure participants' general agreement to the method of taking an *internal sample* as a good way to determine what kind of animal it is ("taking a sample from the inside of the animal is a good way to determine what kind of animal it is"). Whereas the first two questions asked about the nature of participants' essentialist frameworks, the third question was a measure of if an essentialist framework was appropriate for determining what kind if animal the scientists had found. All three questions were measured on a 5-point scale ranging from *strongly disagree* (-2) to *strongly agree* (2).

Participants were given one additional question to measure tendencies toward psychological essentialism. This question appeared at the beginning of the *Origin Belief* section, but is discussed here as it is always considered with the other cognition variables in the reported analyses. Participants were asked "are individual member of the same species different from one another?" This question comprises the *differences in individual species* variable and was designed to evoke non-essentialist responses. Unlike the other measures of psychological essentialism, this question was expected to have minimal variation in order to serve as a point of comparison for the additional measures of psychological essentialism derived from previous research.

After endorsing a *yes* or *no* response to the question, with a no response reflecting a stance consistent with psychological essentialism, participants were asked to justify their answers. Coding of follow-up responses as to why individual members of a species were the same or different was conducted by two independent raters for 85.4% (n = 440)

of the participant responses (α = .98). The codes of the first rater were used and this rater coded the remainder of the responses. Participants' responses as to why individual members of a species were or were not different from one another were coded into 4 categories of reference: (1) genetics, biology, internal "essences;" (2) personality, preferences, or experiences; (3) phenotypes or physical differences; and (4) gender or age. Responses that did not clearly reference any of these categories primarily referenced differences between species (not within) and were categorized as unable to be coded.

Section 6: Informal religious and scientific beliefs and stereotypes. This section instructed participants to use the provided definitions for the "natural world," "scientific explanations," and "explanations of higher power" in answering the following questions (see Table 2-4). Participants were also told that "people have differing opinions about the usefulness of scientific explanations and explanations of higher power for explaining the natural world" and were instructed to reflect on the opinions of different types of people about these types of explanations.

Table 2-4
Definitions given to participants for the natural world, scientific explanations, and explanations of higher power

Natural world	The physical world, and the living and non-living things that make up the world. Includes biological processes (e.g., photosynthesis, reproduction), non-biological kinds (e.g., rocks, the atmosphere), and non-biological processes (e.g., tornados, tsunamis). The natural world does not include man-made things or technology
Scientific explanations	Explanations derived from the scientific method. The scientific method is a set of techniques used to test hypotheses; it involves gathering data (evidence) through observation and experimentation
Explanations of higher power	Explanations and claims that invoke reference to one or many higher powers with supernatural abilities

Participants responded to five sets of questions: (1) preferred methods for explaining the origin of the natural world, (2) opinions of individuals who use scientific explanations for the origin of the natural world, (3) opinions of individuals who use religious explanations for the origin of the natural world, (4) possible disappointment if the adolescent used scientific explanations for the origin of the natural world, and (5) possible disappointment if the adolescent used religious explanations for the origin of the natural world. For each set of questions, participants provided a response for five individuals: themselves, their mother, their father, their close friends, and their teachers. Thus, each of the 5 sets of questions had 5 individual questions. These questions were designed to measure adolescents' beliefs and the beliefs of those around the adolescent. Collectively, this group of questions is referred to throughout this paper as measures of the "beliefs of others," even though the adolescents' own beliefs are included.

The first set of questions, *self, mother, father, friends',* and *teachers' preferred method of explanation* asked participants to report about the participants (*self*) and their perceptions of others' (*mother, father, friends, teachers*) *preferred method* of explanation for the beginning and continuation of the natural world. A -1 was given for the endorsement of preferring primarily scientific explanations, a 0 for a mixture of scientific and religious explanations, and a +1 for preferring primarily religious explanations[3]. Higher scores represent a higher preference for religious explanations. Participants who

[3] Although "religious explanations" are used to describe "explanations of higher power" throughout this paper, participants were never asked directly about religion in this section; they were always asked about "explanations of higher power."

selected the response that *I do not talk to this person about this* were excluded from the analyses for *preferred method*.

The second set of questions asked participants to report about *opinions toward scientific explanations* and *opinions toward religious explanations*. Participants were asked if their own view (*self*) as well as the opinion of their *mother, father, friends,* and *teachers* toward these types of explanations tended to be *mostly positive* (+1), *neutral* (+0), or *mostly negative* (-1). Higher scores indicated more positive responses.

The final two sets of questions also followed this format, asking about adolescents' perception of the potential disappointment they would feel, as well as that of their mother, father, friends, and teachers, if the adolescent was to use scientific explanations (*scientific disappointment*) or explanations of higher power (*religious disappointment*) for the origin of the natural world. Responses that indicated the person would be disappointed with the use of particular types of responses (e.g., scientific or religious) were scored -1, neutral responses were scored 0, and the indication that the person would not be disappointed were scored +1. Similar to the *opinion* variables, higher scores indicated more positive responses in that higher scores indicated less/no disappointment.

The four variables, *opinions toward science/religious explanations* and *scientific/religious disappointment,* were combined into an *overall view of religious explanations* (generally referred to as *overall view*) for *self, mother, father, friends,* and *teachers.* Two of the variables, *opinions toward scientific explanations* and *scientific disappointment* were reverse-coded before summing. Each *overall view of religious explanation* variable ranged from -4 (negative view of religious explanations, positive

view of science) to +4 (positive view of religious explanations, negative view of science). A middle-range score (0) would be evidence of equal views of religious and scientific explanations (both high, both average or both low).

There were two additional types of questions included in this section: discussion and stereotype questions. Discussion variables asked participants to report in an open-ended format who they talk to the most and the least about scientific and religious explanations. Based on participants' responses, these *most* and *least scientific/religious talk* variables were given one of 5 categorical codes by the author: family, friend, school teachers, religious leaders, and other. The other category was eclectic, including self, strangers, and enemies, although it was not used frequently.

The final questions in this section were designed to examine stereotypes of individuals who use primarily scientific or religious explanations of the origin of the natural world by asking participants to select characteristics they believed to be more common among these types of individuals. Participants were given a set of 14 opposing attributes (e.g., smart vs. dumb, dull vs. funny), once for a person who uses primarily scientific explanations for the origin of the natural world, and once more for a person who uses primarily religious explanations for the origin of the natural world. Participants were instructed to circle a 1, on the left side of the table, if the characteristic on the left was much more descriptive of the type of person in question (e.g., a person using scientific or religious explanations) compared to an "average person." Participants were instructed to circle a 2, in the center of the table, if the characteristics on the left/right were equally descriptive of the type of person in question compared to an "average

person" (e.g., neither attribute was more or less descriptive). Participants were instructed to circle a 3, on the right side of the table, if the characteristic on the right was much more descriptive of this type of person than the "average person." Positive attributes (e.g., smart, considerate) and negative attributes (e.g., selfish, untrustworthy) were both present on the left and the right, such that participants could not simply circle all 1's or all 3's to endorse all positive or negative attributes.

Traits were all coded such that the attribution of a positive trait (smart, considerate, outgoing[4], wealthy, good looking, funny, generous, trustworthy, normal, nice, and has lots of friends, religious, spiritual, someone you would want to be friends with[5]) was scored +1, and the attribution of the paired opposite negative trait (dumb, inconsiderate, shy, poor, ugly, dull, selfish, untrustworthy, weird/odd, mean, and has very few friends, irreligious, secular, someone you wouldn't want to be friends with) was scored -1, regardless of whether the trait appeared on the left of the right hand side of the table. For example, if participants selected smart as more representative of a particular type of person, this was coded as +1. If they selected dumb as more representative of this type of person, this was coded as a -1. If they selected the middle number, consistent with neither trait being more like this person than average, this was coded as +0.

[4] The outgoing-shy pair was examined independently prior to the inclusion in an aggregated stereotype measure given the possibility that cultural orientation may influence whether shy or outgoing is considered a "positive" trait. However, as shown in Chapter 3, there were no differences in the Chinese or American adolescents' attribution of shy or outgoing to someone using scientific or religious explanations. Thus, it was scored with "outgoing" as the positive trait and included in the stereotype variables as described.

[5] Selection of religious, spiritual, and someone you would want to be friends with were scored as +1, consistent with the coding of the positive traits; their opposite traits, irreligious, secular, and someone you wouldn't want to be friends with, were coded as -1, consistent with the negative traits. However, none of these traits were included in the stereotypes and no claims about the positivity/negativity of these traits were intended by this coding.

Three of the 14 trait-pairs, religious/irreligious, spiritual/secular, and someone I would/wouldn't want to be friends with, were not included in the stereotype averages. These specific trait pairs were examined independently because of the theoretical interest in these traits as highly descriptive of the cultural biases toward science and religion more generally.

From the remaining 11 trait pairs, an *average scientific stereotype* and *average religious stereotype* were created on the same -1 to +1 scale. For these stereotypes, participants' codes for the 11 trait-pairs included were summed and divided by 11. Participants endorsed these traits for someone who uses primarily scientific explanations (*average scientific stereotype*) and for someone who uses primarily explanations of higher power (*average religious stereotype*). For both of these average stereotypes, +1 scores represent more positive stereotypes (e.g., more positive attributes endorsed) and -1 scores represent more negative stereotypes (e.g., more negative attributes endorsed). A score close to 0 could represent either of two options: an equal number of positive/negative attributes endorsed (+1 scores and -1 scores averaged together to zero) or the consistent endorsement of neither attribute being more descriptive than average (a 0 code).

Section 7: Formal religious beliefs. The final section of the survey consisted of 4 primary questions. These questions asked participants if they had *ever attended* a religious service (yes/no categorical codes) and if so, which one. Participants were provided with the 5 religious officially recognized and regulated by the Chinese government (*Catholicism, Protestantism, Buddhism, Islam,* and *Daoism*), although there

was an *other* option, where participants could list a different religion with which they had attended a religious service. A similar question asked participants if they *currently attend* a religious service, and if so which religious affiliation. Participants chose from the 5 religious affiliations previously listed with an *other* option. The other codes for both of these variables were examined and recoded by the author where appropriate (e.g., if the other response listed a specific protestant sect of Christianity, it was re-coded as *Protestantism*).

Two additional follow-up questions were asked of participants who reported they were *currently attending* a religious service: *frequency of attendance* and *attend with.* Specifically, *frequency of attendance* provided participants with a 6-point scale ranging from *once a year* to *several times a week.* Although participants were given only 6 choices, coding was on a 7-point scaled including a code for *never* if participants reported in the previous question that they did not currently attend religious services. Thus, responses were on a 7-point scale ranging from *never* (+0) to *once a month* (+3) *to several times a week* (+6).

To examine who adolescents *attend with,* participants were asked to circle the individuals with whom they attended religious services (*father*, *mother*, *other family member*, *friend*, and *other*; *other family* and *other* options requested further elaboration by the participant). Participants' closed-ended endorsements and explanations for other family and other were coded into 8 categories by the author: mother-only, father-only, both parents, grandparents (either one or both), other family (e.g., siblings, aunts, uncles, etc.), friends, other (e.g., stranger, neighbor), and multiple categories (e.g., both parents

and friends). With the exception of *frequency of attendance*, participants were asked to circle all the responses that apply when more than one was relevant so that if participants had previously attended religious services from multiple religions or if they attended religious services with multiple individuals, they would circle multiple options.

For participants who reported they had never attended a religious service, they were asked if they had ever *thought about attending* (yes/no). Participants' responses, and their open-ended explanations, were used as descriptive, uncoded measures.

Of particular interest, however, is the measure of religious belief that will be used to test Hypotheses 2.1 and 2.2: *belief in a higher power.* The use of only one index for religious belief is further discussed in Chapter 3. Participants were asked if they believed in a higher power; responses were scored on a 3-point scale: *no* (-1), *not sure* (0), and *yes* (+1). The other variables discussed throughout this chapter will be compared to *belief in a higher power* in a specific examination of the strength of this variable in predicting creation belief (Hypothesis 2.1).

Procedure

Students from both cultural samples were recruited from their high school (one Chinese and one American) and participated during class time. The Chinese adolescents were invited to participate in this survey during one of their English classes. Instructions were given in Chinese by the Chinese teachers and students were instructed to provide all responses in Chinese. If participants had questions while completing the survey, they were instructed to raise their hand and ask the teacher; the Chinese teacher would translate the question to the author of this paper. Reponses were re-translated and told to

the students in Chinese. Simple questions, such as if participants should put their names on the paper, were addressed in English if the participant asked the question in English voluntarily.

The American adolescents were invited to participate in this survey during one of several types of courses: Advancement Via Individual Determination (AVID), Freshman Focus, or mathematics courses (including algebra, geometry, and California High School Exit Examination [CAHSEE] math). Instructions were given in English and participants were instructed to raise their hand and ask their teacher or the author of this paper if they had any questions. The author of this paper responded to all content-related questions as classroom teachers were instructed to direct these questions to the author.

For both cultural samples the survey took most adolescents about 45 minutes to complete. No participants from either cultural sample were recruited from a science class. After completing the survey, participants' surveys were collected, stored, and marked with a participant number to ensure anonymity.

Chapter 3—Results

Differences in Predictor Variables by Culture, Gender, and Age

The results presented in this chapter focus primarily on whether the independent variables are significantly different between cultures (Chinese vs. American), genders (male vs. female), as well as the relationship between age and the variables. The nature of the differences in these variables are described in this chapter to examine Hypotheses 2.2, 3.2 and 3.3; these differences lay the foundation for the examination of the factors that influence *creation belief* and *evolutionary knowledge* (Hypotheses 2.1, 2.3, 3.1 and 3.3) in Chapter 4.

Demographic Variables

Within the Chinese sample, there were 36.6% male (n = 87) and 62.6% female (n = 149) adolescents, with .8% (n = 2) declining to answer. Within the American sample, there were 51.6% male (n = 143) and 45.5% female (n = 126) adolescents, with 2.9% (n = 8) declining to answer. The difference in the number of males and females between the two samples was statistically significant, χ^2 (1) = 13.46, $p < .001$, $\phi = -.16$, with the Chinese sample having a significantly lower number of males, compared to the number of females, than the American sample. This difference is one of the primary reasons for the consideration of gender in the following analyses.

Participants in both cultural samples were recruited from all high school grades. The ages reflect this method of recruitment as Chinese participants ranged in age from 14.04 to 18.81 years (M = 16.36 years, SD = .76 years) and American participants ranged

in age from 14.02 to 19.75 years (M = 16.25 years, SD = 1.31 years). An independent samples *t*-test indicated that *age* was not significantly different by *culture*.

Science Preference

Science preference was measured by participants' responses to three questions: *favorite science, least favorite science,* and *liking of biology*.

Using measures of science preference as a proxy for science exposure in the examination of Hypothesis 3.2, 21.8% (n = 48) of the Chinese participants reported a science as their favorite school subject (*favorite science*), with the remaining 78.2% (n = 172) listing a non-science subject as their favorite school subject. This is contrasted with 14.3% (n = 38) of the American participants reported a science as their favorite school subject, with the remaining 85.7% (n = 227) listing a non-science as their favorite school subject. This difference was significant, χ^2 (1) = 4.61, $p < .05$, ϕ = -.10.

This finding cannot be accounted for by gender, as a 2 (*gender*) x 2 (*favorite science*) chi-square analysis suggested that the listing of a science or a non-science as a favorite subject did not differ by *gender*. Females were equally likely to list a science as their favorite subject (n = 47, 17.4%) compared to their male counterparts (n = 40, 17.6%).

As a partial test of Hypothesis 3.3, a logistic regression analysis indicated that *age* significantly predicted *favorite science* (β = -.31, Wald χ^2 = 7.19, $p < .01$). This difference, however, was not large. The odds ratio indicated that younger adolescents were only .73 times more likely to list a science as their favorite subject than the older adolescents.

An alternative examination of science preference by culture (Hypothesis 3.2) examined participants' least favorite school subject (*least favorite science*). 25.9% (*n* = 52) of the Chinese participants listed a science as their least favorite school subject with the remaining 74.1% (*n* = 149) listing a non-science. This is contrasted with the American participants of whom only 7.9% (*n* = 20) listed science as their least favorite subject with the remaining 92.1% (*n* = 233) listing a non-science as their least favorite school subject. That the Chinese participants more frequently reported science as their least favorite school subject compared to the American participants was confirmed by chi-square analyses, χ^2 (1) = 27.09, $p < .001$, $\phi = -.24$. With the findings from *favorite science,* this suggests that science subjects were more polarizing in the Chinese sample. Whereas American students were not likely to favor or least favor science, just under half of the Chinese sample considered a science subject their favorite or least favorite subject.

Although there was not a difference in *favorite science* by gender, a 2 (*gender*) x 2 (*least favorite science*) chi-square analysis indicated that science was more frequently listed as a least favorite subject among females (*n* =58, 22.4%), than males (*n* = 18, 8.9%, χ^2 (1) = 14.99, $p < .001$, $\phi = .18$). In a partial examination of Hypothesis 3.3, a logistic regression analysis indicated that *age* did not significantly predict *least favorite science.* Younger and older adolescents were equally likely to list a science as their favorite subject than the older adolescents.

The final measure of science preference indicated that cultural differences in favoring/least favoring science as a school subject did not seem to carry over into the specific subject of biology. An independent samples *t*-test indicated that Chinese (*M* =

.01, *SD* = .88, *n* = 223) and American (*M* = -.07, *SD* = 1.09, *n* = 251) adolescents' reports of *liking of biology* compared to other subjects did not statistically differ; both groups reported liking biology about the same as other most other subjects. With the caveat that science preference is an imprecise replacement for science exposure, these findings partially support Hypothesis 3.2.

Consistent with the above findings, there were no mean differences between males' (*M* = .05, *SD* = .99, *n* = 206) and females' (*M* = -.07, *SD* = .99, *n* = 259) reports of *liking of biology.* A linear regression analysis was conducted in the final examination of science preference portion of Hypothesis 3.3. This analysis indicated that *age* was a significant, negative predictor of *liking of biology* (R^2 = .03, β = -.18, $p < .001$). The finding that younger adolescents liked biology more than older adolescents is consistent with the finding that younger adolescents were likely to list a science as their favorite school subject compared to a non-science. These findings are in the opposite direction as predicted.

Cultural Interdependence

The primary measure of *cultural interdependence* was 6 questions derived from the Asian Values Scale (Kim et al., 1999). Findings from Independent Samples *t*-tests comparing the two cultural groups can be found in Table 3-1. Chinese adolescents scored higher than American adolescents on 4 of the 6 questions measuring *emotional self-control, collectivism, humility,* and *filial piety.* However, American adolescents scored higher than the Chinese adolescents on the measure of *family recognition through achievement,* after reverse-coding the question. Finally, there was no difference between

the Chinese and American adolescents on *conformity to norms*. In terms of the average measure of *cultural interdependence,* which included all 6 questions, the Chinese adolescents scored significantly higher on Asian Values (M =.84, SD = .49) than the American adolescents (M =.50, SD = .63, t (474) = 6.49, $p < .001$).

Table 3-1
Means, standard deviations, and differences in cultural interdependence between the American and Chinese adolescents

	Chinese		American		
Sub-Scale	*M* (*SD*)	*n*	*M* (*SD*)	*n*	Inference Test
Conformity to Norms	.59 (1.17)	237	.68 (1.08)	257	$t(492) = -.97$
Family Recognition through Achievement	-.19 (1.39)	237	.23 (1.47)	238	$t(493) = 3.31$*
Emotional Self-Control	1.33 (1.01)	237	.74 (1.17)	249	$t(484) = 5.98$**
Collectivism	.71 (1.21)	235	.15 (1.28)	248	$t(481) = 4.87$**
Humility	1.05 (1.08)	237	.29 (1.19)	248	$t(483) = 7.28$**
Filial Piety	1.53 (.89)	236	1.00 (1.15)	251	$t(485) = 5.64$**
Average	.84 (.49)	234	.50 (.63)	242	$t(474) = 6.49$**

Note. *$p < .01$, ** $p < .001$.

Independent samples *t*-tests indicated no significant difference in the overall mean agreement to the Asian Values Scale between males (M = .64, SD = .55, n = 207) and females (M = .70, SD = .57, n = 260); both reported similar levels of agreement. An examination of individual questions revealed that there were no significant differences by *gender* for any of the questions, but there was a trend for females (M = 1.35, SD = 1.05, n = 267) to more strongly agree than males (M = 1.16, SD = 1.05, n = 211) to the question about filial piety, $t(476) = 1.94$, $p = .05$. A linear regression analyses indicated that *age*

did not significantly predict *cultural interdependence,* or responding for any of the individual questions.

Interestingly, cultural differences in participants' scores on *cultural interdependence* did not translate into predictable differences in adolescents' perceptions of their *academic* and *social choice*. There were no differences in the Chinese (M =.56, SD = .55, n = 237) and American (M =.51, SD =.66, n = 259) adolescents' perceptions about the extent to which they make academic choices independent of their parents. Both groups of adolescents' mean scores reflected a stance that they made academic choices together with their parents (0) or that they made academic choices independent of their parents (+1); mean scores were somewhat between these two choices.

With regard to social choices, the Chinese adolescents perceived they made their social choices more independently from their parents (M = .75, SD = .51, n = 237) than the American adolescents (M = .51, SD = .67, n = 258; $t(493) = 3.65$, $p < .001$). This difference may be driven by the difference in the living situations of the Chinese and American adolescents. The Chinese students lived in dormitories and many only visited their families during holidays, whereas 88% of the American participants who reported the specifics of their living situation lived full-time with at least one member of their family. This difference would likely lead directly to reported differences. Although the Chinese participants reported their parents had some say in their non-regulated "compulsory" school attendance and thus academic life, the physical distance between Chinese adolescents and their parents likely has a direct influence on the ability of parents to exert control or influence in the social decisions made by adolescents.

Independent samples *t*-tests indicated that there were no differences in perception of *academic choice* between the male (M = .53, SD = .64, n = 216) and the female (M = .53, SD = .59, n = 270) adolescents. There were also no differences between the male (M = .64, SD = .61, n = 214) and female (M = .65, SD = .61, n = 271) adolescents in the perception of *social choice*. Furthermore, two independent linear regression analyses indicated that *age* did not significantly predict *academic* or *social choice.*

Epistemological Stance

Participants were given two scenarios to examine epistemological stances: *universe* and *species*. Each will be discussed in turn.

Universe. A paired samples *t*-test indicated that the Chinese participants had higher *scientific agreement* (M = .74, SD = .87) than *religious agreement* (M = -.08, SD = 1.18, $t(234) = 7.75$, $p < .001$). Despite this preference, about half of the adolescents suggested that these perspectives could be reconciled (48.3%, n = 115) with the remaining participants suggesting they could not be reconciled (47.5%, n =113) or declining to answer (4.2%, n =10).

Conversely, a paired samples *t*-test indicated that the American participants had higher *religious agreement* (M = .41, SD = 1.06) than *scientific agreement* (M = -.18, SD = 1.09, $t(240) = 4.95$, $p < .001$). Similar to the Chinese adolescents, however, about half of the American participants suggested these perspectives could be reconciled (48.0%, n =133), with the remaining participants suggesting they could not be reconciled (28.9%, n =80) or declining to answer (23.1%, n = 64).

Chi-square analyses examining the number of Chinese and American adolescents holding one of the three stances indicated a significant relationship between *culture* and *epistemological stance*, χ^2 (2) = 35.84, $p < .001$, $\phi = .28$. To determine the specifics of these differences, chi-square analyses were conducted to compare difference between the Chinese and the American adolescents within each of the epistemological stances. Although the number of Chinese adolescents holding an absolutist stance ($n = 34$) was not significantly different from the number of Americans ($n = 48$) holding the same stance, the American adolescents held a multiplist stance ($n = 118$) more frequently than the Chinese adolescents ($n = 80$, χ^2 (1) = 7.29, $p < .01$). Conversely, the Chinese adolescents endorsed an evaluativist stance ($n = 115$) more frequently than the American adolescents ($n = 49$, χ^2 (1) = 26.56, $p < .001$).

Epistemological stance also differed by *gender*. A 2 (*gender*) x 3 (*universe epistemological stance*) chi-square analysis indicated a significant relation between these variables, χ^2 (2) = 8.93, $p < .05$, $\phi = .14$. Of the males, 21.9% ($n = 42$) responded with an absolutist response, 48.4% ($n = 93$) with a multiplist response, and the remaining 29.7% ($n = 57$) with an evaluativist response. The females, conversely, were more likely to provide an evaluativist response (43.3%, $n = 107$), with 15.8% ($n = 39$) of the females giving an absolutist response, and 40.9% ($n = 101$) providing a multiplist response. Chi-square analyses were conducted within each of these stances to examine the location of the significant differences between the genders. These results suggested that there were no differences in the frequency with which males and females selected an absolutist or a multiplist stance; there was, however, a significant difference in the selection of the

evaluativist response, χ^2 (1) = 15.24, $p < .001$, with females selecting this option more often than males. A linear regression analysis indicated that *age* was not a significant predictor of *universe epistemological stance.*

Species. A paired samples *t*-test indicated the Chinese participants had significantly higher *scientific agreement* (*M* = 1.12, *SD* = .77) than *religious agreement* (*M* = -.55, *SD* = 1.10, *t*(231) = 16.83, $p < .001$). However, just under half of the adolescents suggested that these perspectives could be reconciled (37.8%, *n* = 90) with the remaining participants suggesting they could not be reconciled (52.5%, *n* =125) or declining to answer (9.7%, *n* = 23). A paired samples *t*-test indicated no significant difference between the American participants' mean *scientific agreement* (*M* = .22, *SD* = 1.08) and *religious agreement* (*M* = .11, *SD* = 1.07). Similar to the Chinese adolescents, just under half of the American participants suggested these perspectives could be reconciled (39.4%, *n* =109), with the remaining participants suggesting they could not be reconciled (30.3%, *n* = 84) or declining to answer (30.3%, *n* = 84).

Similar to the universe scenario, despite the differences in the content of endorsement of perspectives between the Chinese and American adolescents, it is still possible to examine *epistemological stance* which is theoretically independent from content. A chi-square analysis examining the number of Chinese and American adolescents holding one of the three stances indicated a significant relationship between *cultural membership* and *species epistemological stance*, χ^2 (2) = 18.89, $p < .001$, $\phi = .21$. To determine the specifics of these differences, chi-square analyses were conducted to compare differences between the Chinese and the American adolescents within each of

the epistemological stances. Similar to the *universe* scenario, although the number of Chinese adolescents holding an absolutist stance (n = 59) was not significantly different from the number of Americans (n = 63) holding the same stance, the American adolescents held a multiplist stance (n = 106) more frequently than the Chinese adolescents (n = 73, χ^2 (1) = 6.08, $p < .05$). Conversely, the Chinese adolescents endorsed an evaluativist stance (n =94) more frequently than the American adolescents (n = 51, χ^2 (1) = 12.75, $p < .001$).

As with the *universe* scenario, a 2 (*gender*) x 3 (*species epistemological stance*) chi-square analysis indicated a significant relationship between these two variables, χ^2 (2) = 16.06, $p < .001$, $\phi = .19$. When asked to reason about opinions on the origin of species, 36.5% (n = 70) of the males gave an absolutist response, 38.0% (n = 73) gave a multiplist response, and 25.5% (n = 49) gave an evaluativist response. Conversely, more females tended toward more sophisticated stances. Of the females, 20.2% (n = 50) provided absolutist responses, 41.9% (n = 104) provided multiplist responses, and 37.9% (n = 94) gave evaluativist responses. Chi-square analyses conducted to examine differences in the selection of an epistemological stance between the genders indicated a trend toward a difference in the selection of the absolutist response, χ^2 (1) = 3.33, $p = .07$; males tended to select this response more than females. Additionally, there were significant differences in the selection of the multiplist, χ^2 (1) = 5.43, $p < .05$, and the evaluativist responses, χ^2 (1) = 14.16, $p < .001$, with females being more likely to select both of these responses compared to the males. A linear regression analysis indicated that *age* did not significantly predict *epistemological stance.*

Scenario comparison. The differences between the Chinese and the American adolescents for the two scenarios tended to be in the same direction. In both scenarios, Chinese adolescents tended to favor the *scientific perspective* over the *religious perspective* whereas American adolescents tended to favor the *religious perspective* over the *scientific perspective*. Moreover, in both scenarios, Chinese adolescents tended to endorse an evaluativist epistemological stance more than American adolescents; whereas American adolescents tended to endorse a multiplist epistemological stance more than Chinese adolescents.

55.9% (n = 133) of the Chinese and 49.1% (n = 136) of the American adolescents were consistent in their level of epistemological reasoning across the two scenarios. That is, about half of the adolescents who endorsed an *epistemological stance* in the *universe* scenario were likely to endorse that same stance in the *species* scenario. Of the participants who were not consistent in their epistemological stances across the two scenarios, the majority were only one-step changes (absolutist-multiplist or multiplist-evaluativist, in either direction) with this pattern describing 27.7% of the Chinese participants (n =66) and 22.1% of the American participants (n =61). Very few participants reasoned at an absolutist stance in one scenario and at an evaluativist stance in the other, with only 10.1% of the Chinese participants fitting this profile (n = 24) and only 4.4% of the American participants (n =12). There was not a significant difference in the frequency of changes in epistemological stances between the Chinese and the American participants. This type of comparison was not possible for 6.3% of the Chinese

participants (n = 15) and 24.5% of the American participants (n = 68) who only responded to questions from one of the two scenarios.

Chi-square analyses were conducted to examine if the *universe* or *species* scenario was more likely to evoke more sophisticated *epistemological stances*. Given the overall differences in epistemological stances between the Chinese and the American adolescents, separate analyses were conducted within the Chinese and the American samples. These analyses suggest significant differences in *epistemological stances* within the Chinese (χ^2 (4) = 63.98, p < .001, ϕ = .54) and American (χ^2 (4) = 85.05, p < .001, ϕ = .64) samples across the two scenarios.

To better understand the direction of these differences, correlational analyses were conducted excluding participants who were consistent in their *epistemological stances* across the two scenarios. In doing so, these correlational analyses would suggest if either scenario is generally associated with a more or less sophisticated stance compared to the other. These analyses suggested the relationship in the *epistemological stances* between the *universe* and the *species* scenarios across cultures was fairly large and negative (r = -.35, p < .001). The same pattern also held separately within the Chinese (r = -.40, p < .001) and within the American (r = -.28, p < .001) samples. In reasoning about the *universe* scenario, participants tended to reason at more sophisticated epistemological levels than when reasoning about the *species* scenario.

This interpretation was further supported by a more specific look at the direction of changes in *epistemological stances* between the two scenarios within each cultural sample (see Table 3-2). The data reported above suggested that of the participants whose

epistemological stances changed across the scenarios, most were one-step changes. This finding, however, did not address the direction of that change (e.g., to a more or a less sophisticated epistemological stance). An examination of the direction of changes in *epistemological stance* within each cultural group indicated that over half of the participants who changed *epistemological stances* between the *universe* and the *species* scenarios changed in a downward direction, toward a less sophisticated stance. This indicated that the *species* scenario, which was always seen second by participants, evoked less sophisticated stances.

Table 3-2
Percentage of participants per direction change in epistemological stances between the two scenarios by culture

Direction of change	Stances	Chinese (*n* =223)	American (*n* = 209)
2-step change (down)	Evaluativist – Absolutist	9.9	3.8
1-step change (down)	Multiplist - Absolutist Evaluativist - Multiplist	16.6	15.8
No Change	No Change	58.7	65.1
1-step change (up)	Absolutist - Multiplist Multiplist – Evaluativist	13.5	13.4
2-step change (up)	Absolutist - Evaluativist	1.3	1.9

Of the 41.3% of Chinese participants who changed epistemological stances, 64.2% of those participants had either a one- or a two-step downward change. Of the 34.9% of American participants who changed epistemological stances, 56.2% had either a one- or a two-step downward change. These differences, considered with the correlational analyses, suggest that overall participants endorsed more sophisticated *epistemological stances* for the *universe* scenario. Changes in *epistemological stance*

from the scenario about the origin of the universe to the scenario about the origin of species were generally changes toward a less sophisticated epistemological stance.

Cognitive Variation

Teleological reasoning. An independent samples *t*-test indicated no mean difference between Chinese (M = 3.11, SD = .95, n = 190) and American (M = 3.10, SD = .86, n = 137) adolescents' *teleological preference-biological kinds*. Both groups, on average, selected a teleological response 3 times across the 4 questions. There was also no difference in *teleological preference-biological kinds* between males (M =3.08, SD = .88, n = 150) and females (M = 3.11, SD = .94, n = 173); both groups tended to prefer teleological explanations. A linear regression analysis indicated *age* was not a significant predictor of *teleological preference-biological kinds.*

There were no cultural differences in the *teleological comparison-biological kinds*; Chinese (M =.49, SD = .83, n = 80) and the American M =.50, SD = .58, n = 50) adolescents tended to favor teleological mechanistic explanations over social teleological explanations. There were also no differences between males and females in *teleological comparison-biological kinds*; males (M = .46, SD = .63, n = 56) and females (M = .51, SD = .83, n = 70) both tended to favor teleological mechanistic responses over teleological social responses. A linear regression analysis indicated that *age* was not a significant predictor of *teleological preference-biological kinds*.

Preference for teleological explanations for biological kinds in both cultural groups was also evident in participants' endorsement of teleology as the *best explanation* for why members of the same species "stay together." Of the Chinese (n = 224) and the

American (n = 181) adolescents who answered the question, the teleological explanation was selected 90.2% of the time for Chinese and 81.2% of the time for American adolescents. Of the Chinese (n = 215) and the American (n = 176) adolescents who answered the question about the *worst explanation* for why members of the same species "stay together," the teleological explanation was the least selected; it was chosen only 14.0% of the time for the Chinese and 26.7% of the time for the American adolescents.

That both Chinese and American adolescents tended to favor functional teleological explanations for the existence and nature of specific anatomical, external parts is consistent with the stance of adults in previous studies (Kelemen, 1999b). However, an examination of the prevalence of *teleological preference-natural kinds* is a more stringent test of promiscuous teleology as using teleology as an explanation for a natural kind is scientifically unjustified and uncommon in adults in modern societies. Independent samples *t*-tests indicated that out of a possible score of 2, Chinese adolescents reported a significantly higher level of *teleological preference-natural kinds* (M = 1.30, SD =.67, n = 199) than American adolescents (M = 1.13, SD = .72, n = 156; $t(353) = 2.26$, $p < .05$). Both groups, however, had mean scores over 1, suggesting that teleological reasoning occurred for both groups, on average, over 50% of the time. Independent samples *t*-tests indicated that there were no differences between males (M = 1.29, SD =.70, n = 157) and females (M = 1.18, SD =.69, n = 192) in their preference for *teleological preference-natural kinds*. A linear regression analysis indicated that *age* was not a significant predictor of *teleological preference-natural kinds.*

An independent samples *t*-test examining the participants who gave exclusively teleological responses suggested that there were no differences in the *teleological comparison-natural kinds* between the Chinese (M = 1.12, SD =.67, n = 83) and the American adolescents (M = 1.08, SD =.79, n = 52). However, as a score of 2 would reflect the complete selection of social teleological responses, these average scores suggested that both groups tended to select at least one social teleological response.

Similar to the *biological kinds,* there were no differences between males and females in *teleological comparison-natural kinds*. Males (M = 1.07, SD = .74, n = 67) and females (M = 1.15, SD = .68, n = 66) both selected, on average, at least one social teleological response. A linear regression analysis indicated that *age* was not a significant predictor of *teleological comparison-natural kinds.*

Psychological essentialism. Psychological essentialism was measured by three sets of questions: *differences in individual species, actual/possible variation,* and preference toward a *localized* or a *distributed view*. When asked if individual members of the same species differ, a small number of Chinese participants (2.1%, n = 5) and a fairly large number of American participants (31.8%, n = 88) did not respond. Of those who provided responses, Chinese adolescents were significantly more willing to agree that individual members of a species differed (95.7%, n = 223) than American adolescents (65.6%, n = 124; χ^2 (1) = 64.69, p < .001, ϕ = -.39). Agreeing with this type of statement is inconsistent with the perspective of psychological essentialism, which holds the assumption that individual members of the same species are *not* different as within-species similarity results from some internal, shared essence. This pattern of

responding suggested the possibility that Chinese adolescents were less reliant on essentialist frameworks than American adolescents. Participants' justifications for their responses are summarized in Table 3-3.

Table 3-3
Percentage of responses coded about why individual members of the same species vary

	Chinese	American
Participants who agreed that members of a species vary		
Genetics, biology, essences	16.5	8.5
Personality, preferences, experiences	47.9	65.9
Phenotypes, physical differences	22.9	12.2
Reference to gender or age	1.6	--
Unable to be coded	27.1	22.0
N	188	82
Participants who did not agree that members of a species vary		
Genetics, biology, essences	14.3	8.1
Personality, preferences, experiences	14.3	29.7
Unable to be coded	85.7	64.9
N	7	37

Note. Percentages are not independent values; an individual could have been given and counted in multiple codes; percentages were calculated based on the *n* for participants' agreement and cultural membership.

Chi-square analyses also indicated that there was a significant relationship between gender and essentialist responding, $\chi^2 (1) = 9.26$, $p < .01$, $\phi = .15$. Males were less likely to agree with the statement that individual members of the species differ (76.2%, $n = 144$) than females (87.6%, $n = 198$). However, a logistic linear regression analysis indicated that *age* was not a significant predictor of whether or not participants thought *individual species differ* or not.

To further examine the possibility that Chinese adolescents may be less essentialist in their thinking than American adolescents, as suggested by *differences individual species,* participants' responses to the question of *actual* and *potential variation* of an external anatomical property within species was examined. An

independent samples *t*-test examining differences in *actual variation* by *culture* confirmed the interpretation that Chinese adolescents were less essentialist in their thinking than American adolescents. Chinese participants had lower mean scores for *actual variation* (M = .83, SD = .85, n =217) than American adolescents (M =1.28, SD = .80, n = 163; $t(378) = 5.14$, $p < .001$). This finding cannot be accounted for by *gender*; an independent samples *t*-test indicated no difference in the *actual variation* scores for males (M = 1.08, SD =.87, n = 172) and females (M = .98, SD = .84, n =203). A linear regression analysis indicated that *age* did not significantly predict *actual variation.*

An independent samples *t*-test indicated that Chinese adolescents also had lower mean *possible variation* scores (M = .48, SD = .70, n =215) than the American adolescents (M = .71, SD = .77, n = 166, n = 166; t (379) = 3.07, $p < .01$). This is consistent with the findings with *actual variation* suggesting that American adolescents were more essentialist in their reasoning than Chinese adolescents. An independent samples *t*-test indicated no difference in *possible variation* by *gender*. Males (M = .62, SD = .75, n = 170) and females (M = .54, SD = .72, n = 205) had similar mean levels of *possible variation.* A linear regression analysis indicated that *age* was not a significant predictor of *possible variation.*

Although *actual* and *possible variation* were highly correlated (r (380) = .35, $p <$ .001), *actual variation* appeared to be a more stringent measure of psychological essentialism than *possible variation.* A dependent samples *t*-test indicated that participants were more essentialist when asked about *actual variation* (M = 1.03, SD = .86, n = 373) than *possible variation* (M = .58, SD = .74; $t(372) = 9.52$, $p < .001$).

One final question to examine is if differences in essentialist responding may be explained by teleological preference. This analysis specifically examines the possibility that those who endorsed more teleological explanations for physical traits (e.g., long necks, soft feathers) may be more essentialist in their reasoning, regardless of overall cultural differences. This question derives from research suggesting that functional, that is, teleological, properties are perceived to be more heritable (Springer & Keil, 1989; Weissman & Kalish, 1999), and heritability is intimately connected with an essentialist framework. Correlational analyses conducted across the cultures suggested no significant correlations between participants' *teleological preference-biological kinds* and their perception about *actual variation* (r = -.04) or *possible variation* (r = -.01), suggesting that differences in the essentialist thinking between the Chinese and American adolescents cannot be accounted for by preference for functional—heritable—explanations of biological parts. Analyses conducted within each sample revealed a similar pattern of non-significant findings. This suggests that teleological and essentialist frameworks are distinct conceptual frameworks.

The final measure of psychological essentialism examines the nature of, or preference for, particular models of or frameworks for essentialist thinking. Paired samples *t*-tests were conducted separately within each cultural group examining the mean agreement to a method reflecting a *localized* or a *distributed view of essences*. These analyses suggest the Chinese adolescents favored a *localized view* (M = -.12, SD =1.21) over a *distributed view* (M = -.54, SD =1.34) of essences, t (212) = 3.45, $p < .01$. The same analysis run for the American participants suggested the opposite pattern of

findings; American adolescents also favored a *distributed view* (M = .18, SD = 1.07) over a *localized view* (M = -.11, SD = 1.10) of essences, $t(167) = 2.38$, $p < .05$. Between culture differences were examined with independent samples *t*-tests. The results indicated that there was no difference between Chinese (M = -.12, SD = 1.21, n = 217) and American (M = -.17, SD = 1.11) adolescents responses for the *localized view* although American adolescents tended to more strongly favor the *distributed view* (M = .16, SD = 1.08, n = 175) than Chinese adolescents (M = -.53, SD =1.34, n = 219; $t(392) = 5.50$, $p < .001$).

When asked if taking *internal samples* was a *good method* to determine what kind of thing something is, Chinese adolescents agreed more strongly (M = .86, SD = 1.05, n = 217) than American adolescents (M = .50, SD = 1.12, n = 170; $t(385) = 3.23$, $p < .01$). That Chinese adolescents agreed more strongly to the method of taking an internal sample is inconsistent with the interpretation from the previous analyses that American adolescents are more essentialist in their thinking than Chinese adolescents. However, these questions are not a direct test of essentialist proclivities, but rather the type of essentialist reasoning individuals are likely to favor.

Across the various measures of essentialist thinking, there is consistent evidence that American adolescents may be more essentialist in their thinking than Chinese adolescents. In further analyses examining Hypotheses 2.1 and 3.1 in Chapter 4, the measures of psychological essentialism from previous research, *actual* and *possible variation* (Shtulman & Schulz, 2008), will be used as the most direct and clear measure of psychological essentialism.

Independent samples *t*-tests were conducted to examine the possibility that males and females may differentially endorse *localized* and *distributed views* of essences. There were no significant differences; males (M = -.15, SD = 1.35, n = 177) endorsed the *distributed view of essences* at equal rates as females (M = -.29, SD = 1.21, n = 211). Males (M = -.17, SD = 1.21, n = 175) and females (M = -.06, SD = 1.12, n = 208) endorsed the *localized view* at equal rates.

A linear regression analysis indicated that *age* was a marginally significant predictor of participants' agreement to a *localized view of essences* (R^2 = .01, β = .09, p = .09). Older adolescents tended to more strongly endorse a localized view than younger adolescents. An additional analysis indicated that *age* was not a significant predictor of participants' agreement to a *distributed view of essences.*

Religious Beliefs

Several aspects of religious belief and attendance were measured, including the types of religious services participants have *ever attended*, if they were *currently attending* a religious service, and, if they were attending, the *frequency of attendance* and with whom they were attending (*attend with*). Percentages of Chinese and American participants' previous attendance (*ever attended*) are in Table 3-4. Although about half of the Chinese participants (54.8%) had reported never attending, 58% of these participants reported having *thought about attending*. Reasons cited for thinking about attending included comments such as "because I want to know about some religious beliefs in the world/learn about rituals in world religious," "because I want to know more/I'm curious," and "because I want to try things I haven't tried before." The 42%

who had never attended a religious service and had not considered attending cited reasons such as "because I believe in science," "because I don't have friends that are religious, nor do I have relatives that have this type of activities," and "because I don't believe in superstition/the existence of gods."

Only 20.0% of the 207 American participants who responded to this question about exposure to religious services reported they had never attended any religious service. Of those who had never attended a religious service and also responded to the question about whether they had *thought about attending*, 81.3% (n = 14) reported not having considered attending a religious service. Reasons cited for not considering attending included "because I'm not that religious," "I don't have time for it," and "it's not my thing." For the 2 participants who reported they had never attended but had thought about attending, they reported not knowing why and "wanting to start." Previous attendance was not different by gender, and age was not a significant predictor.

Table 3-4
Percentages of students with exposure to religious services

Religious Service	Chinese	American
Catholic	3.0	58.0
Protestant	2.6	22.7
Buddhist	35.5	1.9
Islamic	2.6	1.0
Daoist	3.0	.5
Other/Unknown	--	3.9
No exposure	54.8	20.0

Note. 4 Chinese and 8 American participants listed exposure to multiple religions' services and thus contributed to the calculation of multiple percentages.

Table 3-5 summarizes Chinese and American participants' reports about their *current attendance.* Of the 230 Chinese participants who responded to the question about *currently attending* some religious service, the majority (62.6%, n = 144) reported not

currently attending any service. Of the participants who currently attended religious services and reported a frequency of attendance (n = 69), these participants reported attending an average of once a year to several times a year (M = 1.59, SD = .93).

Table 3-5
Percentages of students currently attending religious service

Religious Service	Chinese	American
Catholic	2.2	36.8
Protestant	2.6	14.2
Buddhism	23.9	1.5
Islam	3.1	.5
Daoism	1.8	.5
Other	--	3.5
None	62.6	43.1

Note. 3 Chinese adolescents were counted more than once in the above percentages as they listed multiple religious affiliations they attended.

These data should be interpreted cautiously; the Chinese students lived on campus full-time and had school activities every day of the week. Younger students had Sunday morning off from classes, but by the latter part of the high school years, classes continued Saturday and Sunday mornings as any other day of the week. Thus, the structure of the Chinese students' school schedule was substantially different from that of the American students and did not permit the same type of religious involvement, even if desired by the adolescent. Although the structural differences that are partially responsible for driving this difference are telling of religious exposure as well as cultural religious belief and support, analyses of mean differences in frequency of attendance will not be conducted as it is not possible to tease apart differences in attendance as a function of personal or familial desire from structure of school activities. However, these participants did report that when they attended a religious service, an average of once or twice a year, they

generally attended with a family member, and they never reported attending alone (see Table 3-6).

Of the American participants who responded to the question about *currently attending* some religious service (n =204), about half reported not currently attending any service (43.1%) or attending Catholic religious services (36.8%; see Table 3-5). American participants who currently attended religious services and reported a frequency of attendance (n = 114), reported attending religious services several times a month to once a week (M = 4.32, SD = 1.43). 40.4% of participants who reported currently attending a religious service reported attending with multiple categories of people (e.g., mother and friend, parents and other family; see Table 3-6).

Table 3-6
Percentage of students who attend religious services with others

Category	Chinese	American
Father only	7.1	5.3
Mother only	25.7	16.7
Both Parents	20.0	6.1
Grandparent(s)	4.3	.9
Other Family	20.0	20.2
Friend	7.1	7.9
Multiple categories	15.7	40.4
None	--	2.6

Note. 70 Chinese participants and 114 American participants contributed to the calculation of these percentages.

Currently attending religious services did not differ by gender. A logistic regression indicated that *age* was a marginally significant predictor of *current attendance* (β = -.18, Wald χ^2 = 3.49, p = .06). The odds ratio indicated that younger adolescents were .83 times more likely to currently attend a religious service than older adolescents.

The primary measure of religious belief included in this research is adolescents' *belief in a higher power*. This variable was used to examine Hypothesis 2.1 (see Chapter 4) and 2.2 (below), and as a comparative variable in Hypothesis 3.1 (see Chapter 4). This is the primary measure because adolescents' reports of belief can be compared across the two cultural samples; belief here is not influenced by school structure beyond cultural influences as is the case with measures of religious service attendance. In a test of Hypothesis 2.2, an independent samples *t*-test indicated that, on average, American adolescents were more certain ($M = 1.43$, $SD = .62$, $n = 197$) about the existence of a higher power than the Chinese adolescents ($M = 1.09$, $SD = .75$, $n = 225$; $t(420) = 5.01$, $p < .001$).

That American adolescents were more likely to believe in a higher power than the Chinese adolescents is further understood by considering the frequency counts within each cultural group. Of the Chinese participants who answered this question, nearly one-quarter claimed to not believe in God (24.0%), about half claimed not to be sure (43.1%), and the remaining 32.9% claimed to believe in God. Of the American participants who answered this question, only 6.6% claimed not to believe in God. About an equal number of participants claimed that they were unsure if they believed in a higher power (44.2%) or that they believed in a higher power (49.2%). The mean differences in belief in a higher power between the Chinese and American participants appears to be driven by a higher number of Chinese participants who claimed not to believe in a higher power, compared to the American participants.

An independent samples *t*-test indicated that this difference cannot be accounted for by *gender* as there was no difference in *belief in a higher power* between males (M = 1.25, SD = .72, n = 180) and females (M = 1.24, SD = .71, n = 236) across the cultural samples. A linear regression analysis indicated that *age* was not a significant predictor of *belief in a higher power*.

Beliefs of Others

"Beliefs of others" represents a category of variables (*preferred method, science/religious opinions, science/religious disappointment,* and *overall view of religious explanations*) that were examined for five categories of individuals: self, mother, father, close friends, and teachers. Analyses of the differences by culture are summarized in Table 3-7. American adolescents generally favored religious methods and explanations whereas the Chinese adolescents generally favored scientific methods and explanations. This was true of the adolescents themselves and their perceptions of others.

Differences by *gender* and *age* as a significant predictor were inconsistent across these variables. An independent samples *t*-test indicated that males perceived their teachers to have more positive *overall views* (M = -.78, SD = 1.39) than females (M = -1.17, SD = 1.47, $t(275) = 2.23$, $p < .05$). Table 3-8 summarizes the linear regression analyses in which *age* was a significant predictor.

Table 3-7

Chinese and American adolescents' own beliefs and perceptions of their mothers', fathers', friends', and teachers' beliefs about scientific and religious explanations for the natural world

	Chinese	American	
	M (*SD*)	*M* (*SD*)	Inference Test
Self			
(a) Preferred method for explanations of the natural world	-.59 (.62)	02 (.81)	*t*(280)=7.00***
(b) Opinions of scientific explanations	.68 (.56)	.13 (.65)	*t*(332)=6.68***
(c) Opinions of religious explanations	-.02 (.72)	.19 (.66)	*t*(314)=2.55*
(d) Disappointment felt for use of scientific explanations	.59 (.66)	.17 (.65)	*t*(295)=5.37***
(e) Disappointment felt for use of religious explanations	.06 (.77)	.11 (.69)	*t*(299)=.60
Overall view of religious explanations	-1.18 (1.53)	.02 (1.66)	*t*(281)=6.26***
Mother			
(a) Preferred method for explanations of the natural world	-.23 (.80)	.51 (.61)	*t*(254)=7.67***
(b) Opinions of scientific explanations	.37 (.68)	.03 (.69)	*t*(327)=4.46***
(c) Opinions of religious explanations	.02 (.72)	.35 (.60)	*t*(311)=4.19***
(d) Disappointment felt for use of scientific explanations	-.04 (.68)	.59 (.62)	*t*(303)=8.36***
(e) Disappointment felt for use of religious explanations	.11 (.73)	.27 (.65)	*t*(298)=1.96^{+}
Overall view of religious explanations	-.82 (1.63)	.65 (1.41)	*t*(283)=7.92***
Father			
(a) Preferred method for explanations of the natural world	-.48 (.69)	.41 (.72)	*t*(233)=8.85***
(b) Opinions of scientific explanations	.52 (.61)	-.08 (.66)	*t*(324)=8.47***
(c) Opinions of religious explanations	.03 (.73)	.30 (.65)	*t*(310)=3.35**
(d) Disappointment felt for use of scientific explanations	.02 (.66)	.67 (.54)	*t*(301)=9.38***
(e) Disappointment felt for use of religious explanations	.12 (.75)	.22 (.68)	*t*(298)=1.13
Overall view of religious explanations	-1.04 (1.47)	.61 (1.44)	*t*(282)=9.37***

Table 3-7, Continued	Chinese	American	
	M (*SD*)	*M* (*SD*)	Inference Test
Friend			
(a) Preferred method for explanations of the natural world	-.35 (.75)	.11 (.75)	*t*(238)=4.39***
(b) Opinions of scientific explanations	.50 (.62)	.05 (.57)	*t*(325)=6.68***
(c) Opinions of religious explanations	.00 (.74)	.08 (.81)	*t*(309)=.98
(d) Disappointment felt for use of scientific explanations	.45 (.69)	.10 (.53)	*t*(303)=4.81***
(e) Disappointment felt for use of religious explanations	.07 (.74)	.10 (.58)	*t*(297)=.77
Overall view of religious explanations	-.85 (1.55)	.04 (1.32)	*t*(277)=5.03***
Teacher			
(a) Preferred method for explanations of the natural world	-.82 (.45)	-.39 (.69)	*t*(256)=5.81***
(b) Opinions of scientific explanations	.83 (.39)	.26 (.58)	*t*(325)=6.68***
(c) Opinions of religious explanations	.08 (.81)	.05 (.57)	*t*(310)=.77
(d) Disappointment felt for use of scientific explanations	.69 (.54)	.05 (.57)	*t*(300)=9.21***
(e) Disappointment felt for use of religious explanations	-.06 (.77)	.10 (.57)	*t*(300)=1.98*
Overall view of religious explanations	-1.51 (1.39)	-.16 (1.11)	*t*(281)=8.72***

Note. $^{+}p < .10$, $*p < .05$, $**p < .01$, $***p < .001$. Overall view of higher power is a composite of (b) through (e), with (b) and (d) reverse coded. The number of Chinese participants that answered these questions ranged from $n = 167$ to $n = 193$; the number of American participants that answered these questions ranged from $n = 68$ to $n = 141$.

Table 3-8

Linear regression analyses with age as a significant predictor of "beliefs of others"

Self	R^2	β
Overall view of religious explanations	.02	-.14*
Mother		
Overall view of religious explanations	.02	-.14*
Father		
Preferred method for explanations of the natural world	.02	-.13*
Overall view of religious explanations	.02	-.13*
Friend		
Preferred method for explanations of the natural world	.02	$-.13^{+}$

Note. $^{+}p < .10$, $*p < .05$.

Correlational analyses indicated that participants' responses for *preferred method* of explanations for the origin of the natural world for *themselves*, their *mothers*, *fathers*, *friends*, and *teachers* were highly correlated (see Table 3-9). Furthermore, the *overall views of higher power* for these categories of individuals were also highly correlated (see Table 3-10). Additionally, the correlations between *preferred method* for explanations of the natural world and the category counterpart *overall view of higher power* were all also significant and fairly large (see Table 3-11). Given these large, positive correlations, future analyses will consider exclusively the adolescents' own *preferred method* for explanations of the origin of the natural world as a comparison variable in Hypothesis 2.1 and 3.1; including all of these variables together in an overall model would yield statistically redundant information.

Table 3-9
Correlation between preferred method of explanation for the origin of the natural world for self, mother, father, friend, and teachers

	1. Self	2. Mother	3. Father	4. Friends	5. Teachers
2	.48**	--			
3	.46**	.71**	--		
4	.49**	.39**	.44**	--	
5	.37**	.19*	.36**	.40**	--

**$p < .001$, * $p < .01$.

Table 3-10
Correlations between overall view of religious explanations for self, mother, father, friends, and teachers

	1. Self	2. Mother	3. Father	4. Friends	5. Teachers
2	.50	--			
3	.54	.78	--		
4	.63	.37	.42	--	
5	.56	.39	.44	.63	--

Note. All correlations are significant at the $p < .001$ level.

Table 3-11
Correlation between preferred method of explanation and overall view of religious explanations

	Correlation
Self	.54
Mother	.51
Father	.51
Friends	.37
Teachers	.28

Note. All correlations are significant at the $p < .001$ level.

Despite the high correlation between adolescents' own beliefs and their perception of the beliefs of others, adolescents reported discussing scientific and religious explanations for the natural world with a variety of individuals. The *most/least scientific/religious discussion* variables are summarized in Table 3-12 by culture. It is worth reiterating that the structural constraints in the school in the Chinese system dramatically limited students' opportunities to interact with their parents. Thus, these data are reported for descriptive, not direct comparison, purposes.

Religious and Scientific Stereotypes

Participants considered the typicality of 14 traits for individuals who use primarily scientific or religious explanations. Eleven of these traits were included in the average stereotype variables. The 3 traits that were not included in the composite stereotype variables are considered first: spiritual (vs. secular), religious (vs. irreligious), and someone with whom they would like to be friends (vs. someone they would not want to be friends with).

Table 3-12
Percentage of adolescents who report discussing scientific and religious explanations with others by culture

Most Talk Science	Chinese	American
Family	22.2	23.3
Friend	52.4	13.6
School Teacher	28.6	39.8
Religious Leader	--	--
Other	2.6	23.3
n	189	103
Least Talk Science		
Family	63.8	46.2
Friend	19.5	24.0
School Teacher	12.4	5.8
Religious Leader	--	--
Other	5.4	24.0
n	185	104
Most Talk Religion		
Family	20.4	48.3
Friend	64.7	7.9
School Teacher	11.4	16.9
Religious Leader	--	--
Other	6.6	27.0
n	167	89
Least Talk Religion		
Family	42.8	27.3
Friend	15.6	33.0
School Teacher	31.8	13.6
Religious Leader	--	--
Other	10.4	27.3
n	173	88

Note. These percentages are not independent; participants could contribute to multiple percentages if they listed multiple categories.

Chinese adolescents rated someone who uses primarily scientific explanations as more spiritual (M = .24, SD = .70, n = 157) compared to American adolescents (M = -.10, SD = .71, n = 124; $t(279) = 4.10$, $p < .001$). Chinese adolescents were also more likely to claim that they would want to be friends with this type of person (M = .43, SD = .70, n = 155) than American adolescents (M = .10, SD = .67, n = 123; $t(276) = 4.03$,

p<.001). Interestingly, however, these groups did not differ in their ratings of this type of person as religious; Chinese (M = -.15, SD = .69, n = 149) and American (M = -.14, SD = .69, n = 125) adolescents viewed someone who used scientific explanations as equally religious.

For individuals who were described as using primarily religious explanations, independent samples t-tests indicated that there was no difference between Chinese (M = .21, SD = .70, n = 142) and American (M = .22, SD = .72, n = 125) adolescents in ratings of their spirituality. There was no mean difference in Chinese (M = .22, SD = .75, n = 146) or American (M = .13, SD = .68, n = 123) adolescents rating regarding whether they would want to be friends with someone who used primarily religious explanations for the natural world. However, the American adolescents tended to ascribe religious as a highly descriptive attribute (M = .36, SD = .68, n = 128) at higher mean levels than the Chinese adolescents (M = .16, SD = .74, n = 143; $t(269) = 2.29$, $p < .05$), a result suggesting that explanations about origins may be a more religious issue in an American cultural context compared to a Chinese cultural context.

The mean attribution of these three traits for individuals who use scientific or religious explanations did not differ by *gender*, nor was *age* a significant predictor for in any of the linear regression analyses.

An examination of the 11 traits included in the stereotype variables individually by *culture* suggests that mean differences were primarily found between the positive and negative traits assigned to someone who used primarily scientific explanations; overall, the Chinese adolescents attributed the positive traits at higher mean levels than the

American adolescents. Mean values for these 11 traits used to form the stereotype average variables are in Table 3-13 by culture.

Despite the general pattern of cultural differences, there were only inconsistent differences in these traits by *gender*. Females (M = .39, SD = .67, n = 150) were more likely to believe that those who use primarily scientific explanations were more considerate than males believed them to be (M = .22, SD = .70, n = 124; $t(272) = 2.02$, $p < .05$). Additionally, females tended to be more likely to believe someone who uses religious explanations was funny (M = .31, SD = .71, n = 143) compared to males (M = .14, SD = .73, n = 126; t (267) = 1.95, p = .05). Finally, males (M = .11, SD = .64, n = 125) were marginally more likely than females (M = -.01, SD = .57, n = 135) to perceive individuals who use religious explanations as wealthy, $t(258) = 1.69$, p = .09. A series of linear regression analyses indicated that *age* was only a significant predictor of adolescents perceptions of whether individuals who use scientific explanations were funny; with age, adolescents tended not to believe that those who used scientific explanations were funny (R^2 = .02, β = -.13, $p < .05$).

From these 11 traits the *average scientific stereotype* and the *average religious stereotype* were created. Independent samples *t*-tests indicated that although there were no differences between the Chinese (M = .18, SD = .34, n = 128) and the American (M = .23, SD = .36, n = 113) adolescents on *average religious stereotype*, the Chinese adolescents had significantly higher mean scores on the *average scientific stereotype* (M = .32, SD = .33, n = 138) compared to the American adolescents (M = .15, SD = .33, n = 112; t (248) = 4.07, $p < .001$).

Table 3-13
Mean scores and differences on stereotype traits

	Chinese		American		
	M (*SD*)	*n*	*M* (*SD*)	*n*	Inference Test
Some who uses primarily scientific explanations					
Smart	.52 (.62)	164	.43 (.63)	132	*t*(294) = 1.18
Considerate	.40 (.69)	154	.19 (.69)	123	*t*(275) = 2.50*
Outgoing	.22 (.77)	158	.17 (.69)	126	*t*(282) = .53
Wealthy	-.06 (.60)	152	.14 (.62)	124	*t*(274) = 2.67**
Good Looking	.09 (.60)	149	.07 (.58)	126	*t*(273) = .32
Funny (RC)	.49 (.67)	160	.05 (.69)	129	*t*(287) = 5.46***
Generous (RC)	.41 (.76)	152	.10 (.71)	127	*t*(277) = 3.45**
Trustworthy (RC)	.46 (.68)	153	.28 (.69)	126	*t*(277) = 2.27*
Normal (RC)	.20 (.80)	151	-.02 (.71)	125	*t*(274) = 2.34*
Nice (RC)	.46 (.73)	153	.10 (.69)	126	*t*(277) = 4.25***
Has lots of friends	.25 (.72)	157	.00 (.62)	124	*t*(279) = 3.11**
Average	.32 (.33)	138	.15 (.33)	112	*t*(248) = 4.07***
Some who uses primarily religious explanations					
Smart	.21 (.73)	153	.32 (.68)	127	*t*(278) = 1.34
Considerate	.28 (.70)	151	.27 (.71)	124	*t*(273) = .05
Outgoing	.16 (.71)	151	.20 (.66)	127	*t*(276) = .55
Wealthy	-.02 (.62)	138	.10 (.59)	125	*t*(261) = 1.67
Good Looking	.11 (.58)	138	.13 (.57)	125	*t*(261) = .27
Funny (RC)	.32 (.69)	146	.14 (.75)	126	*t*(270) = 2.05*
Generous (RC)	.28 (.73)	145	.37 (.69)	126	*t*(269) = 1.04
Trustworthy (RC)	.24 (.76)	143	.32 (.72)	126	*t*(267) = .88
Normal (RC)	.14 (.79)	142	.18 (.73)	125	*t*(265) = .46
Nice (RC)	.27 (.69)	143	.31 (.70)	126	*t*(267) = .52
Has lots of friends	.16 (.71)	145	.15 (.66)	126	*t*(269) = .09
Average	.18 (.34)	128	.23 (.36)	113	*t*(239) = 1.13

Note. *$p < .05$, **$p < .01$, ***$p < .001$. Means are on a 3-point scale. A 1indicates a stance that the listed trait is more descriptive of this type of person than the average person, compared to the opposite of the listed trait. A -1 indicates the participant selected the opposite trait as more descriptive of this type or person. (RC) indicates these variables were reverse-coded; participants saw the negative trait in the left-hand column.

Paired samples *t*-tests conducted within each culture support these results. Chinese adolescents had significantly more positive *average scientific stereotypes* (M = .33, SD = .34, n = 117) than *average religious stereotypes* (M = .20, SD = .35; t (116) = 3.25, $p < .01$). Alternatively, American adolescents had significantly more positive

average religious stereotypes (*M* = .24, *SD* = .37, *n* = 101) than *average scientific stereotypes* (*M* = .15, *SD* = .33; *t* (100) = 2.17, *p* < .05.

A similar set of independent samples *t*-test analyses indicated that *average scientific* or *average religious stereotypes* did not significantly differ by *gender* across the two cultural samples. Males (*M* = .23, *SD* = .35, *n* = 113) and females (*M* = .25, *SD* = .34, *n* = 135) had similar *average scientific stereotypes.* Males' (*M* = .21, *SD* = .35, *n* = 118) and females' (*M* = .21, *SD* = .36, *n* = 120) mean *average religious stereotypes* were also not significantly different. Dependent samples *t*-tests conducted within each gender likewise indicated that males did not differ in their *average religious* (*M* = .22, *SD* = .35, *n* = 104) or their *average scientific* (*M* = .24, *SD* = .34) *stereotypes.* Similarly, females did not differ in their *average religious* (*M* = .22, *SD* = .36, *n* = 112) or their *average scientific* (*M* = .26, *SD* = .35) *stereotypes.*

A linear regression indicated that *age* was a marginally significant predictor of participants' *average religious stereotype* (R^2 = .01, β = -.11, *p* = .09) such that across both cultures with age, participants' *average religious stereotypes* became more negative. An additional linear regression indicated that *age* was not a significant predictor of participants' *average scientific stereotypes.*

Chapter Summary

Although the analyses reported above suggested a variety of differences in the variables by cultural group, gender, and age, together they provide a picture about the overall nature of the differences in the measured variables. The differences in the independent variables are examined in Chapter 4 to explore Hypotheses 2.1 and 3.1 in

order to better understand their relationship to creation belief and evolutionary knowledge between and within cultures.

An examination of variation in adolescents' attitudes toward science indicated that across cultures adolescents reported liking science generally, and biology specifically less with age. Although science preference may be related to science exposure, this finding is in the opposite direction as predicted by Hypothesis 3.3. Thus, the influence of age on evolutionary knowledge, which will be examined in Chapter 4, may also be in the opposite direction as predicted by Hypothesis 3.3. Furthermore, although American adolescents tended not to list a science as their favorite or least favorite school subject, about half of the Chinese adolescents tended to list science as either their favorite or their least favorite school subject. These findings provide partial support for Hypothesis 3.2. Finally, females were more likely than males to report a science as their least favorite subject. Thus, the possibility that these differences will translate into reliable differences in creation belief or evolutionary knowledge will be examined in the next chapter.

Chinese adolescents tended to endorse an evaluativist stance, the most sophisticated epistemological stance, more frequently than American adolescents, who tended to endorse the more adolescent-typical multiplist stance. Across cultures this was also found of females, who tended to endorse an evaluativist stance more than males. Despite the role of age, experience, and education in epistemological development, there were no differences in epistemological stances by age for either scenario.

Of particular interest relative to the findings about epistemological stances is the difference between the scenarios. In both cultural groups there was a tendency for more

sophisticated epistemological stances in the scenario in which adolescents were asked to reason about the different opinions concerning the origin of the universe compared to how adolescents reasoned about different opinions for the origin of species specifically. This was true across and within each culture. There is a general belief that creation-evolution debates about origins are restricted to cultures with prevalent religious beliefs (e.g., it is more controversial in America, an actively religious country, than England, a historically religious, non-active religious country). However, the less sophisticated epistemological stances in the scenario about the origin of species suggests that specific arguments about the origin of species evoked less sophisticated reasoning about the nature and value of knowledge and thinking in the culturally non-religious Chinese and the culturally-religious American adolescents.

That China is a less religious culture than America was supported by the data adolescents provided about their religious involvement. Over half of the Chinese adolescents in this sample had never attended a religious service. Of those who had previous exposure to a religious service, most reported having attended some form of a Buddhist religious service. Although just over 60% reported not currently attending religious services, those who did report they currently attended some type of religious service indicated a low level of involvement, attending religious services only once or twice a year. Furthermore, the Chinese educational system is structured such that religious involvement is quite difficult, with students attending school 7 days a week. Only the youngest students had several hours off on Sunday mornings, and all students lived on campus to facilitate their studies and rigorous schedules.

The low religious involvement and educational structure of Chinese adolescents is in stark contrast to the religious involvement and educational structure of American adolescents. 80% of the American adolescents had experienced some type of religious service, primarily Catholic or protestant and about 50% of the Americans reported currently attending a religious service on average, several times a month to once a week. These differences are likely responsible for the overall mean differences in Chinese and American adolescents' reports about their belief in a higher power. The American adolescents were more confident that there was a higher power than the Chinese adolescents, consistent with Hypothesis 2.2.

That Chinese adolescents were, on average, less religiously inclined compared to American adolescents was reflected in the overall ratings of Chinese and American adolescents' reports about their own use of religious or scientific explanations for the origin of the natural world and their overall view of religious explanations. For the adolescents themselves, as well as their perceptions of their mothers, fathers, friends, and teachers, American adolescents had more positive overall views of religious explanations than Chinese adolescents.

These differences, however, were only reflected in differences in stereotypes for individuals who used primarily scientific explanations. Although the cultural groups did not differ in their average religious stereotypes, Chinese adolescents had significantly more positive average scientific stereotypes. Moreover, Chinese adolescents perceived someone who used primarily scientific explanations to be more spiritual and someone they would want to be friends with compared to American adolescents. Conversely,

American adolescents perceived someone who used primarily religious explanations to be more religious than Chinese adolescents. This suggests that issues of religious and scientific explanations for origins may be more closely connected with religious beliefs and institutions in an American culture than in a Chinese culture.

Finally, Chinese and American adolescents had similar levels of teleological preference for biological kinds. However, Chinese adolescents preferred teleological explanations for natural kinds more than American adolescents, although both selected teleological explanations more than what would have been expected from previous research with adults. Specifically, there was a tendency to endorse social teleological explanations for natural kinds more than suggested by previous research.

The cultural differences in tendencies toward psychological essentialism were in the opposite direction; across the various measures of essentialist reasoning Chinese adolescents expressed a more consistent appreciation of within-species variation, a stance contrary to an essentialist framework. That Chinese adolescents were less inclined toward essentialism in their thinking overall than Americans adolescents should, according to previous research, contribute to more sophisticated evolutionary reasoning as a psychological essentialist framework is inconsistent with advanced evolutionary reasoning. This possibility will be examined in tests of Hypothesis 3.2 in the following chapter.

Chapter 4—Results

Predictors of Creation Belief and Evolutionary Knowledge

The results presented in this chapter focus on understanding the predictors of creation belief (Hypotheses 1.1, 2.1, 2.3) and evolutionary knowledge (Hypotheses 1.2, 3.1, 3.3), as well as the relationship between them (Hypotheses 1.3 and 1.4).

Analyses will be reported in three sections: (1) correlational analyses to examine the relationship between creation belief and evolutionary knowledge, and mediation analyses to examine if the influence of culture on creation belief and evolutionary knowledge can be explained. According to Baron and Kenny (1986), three requirements need to be met prior to examining mediation. Thus, the correlation matrix between the 16 variables examined in this chapter[6], the dependent variables, and culture (see Appendix D) was examined to determine whether (1) culture was significantly correlated to the dependent variables, creation belief and evolutionary knowledge, (2) culture was significantly correlated to the potential mediators, and (3) the potential mediators was significantly correlated with the dependent variables. After establishing which variables meet these criteria for mediation, a mediation model was examined in which the variables that were potential mediators between culture and the dependent variable were included in the second step of a regression model after culture. The reported models provide beta weights as well as the percentage change in the beta weight for culture between Model 1,

[6] Gender, age, favorite science, least favorite science, liking of biology, cultural interdependence, species epistemological stance, universe epistemological stance, teleological preference for biological kinds, teleological preference for natural kinds, actual variation, possible variation, belief in a higher power, preferred method, scientific stereotypes, religious stereotypes

without the potential mediators, and the Mediation Model, where culture is included with the potential mediators.

Creation Belief and Evolutionary Knowledge

Correlational analyses were conducted to examine if *creation belief* and *evolutionary knowledge* were statistically related. Including both cultural groups, this analysis indicated that these variables were uncorrelated (r (450) = -.02, p = n.s.).

To directly examine Hypotheses 1.3 and 1.4, these correlational analyses were conducted separately within both cultures. Within the American sample *creation belief* and *evolutionary knowledge* were uncorrelated (r (187) = .05, p = n.s.; Hypothesis 1.3). There was a trend for a small, positive correlation in the Chinese sample (r (233) = .12, p = .06; Hypothesis 1.4). Thus, Hypothesis 1.3 was supported as there was no relationship between these variables in the American adolescents. Hypothesis 1.4, however, was not supported; although there was a relationship between these variables in the Chinese sample, this relationship was not in the predicted direction. Given that there was no significant correlation between *creation belief* and *evolutionary knowledge* between the cultures or within the American sample, and the finding that the correlation in the Chinese sample was small and only marginally significant, the analyses reported below will follow that of previous research. *Creation belief* and *evolutionary knowledge* will be examined and reported separately, as two variables representing conceptually different sub-worlds.

The remainder of this chapter is organized into two general sections: creation belief and evolutionary knowledge. Within each of these sections, analyses of

differences in these variables by culture examine Hypotheses 1.1 and 1.2. The examination of other variables, including gender, age (Hypotheses 2.2 and 3.3), and the other independent variables discussed in the previous chapter (Hypotheses 2.1 and 3.1) were examined. Each set of analyses first examined the influence of the independent variables. Following, cultural group was added to the models to examine the influence of the variables once culture has been included in the model.

The rationale for this analytic method is that if the independent variable was significant without culture in the model but not significant with culture in the model, this suggests that the independent variable serves as a proxy variable for cultural membership; that these variables predicted the same variation in the data. However, if the independent variable remained significant once cultural group was included in the model it suggests that variation in the independent variable is predictive of the outcome beyond between-culture differences. Ultimately these analyses build toward a full model, in which the joint influence of these variables was examined in a step-wise regression model, looking at between- and within-cultural effects.

Creation Belief

Participants were asked to rank 5 explanations for the origin of 9 exemplars. As a descriptive measure, the percentage of individuals choosing each explanation at a rank of 1 to 5 for Chinese and American participants can be found in Appendix E. Not all participants used the ranking system, thus, these incomplete data are reported primarily for descriptive purposes. Participants' responses for the exemplars are discussed in two

groups: the chair (artifact) and the remaining 8 exemplars, which include living and natural kinds.

Artifact: Chair

Before explicitly considering the nature of the creation belief of the adolescents in this sample, it is necessary to examine their reasoning about the origin of the first chair as a check for the comprehension of the question format. The following analyses will examine the extent to which participants provided an artificialist response to the origin of the first chair and whether there were any differences by *culture*, *gender*, or *age* in these responses. The first step in addressing these questions is a chi-square analysis examining if there were significant differences in artificialist and non-artificialist responses to the question asking about the origin of the first chair. This chi-square indicated that, as expected, participants strongly favored artificialist responses (76.4%, $n = 323$) compared to non-artificialist responses (23.6%, $n = 100$; $\chi^2 (1) = 117.56$, $p < .001$).

An examination of the first and the second responses selected as the best explanations can be found in Table 4-1 for the participants who ranked the five responses from best to worse ($n = 276$). These profiles were similar between cultures and are thus displayed across culture. An examination of these data indicated that participants did not have a consistent preference beyond an artificialist response.

A chi-square analysis conducted to examine the relationship between *culture* and the selection of an artificialist response to the origin of the first chair was significant, $\chi^2 (1) = 7.17$, $p < .01$, $\phi = -.13$. 58% ($n = 58$) of the participants who did not select the artificialist response were American and 42% ($n = 42$) of these participants were Chinese.

An additional 2 (artificialist vs. non-artificialist responses) x 2 (*gender*) chi-square analysis indicated a significant relationship between *gender* and the selection of an artificialist response, χ^2 (1) = 5.44, $p < .05$, $\phi = .12$. More males (55.7%, $n = 54$) than females (44.3%, $n = 43$) did select a non-artificialist response. One possibility is that this difference is a function of the proportional variation in *gender* by *culture*, because the Chinese sample had a higher proportion of females compared to males and the American sample had an equal proportion of males and females. Thus, an additional chi-square analysis was conducted to examine this possibility.

Table 4-1
Percentage of participants who selected each response for their first and second choices for the origin of the chair

Response	Selection for "best"	Selection for "second best"
Artificialist	72.5	10.9
Creation	10.1	35.1
Evolution	9.8	19.2
Reincarnation	4.3	5.1
Spontaneous Generation	3.6	29.7

A single categorical code was given to Chinese males, Chinese females, American males and American females so that a 4 (Culture/Gender) x 2 (artificialist vs. non-artificialist response) chi-square could be conducted. Consistent with the previous independent analyses, the chi-square was significant (χ^2 (3) = 9.67, $p < .05$, $\phi = .16$). Bonferroni-adjusted tests of the significant differences between the proportions of each cell relative to the expected counts indicated this difference was driven by a relative overrepresentation of Chinese females in the artificialist response group (82.7%, n =110) compared to their representation in the non-artificialist group (17.3%, $n = 23$; $p < .05$) and a relative overrepresentation of American males in the non-artificialist response

group (35.0%, $n = 35$) compared to their representation in the artificialist response group (65.0%, $n = 65$; $p < .05$). This finding clarifies the nature of the gender and culture differences reported independently above; given that females were more likely to select the artificialist response and that the Chinese sample was heavily female, this chi-square analysis suggested that the gender and culture differences in artificialist responding were highly related.

A logistic regression analysis indicated that *age* did not significantly predict the selection of an artificialist response or some other response to the origin of the first chair.

Summary. Those who selected a non-artificialist response for the origin of the first chair were more frequently American and male. However, the overall finding that artificialist responses were the most common type of response was consistent with the expected findings, suggesting that overall participants understood the questions and the format.

Cultural Differences in Creation Belief: Living and Non-living Natural Kinds

An examination of participants' mean level of creation belief for the 8 individual exemplars in separate independent samples *t*-tests indicated that for each individual exemplar, American adolescents had significantly higher mean levels of creation endorsement than Chinese adolescents (see Table 4-2). The Chinese adolescents were consistently low, with relatively low standard deviations. The American adolescents' mean creation beliefs were, on average, higher than that of the Chinese adolescents; however, the standard deviation of the American sample was generally larger than that of the Chinese adolescents. This suggests that although the American adolescents endorsed

creation more often than the Chinese adolescents, there was less overall consensus within the American sample. The increased variation likely contributed to the low overall mean rates of creation belief in the American sample, but was consistent with the suggestion that an American sample is somewhat divided in terms of creation belief (e.g., Evans, 2001; Evans & Lane, in press).

Table 4-2
Mean creation scores and differences between Chinese and American participants for individual exemplars.

	Chinese		American		
Exemplar	*M* (*SD*)	*N*	*M* (*SD*)	*N*	Inference Test
Fish	.06 (.25)	218	.39 (.49)	196	t (412) = 8.64***
Tree	.10 (.30)	216	.36 (.48)	183	t (397) = 6.56***
Plankton	.04 (.20)	215	.25 (.44)	178	t (397) = 6.33***
Ape	.07 (.26)	218	.40 (.49)	181	t (397) = 8.43***
Rock	.16 (.37)	217	.25 (.43)	176	t (391) = 2.19*
Dog	.07 (.25)	224	.39 (.49)	178	t (400) = 8.65***
Neandertal	.04 (.20)	220	.42 (.49)	171	t (389) = 10.23***
Human being	.06 (.23)	218	.41 (.49)	180	t (396) = 9.49***

Note. *$p < .05$, ***$p < .001$.

Although the mean levels of creation belief for individual exemplars were relatively low in each cultural sample, American adolescents were more likely to endorse creation belief for each individual exemplar than Chinese adolescents, consistent with Hypothesis 1.1. Participants' creation responses for these exemplars were highly correlated (see Table 4-3), consistent with the assumption that beliefs about exemplars' origins measure a similar underlying construct.

An independent samples *t*-test of overall *creation belief* was consistent with these results; American adolescents answered a higher proportion of the questions with creation responses ($M = .34$, $SD = .37$, $n = 217$) than Chinese adolescents ($M = .08$, $SD = .18$, $n = 233$, t (448) = 9.48, $p < .001$).

Table 4-3

Correlations between selection of creation as the best option across exemplars

	1. Fish	2. Tree	3. Plankton	4. Ape	5. Rock	6. Dog	7. Neandertal	8. Human
2	.47	--						
3	.48	.46	--					
4	.46	.51	.51	--				
5	.33	.43	.50	.39	--			
6	.58	.53	.55	.62	.42	--		
7	.51	.45	.49	.51	.33	.64	--	
8	.59	.47	.55	.55	.31	.66	.71	--

Note. All correlations were significant at $p < .001$.

Mediators of Creation Belief

Despite the difference in *creation belief* by *culture*, one of the aims of this research was to explore why these cultural differences exist. Thus, the following analyses examine the possibility that the variables measured may function as mediators of the cultural effect. As discussed at the beginning of this chapter, three requirements must be met before it is possible to consider potential mediators: (1) culture must be correlated with creation belief, (2) culture must be correlated with the potential mediator, and (3) the potential mediator must be correlated with creation belief. Each of these will be discussed in turn; the full correlation matrix is reported in Appendix D.

First, culture was significantly correlated with creation belief (r [450] = .41, $p <$ .001). Second, culture was significantly correlated with multiple potential mediators: gender (r [505] = -.16, $p < .001$), least favorite science (r [470] = -.25, $p < .001$), cultural interdependence (r [476] = -29.41, $p < .001$), species epistemological stance (r [446] = -.14, $p < .01$), universe epistemological stance (r [444] = -.24, $p < .001$), teleological preference for natural kinds (r [355] = -.12, $p < .05$), actual variation (r [380] = .26, $p <$

.001), possible variation (r [381] = .16, p < .01), belief in a higher power (r [422] = .24, p < .001), preferred method of explanation (r [282] = .39, p < .001), and average science stereotype (r [250] = -.25, p < .001).

Of these variables, only 5 were also significantly correlated with creation belief, the third requirement. Specifically, least favorite science (r [414] = -.13, p < .05), cultural interdependence (r [430] = -.11, p < .05), universe epistemological stance (r [413] = -.20, p < .001), belief in a higher power (r [385] = .27, p < .001), and preferred method of explanation (r [268] = .39, p < .001) were significantly correlated with creation belief. Thus, these are the variables that will be considered as potential mediators of the relationship between culture and creation belief.

A two-step regression model was conducted with culture entered first and the potential mediators entered in the second step (see Table 4-4).

Table 4-4
Mediation analyses to explain the relationship between culture and creation belief

	β	%Δβ	R^2	ΔR^2	Overall Model
Model 1			.19***	--	F (1, 213)
Cultural Membership	.43***	--			= 49.21***
Mediation Model			.27***	.08	F (6, 208)
					= 13.09***
Cultural Membership	.31***	38.71			
Least Favorite Science	-.04	--			
Cultural Interdependence	.09	--			
Universe Epistemological Stance	-.14*	--			
Belief in a higher power	.15*	--			
Self Preferred Method	.17*	--			

Note. *p < .05, **p < .01, ***p < .001.

Consistent with the reported correlation analysis, when *culture* was the sole model predictor (Model 1), it was a significant predictor of *creation belief* (R^2 = .19, β = .43, p <

.001). The addition of the 5 potential mediators in the Mediation Model indicated that the requirements for full mediation were not met as *culture* remained significant (β = .31, p <.001). However, there was evidence for partial mediation as *universe epistemological stance* (β = .31, p <.001), *belief in a higher power* (β = .31, p <.001), and *preferred method* (β = .31, p <.001) were also significant predictors of *creation belief.* Furthermore, this model explained significantly more variance (ΔR^2 = .24, p < .05) and the addition of these partial mediators reduced the beta weight value for *culture* by 38.71%. Together, this suggests that although *universe epistemological stance, belief in a higher power,* and *preferred method* do not fully explain the cultural differences in creation belief, these are meaningful aspects of culture in understanding *creation belief.* Additionally, although *belief in a higher power* was a partial mediator between *culture* and *creation belief,* this analysis suggested that it was not the strongest mediator. This finding was contrary to Hypothesis 2.1 which suggested that belief in a higher power would have the largest explanatory value in understanding creation belief.

Summary

An analysis of potential mediators indicated that 5 variables met the criteria established by Baron and Kenny (1986). Of these variables there was evidence for three partial mediators between culture and creation belief: universe epistemological stance, belief in a higher power, self preferred method. Although full mediation could not be established, these variables reduced the beta weight for culture by nearly 40%, suggesting that these three variables explain meaningful aspects of the relationship between cultural

membership and creation belief. The discussion of these findings in Chapter 5 will focus on these partial mediators

Creation Belief Missingness

To examine missingness, a dichotomous variable was created to examine the differences between participants who contributed to the *creation belief proportion* by responding to at least one question (n = 450) and the missing data participants who failed to select a "best" response for the origin of at least one of the eight of the natural and living kind exemplars (n = 65). Analyses were conducted to better understand if these data are missing systematically by examining possible differences between these two groups of participants. The results indicated that the primary difference between participants who had a *creation belief* proportion and those who did not was that the latter were more likely to be American (n = 60) than Chinese (n = 5); there were no other differences that suggested that those who contributed to the *creation belief proportion* and those who did not were systematically different within either sample. The results from these analyses were fully described in Appendix F.

Evolutionary Knowledge

Participants were given 6 questions on evolutionary knowledge, derived from previous research (Shtulman, 2006). Mean differences between the two cultural samples were examined for each individual question; these analyses were summarized in Table 4-5. Differences in the evolutionary knowledge proportion were examined by culture, gender, age, and the independent variables discussed in Chapter 3.

Cultural differences

Using the coding scheme devised by Shtulman (2006; described in Chapter 2 and Appendix C), mean differences by *culture* for each individual question were examined. These analyses indicated two significant differences. For the question about inheritance, *woodpecker,* Chinese adolescents had significantly lower mean scores (M = -.39 SD = .77, n =233) than American adolescents (M = -.22 SD = .56, n =192; $t(423) = 2.58$, $p < .05$). A specific examination of the assigned codes indicated that this difference was not driven by Americans more consistently expressing variational responses (+1). Chi-square analyses indicated that more Chinese than American adolescents provided explanations that were given transformational codes (-1). 70.2% of the participants given a transformational code were Chinese (n = 132) whereas only 29.8% (n = 56) were American, $\chi^2(1) = 30.72$, $p < .001$. However, a higher percentage of American adolescents (67.0%, n =122) were given an ambiguous code compared to the Chinese adolescents (33.0%, n =60; $\chi^2(1) = 21.12$, $p < .001$). These differences were driving the lower mean scores of the Chinese as a specific examination of the variational codes indicated that significantly more Chinese adolescents (74.5%, n =41) were given a variational code compared to the Americans (25.5%, n =14; $\chi^2(1) = 13.26$, $p < .001$).

For the question about adaptation, *moth,* the Chinese adolescents also had significantly lower mean scores (M = -.81 SD = .42, n =188) than the American adolescents (M = -.64 SD = .48, n =61; $t(247) = 2.63$, $p < .01$). As with the *woodpecker* codes, this difference appeared to be driven primarily by more Chinese adolescents responding in a transformational manner than American adolescents. Chi-square

analyses indicated this difference was significant; 79.8% (n =154) of the transformational codes were given to Chinese adolescents compared to only 20.2% (n = 39) of these codes being given to American adolescents, χ^2 (1) = 68.52, p < .001. There were no differences between the number of Chinese (59.3%, n =32) and American (40.7%, n = 22) adolescents given ambiguous codes. Chi-square analyses were not able to be conducted on the variational codes; although only 2 Chinese adolescents were given this code, no American adolescents were.

The higher average scores on evolutionary knowledge for American adolescents was not necessarily evidence that the Americans had more overall variational or sophisticated evolutionary responses, but rather that the Chinese adolescents were more clearly transformational in their evolutionary reasoning. A more direct analysis of the differences in variational responses was conducted with the *evolutionary knowledge* proportion comparisons.

Table 4-5
Mean scores on the evolutionary questions for the Chinese and American adolescents

	Chinese		American		Inference Test
Variable	*M* (*SD*)	*N*	*M* (*SD*)	*N*	
Woodpecker	-.39 (.77)	233	-.22 (.56)	192	*t*(423) = 2.58*
Basketball	-.91 (.37)	233	-.91 (.32)	182	*t*(413) = .07
Moth	-.81 (.42)	188	-.64 (.48)	61	*t*(247) = 2.63**
Common Ancestor	.00 (.15)	226	.01 (.08)	143	*t*(367) = .19
Chimpanzees	-.40 (.70)	224	-.38 (.51)	181	*t*(403) = .33
Bacteria	-.41 (.56)	217	-.33 (.47)	170	*t*(385) = .11
Evolutionary Knowledge proportion	.07 (.13)	237	.02 (.08)	214	*t*(449) = 4.79***

Note. *p < .05, **p < .01, ***p < .001.

The scores of the individual questions were not highly correlated (see Table 4-6). However, unlike the creation belief questions, which were believed to measure a similar

construct across exemplars, each question measures a slightly different aspect of evolutionary knowledge. Thus, a combined proportion score was still appropriate to create, as described in Chapter 2.

Table 4-6

Correlations between evolutionary knowledge measures

	1. Woodpecker (inheritance)	2. Basketball (adaptation)	3. Moth (variation)	4. Common Ancestor (speciation)	5. Chimpanzees (speciation)	6. Bacteria (extinction)
2	.14**	--				
3	.00	-.04	--			
4	.05	-.01	-.08	--		
5	.11*	.13*	-.05	-.01	--	
6	.05	.08	.09	-.01	.16**	--

Note. *$p < .05$, **$p < .01$.

Independent samples *t*-tests indicated that Chinese adolescents demonstrated significantly more *evolutionary knowledge* than American adolescents. Chinese adolescents answered a significantly higher proportion of questions at a variational level ($M = .07$, $SD = .13$, $n = 237$) than American adolescents ($M = .02$, $SD = .08$, $n = 214$; $t(449) = 4.79$, $p < .001$).

Mediators of Evolutionary Knowledge

Additional analyses presented in this chapter were conducted in a similar fashion as reported with *creation belief*. One of the aims of this research was to explain why the cultural differences in *evolutionary knowledge* exist. Thus, the following analyses examine the possibility that the variables measured may function as mediators of the cultural effect. The three requirements outlined above for establishing mediation are also examined here: (1) culture must be correlated with evolutionary knowledge, (2) culture must be correlated with the potential mediator, and (3) the potential mediator must be

correlated with evolutionary knowledge (Baron & Kenny, 1986). Each of these will be discussed in turn; the full correlation matrix is reported in Appendix D.

First, culture was significantly correlated with evolutionary knowledge (r [451] = -.22, $p < .001$). Second, culture was significantly correlated with multiple potential mediators, as outlined on pages 132-133. Of these variables, only 2 were also significantly correlated with evolutionary knowledge, the third requirement. Specifically, the two measures of psychological essentialism, actual variation (r [376] = -.12, $p < .05$) and possible variation (r [377] = -.16, $p < .01$) were significantly correlated with evolutionary knowledge. Thus, only these two variables will be considered as potential mediators of the relationship between culture and evolutionary knowledge.

A two-step regression model was conducted with culture entered first and the potential mediators entered in the second step (see Table 4-4).

Table 4-7
Mediation analyses to explain the relationship between culture and evolutionary knowledge

	β	%Δβ	R^2	ΔR^2	Overall Model
Model 1			.05***	--	F (1, 367) = 18.05***
Cultural Membership	-.22***	--			
Mediation Model			.07*	.02	F (3, 365) = 8.29***
Cultural Membership	.19***	15.79			
Actual Variation	-.04	--			
Possible Variation	.12*	--			

Note. *$p < .05$, **$p < .01$, ***$p < .001$.

Consistent with the reported correlation analysis, when *culture* was the sole model predictor (Model 1), it was a significant predictor of *evolutionary knowledge* (R^2 = .05, β = -.22, $p < .001$). The addition of the 2 potential mediators in the Mediation Model

indicated that the requirements for full mediation were not met as *culture* remained significant ($\beta = .19$, $p < .001$). However, there was evidence for partial mediation as *possible variation* ($\beta = .12$, $p < .05$) was a significant predictor of *evolutionary knowledge.* Although the Mediation Model explained only a small amount of additional variance ($\Delta R^2 = .02$, $p < .05$) the addition of these partial mediators reduced the beta weight value for *culture* by 15.79%. This suggests that although *possible variation* does not fully explain the cultural differences in evolutionary knowledge, it is one aspect of culture in understanding *evolutionary knowledge.* However, this also suggests that there is the influence of culture on evolutionary knowledge requires additional exploration and explanation. Finally, these results are contrary to Hypothesis 3.1 and 3.3; neither *age* nor science preference were significant predictors of *evolutionary knowledge.*

Summary

An analysis of potential mediators indicated that two variables met the criteria established by Baron and Kenny (1986). Of these variables there was evidence for one partial mediator between culture and evolutionary knowledge, participants' denial that within species variation is possible. Although full mediation could not be established, the partial mediation of culture by possible variation reduced the beta weight for culture by about 15%. This suggests that psychological essentialism, as measured by possible variation, explained a meaningful aspect of the relationship between cultural membership and evolutionary knowledge. However, this also suggests that there is considerably more explanation required to understand the relationship between culture and evolutionary knowledge.

Evolutionary Knowledge Missingness

Before proceeding to a discussion of these results, it was necessary to examine if participants who contributed data to the creation of the *evolutionary knowledge* proportions differed in systematic ways from participants who did not. To examine patterns of missingness, a dichotomous variable was created to examine the differences between the participants who contributed to the proportions by responding to at least one question (n = 450) and the missing data participants who skipped the entire section (n = 65). Analyses examined possible differences between these two groups of participants to better understand if these data are missing systematically.

The primary difference between these participants, consistent with the missing data analysis for the *creation belief* proportions, was that the participants who were missing data were more likely to be American (n = 64) than Chinese (n = 1). The additional differences between these participants were all in the same direction as the between-cultural differences described in Chapter 3; thus cultural differences in missingness likely account for the differences between these participants more generally. These analyses suggested that those who contributed to the proportions and those who did not were not systematically different within either cultural sample. The results from these analyses are fully described in Appendix G.

Chapter Summary

Three main findings emerged from these analyses. First, consistent with previous research, there was not a significant correlation between measures of creation belief and evolutionary knowledge. Although there was a marginally significant positive

correlation within the Chinese sample, this finding should be interpreted cautiously because the size of this correlation was small. These findings were consistent with Hypothesis 1.3 but not Hypothesis 1.4.

Second, American adolescents were more creationist than their Chinese counterparts, as predicted in Hypothesis 1.1. Mediation analyses indicated that the relationship between culture and creation belief was partially explained by epistemology, belief in a higher power, and preferred methods for explaining the origin of the natural world. These results did not support Hypothesis 2.1 as belief in a higher power did not explain the most variation in the relationship between culture and creation belief. Hypothesis 2.3 was supported; creation belief was not significantly correlated with age.

Third, evolutionary knowledge was more pronounced in Chinese adolescents than American adolescents; the Chinese adolescents provided a higher proportion of variational responses than their American counterparts. This was consistent with Hypothesis 1.2. Mediation analyses indicated that the relationship between culture and evolutionary knowledge was partially explained by measures of psychological essentialism that examined participants' perceptions of the possibility of within species variation. Although this reduced the relative magnitude of culture in the model by about 15%, additional research will be necessary to explain the variation between culture and evolutionary knowledge. Hypotheses 3.1 and 3.3 were not supported as neither science preference nor age were significantly related to evolutionary knowledge.

Chapter 5—Discussion

The purpose of this research was to examine the factors that contributed to adolescents' beliefs about the origin of species and their understanding of evolutionary theory. Previous research has focused primarily on Western samples with children. The current research recruited Chinese and American adolescent samples to examine how beliefs and knowledge vary between these cultures and to explain why these cultural differences exist. Three research questions were examined: how creation belief and evolutionary knowledge were related, the factors that predicted creation belief, and the factors that predicted evolutionary knowledge. Ten specific hypotheses were tested; the results of these analyses are discussed below.

The first research question examined cultural differences in creation belief, evolutionary knowledge, and the relationship between these variables. As hypothesized, American adolescents endorsed creation belief at higher mean levels than Chinese adolescents (Hypothesis 1.1). Alternatively, Chinese adolescents demonstrated higher mean levels of evolutionary knowledge than American adolescents (Hypothesis 1.2). There was not a significant correlation between creation belief and evolutionary knowledge for American adolescents (Hypothesis 1.3). There was, however, a small, but significant, correlation between these variables for Chinese adolescents. This relationship was in the opposite direction as predicted; Chinese adolescents who had the highest levels of creation belief also tended to evidence the highest levels of evolutionary knowledge (Hypothesis 1.4). This correlation should be interpreted cautiously because it was small. Additionally, an examination of the correlation between evolutionary

knowledge and evolutionary belief, coded in a similar fashion as the creation belief variable, indicated that although Chinese adolescents had high mean levels of evolutionary belief, there was not a significant correlation between their evolutionary belief and evolutionary knowledge.

The direction of the differences in creation belief and evolutionary knowledge are consistent with the rationale for the selection of Chinese and American cultural samples. Differences in religious and scientific input between these two cultures likely are responsible for these differences. These results contribute to an understanding of the underlying processes to the development of beliefs and knowledge. Although previous research has found belief and knowledge to be unrelated (Bishop & Anderson, 1990; Dagher & BouJaoude, 1997; Lawson & Worsnop, 1992; Sinatra, Southerland, McConaughy, & Demastes, 2003), as reviewed in Chapter 1 this research has been conducted primarily in Western samples. However, these data suggest that belief and knowledge were unrelated for Chinese adolescents as well. Despite the variety of factors that differ between Chinese and American adolescents (i.e., Chinese adolescents' higher evolutionary knowledge and lower expression of creation belief, a heightened educational and cultural focus on science, and a decreased influence of religion compared to American adolescents) the expression of belief is independent from the knowledge that supports it.

According to William James' (1890/1983) sub-world hypothesis, individuals may hold conflicting beliefs when these beliefs are located within different sub-worlds. However, this hypothesis fails to explain why origin beliefs and evolutionary knowledge

are also unrelated when evolutionary beliefs are endorsed, as is the case with Chinese adolescents, and should be located within the same scientific sub-world as evolutionary knowledge. This suggests that sub-worlds may not be divided only by content (e.g., scientific, religious). One possibility may be that James' (1890/1983) sub-world describes only one form of cognition. Dual-process models of cognition propose that thinking develops as two independent systems: intuitive (experiential) and analytic cognition (Galotti, 2011). Intuitive cognition is highly efficient and automatic, the result of relying primarily on heuristics and context. Analytic cognition uses effortful, intentional processes to evaluate a problem or situation to arrive at a conclusion. Throughout adolescence, analytic cognition becomes more available, but Galotti (2011) suggests that the preferred use of these various cognitive systems may be an individual difference or a function of the social context.

James' (1890/1983) sub-world hypothesis may describe the cognitive process when thinking is effortful, intentional, and logic-based; sub-worlds may describe the process of approaching information from analytic cognition. However, the results described here, and others like it, may not find a relationship between belief and knowledge not because belief and knowledge are located in different sub-worlds, but because they are supported by different cognitive systems. The reporting of belief may be more accurately described by intuitive cognition. The automatic, heuristic-based reasoning of intuitive cognition is dramatically shaped by prior experiences and assumptions (Berger, 2006); this maps more clearly onto a colloquial understanding of belief—and what "feels right"—than of knowledge.

This distinction between belief and knowledge as it relates to intuitive and analytic cognition may explain how religious (supernatural) and scientific (natural) explanations coexist within individuals (Legare et al., in press). The dual co-existence model proposed by Legare and colleagues (in press) suggests that individuals are flexible in their recruitment and use of apparently conflicting explanations for events, including the origin of species. Part of this flexibility is a function of the social context, although factors that influence the use of intuitive, belief-based thinking or analytic, knowledge-driven thinking may also play an important role. Either way, a dual-process model of cognition may explain how both religious and scientific explanations for an event such as origins or illness may be employed by the same individual, well after brain development has advanced to allow for the integration of multiple and conflicting perspectives (Kagan, 2010).

The use of scientific and religious explanations concurrently is consistent with research in other domains, such as in the case of death, in which both religious and scientific perspectives exist (e.g., Astuti & Harris, 2008; Brent Speece, Lin, Dong, & Yang, 1996; Harris & Giménez, 2005). For example, both Chinese and American children were able to reason about the biological aspects of death by age 6, although into adolescence participants from both cultural samples demonstrated some form of religious explanation for post-death experiences (Brent et al., 1996). Additionally, Harris and Giménez (2005) found that 7- and 11-year-old European children were flexible in their reasoning about death depending on the primed context. Children at both ages reasoned about death from a biological perspective (i.e., the cessation of biological and

psychological processes) when presented a scenario about death that primed biological thinking (Harris & Giménez, 2005). Alternatively, children reasoned about death from a religious perspective (i.e., the continuation of select psychological processes) when presented a scenario about death that primed religious thinking (Harris & Giménez, 2005). Using comparable scenario priming methods, similar results were found with Vezo children between 8- and 17-years-old and adults between 18- and 71-years-old in Madagascar (Astuti & Harris, 2008).

The primary way these results have been interpreted is by suggesting that religious perspectives may be more intuitive, at least in childhood, regardless of religious belief (Bering, 2006). According to some scholars, overcoming the natural proclivities toward and cognitive appeal of belief in an afterlife may require analytic cognitive strategies (e.g., Barrett, 2004). Accepting scientific explanations for phenomena may require overcoming cognitive proclivities (Bloom & Weisberg, 2007; McCauley, 2000). This is consistent with the suggestion that for origin of species, creation beliefs are the natural, intuitive belief (Kelemen, 2004); in order to accept evolutionary explanations for origins creation belief and the cognitive processing that promotes that belief needs to be overcome.

However, the results of the current data suggest that even if creation beliefs are universal in early child development, once evolutionary explanations are accepted (i.e., endorsed as belief) there is not necessarily an equal increase in supporting knowledge. Even within a cultural context that supports scientific belief, this cultural context is not sufficient to support an increase in scientific knowledge. This is consistent with a dual-

process model of cognition. Even if intuitive cognition supports different thinking based on common assumptions and prior beliefs, the knowledge based in analytic, effortful thinking is independent. A more detailed discussion of scientific knowledge will be provided later, as related to research question 3.

That belief and knowledge may be located independently within intuitive and analytic cognition respectively leading to a dissociation between belief and knowledge has been documented outside of scientific knowledge. Barrett and Keil's (1996) concept of theological correctness addresses this point. For example, American religious believers hold beliefs that appear to be somewhat independent of the religious knowledge (e.g., specific theological interpretations and religious texts) that should support their religious beliefs (see also Barrett, 2011).

An examination of the hypotheses under the second research question indicated that American adolescents endorsed belief in a higher power at higher mean levels than Chinese adolescents as hypothesized (Hypothesis 2.2). However, belief in a higher power was not the strongest mediator between culture and creation belief, contrary to Hypothesis 2.1. It was, however, a significant partial mediator and, together with two other partial mediators, reduced the explanatory power of the omnibus culture variable by nearly 40%. This suggests that these variables, including belief in a higher power, are important factors in understanding why cultural differences in creation belief exist. Each of these will be discussed in turn.

Part of the rationale in the selection of an American and a Chinese sample for the current research was that these cultural samples differ in theoretically relevant ways,

including their religious beliefs. Compared to the nationally and culturally non-religious Chinese adolescents (e.g., Central Intelligence Agency, 2009), the high levels of cultural religiosity for American adolescents (Kelemen, 2003) is associated with religious teaching that often includes specific teachings about creation (Giberson, 2010a). However, this kind of interpretation assumes a process explanation; that it is not the belief in a higher power only, but the cultural and religious teaching over the adolescents' development captured by reports of belief in a higher power that is relevant. For such an explanation to be supported, a more specific understanding and explanation of the cultural and cognitive processes that are involved in religious education, adherence, and practice, as well as the development of religious belief more generally are necessary. The current research was unable to examine cultural processes, and this is a limitation of the current research that will be discussed in more detail below.

That individuals' preferred method of explanation was related to creation belief and explained a significant aspect of the effect of culture on creation belief was not surprising. Between-culture differences in preferred method of explanation reported in Chapter 3 indicated that Chinese adolescents nearly ubiquitously reported favoring scientific explanations for origins whereas American adolescents reported a higher variety of responses that tended to favor religious explanations overall.

Part of the initial rationale for the inclusion of the preferred method variable was to examine the possibility that the preferred method and overall views of religious explanations of adolescents' parents, friends, or teachers may differentially influence adolescents' creation beliefs. However, the correlation between individuals' own

preference and their views toward religious explanations and that of those around them were very large and positive. Thus, although this possibility could not be statistically examined, this is indirect evidence consistent with previous research suggesting that parental endorsement (Evans, 2001) and broader cultural factors (Kelemen, 2003) are key in the development of beliefs about the origin of species. This suggests that although preferred method explains a part of why cultural differences in creation belief exist, even this variable warrants considerably more "unpacking" (Whiting, 1975).

The third factor that partially explained the relationship between culture and creation belief was epistemological stance as measured by participants' evaluation of religious and scientific explanations toward the origin of the universe. Less sophisticated stances toward knowledge about the origin of the universe were predictive of increased creation belief; this epistemological stance and the associated increase in creation belief were more common among American adolescents than Chinese adolescents. One explanation is that less sophisticated epistemological stances are more consistent with Christian theology and, in turn, American cultural religiosity (Kelemen, 2003). This kind of religious stance is consistent with creation belief. An absolutist response, measured in this research as the least sophisticated epistemological stance, is consistent with an American Christian perspective in which there is absolute knowledge, as revealed by God. From this perspective, it is the job of humankind to attempt to strip human biases away to fully understand God's perfect and divine revelation (Driscoll & Breshears, 2010; Enns, 2005). This is contrasted with the most sophisticated stance toward knowledge as measured in this research, an evaluativist stance. Such a stance is more

consistent with a scientific approach which implies different assumptions in which knowledge is imperfect, changing, and approximated according to specific empirical measures and assumptions driving the coordination of evidence and theory (Kuhn, 1989). These data suggest that a meaningful aspect of between-culture variation in explaining creation belief is that Chinese adolescents had, overall, more sophisticated epistemological stances toward the origin of the universe.

One of the implications of the finding that only epistemological stance as measured by the universe scenario was correlated with creation belief suggests that although epistemological stance is believed to be domain specific (Buehl & Alexander, 2001; Hofer 2000), origins may not be a cohesive domain. Cognitions about the origin of the universe may be fundamentally different than cognitions about the origin of life. The interpretation that origins as a domain may not be cohesive is consistent with the findings of Sinatra et al.'s (2003) research, which found that epistemological beliefs were negatively related to the acceptance of human evolution but unrelated to the acceptance of the evolution of other species. Participants' epistemological stances measured from these two scenarios were highly correlated; however, these data suggested the scenario about the origins of species evoked significantly less sophisticated epistemological stances in adolescents from both cultural groups. Although debates about origins of species are considered by many to be an American-specific issue, at least compared to other Western countries (Miller et al., 2006), even within the Chinese sample a discussion about the origin of species evoked less sophisticated epistemological reasoning. Regardless of cultural debates about origins, there may be some underlying process or

motivation influencing how individuals approach the question about the origin of life. One possibility is that even if one has accepted an evolutionary stance toward origins generally, as was the case with Chinese adolescents in this research, there may be some unconscious existential or threat-management motivation influencing the way one interacts with these types of conflicting opinions (Giberson, 2010b). This suggests that measures of epistemological reasoning may require more than an explanation of domain and a singularly-scored epistemological stance, especially in scenarios that concern science and religion.

An additional finding concerning epistemology warrants discussion before continuing to a discussion of the third research question. Despite previous research suggesting that age, partially as a proxy for experience, was the most likely candidate to influence epistemology (e.g., Kuhn et al., 2000), the results indicated that age did not influence epistemological stance. That age did not predict epistemology may also account for the finding that age was not significantly correlated with creation belief (Hypothesis 2.3). For American adolescents, late childhood represents the time in which many individuals move away from creation belief (Evans, 2001); and creation belief is uncommon in an Chinese sample from as early as 8 years of age (Smith & Richert, 2011b). Though the pattern with age and epistemology was not expected, these findings suggest that epistemology may not only progress with development, but also with cultural understanding about the relationship between scientific and religious ways of knowing.

One of the tasks of future research is to examine the relationship between epistemological and cultural development. Specifically, research should examine how

cultural processes prime and influence assumed developmental processes about epistemology. Future research should examine whether the process of evidence evaluation in measurements of epistemology about religious material can be philosophically related to the evaluation of empirical, scientific evidence. An examination of this question would look at adolescents' form of reasoning for religious and scientific domains, not the content. As religious content cannot be evaluated similar to material in the natural world, this question would require measurements that include more elaboration of the reasoning process and a coding scheme to examine philosophical points of argument, such as logic, internal consistency, and parsimony. Understanding the process behind the endorsement of the epistemological stances in this research may reveal that the reasoning process underlying a religious response, an absolutist response; understanding this process will allow for an investigation of whether the process of absolutist reasoning is actually less sophisticated than an evaluativist response. It may be that the final outcome of epistemological stance, the only available measurement in this research, may not result from differences in sophistication but rather from orientation.

Additionally, future research should address how epistemology and belief are related, for example, by investigating how priming and social context influences epistemological sophistication and, in turn, origin beliefs. For instance, if religious concepts are primed, will participants more frequently respond to conflicting opinions with absolutist responses? Alternatively, if scientific concepts are primed, will participants more frequently respond to conflicting opinions with evaluativist responses? Finally, if epistemology is context-specific, is the relationship between epistemology and

belief constant? Thus, one of the important questions for future research to address is not whether science and religion are non-overlapping magesteria (Gould, 1997), but how and when the co-existing religious and scientific explanations for the same phenomena are used.

Interestingly, additional variables measuring cognitive variation in teleological preference for natural kinds and psychological essentialism were not significantly correlated with creation belief. These cognitive constraints are empirically related to creation belief in younger samples (Diesendruck & Haber, 2009; Kelemen & DiYanni, 2005) and conceptually related across developmental periods. Although these variables were correlated with culture, the non-significant correlations with the dependent variable did not warrant consideration in the mediation analysis. Despite the high theoretical overlap between teleological and essentialist reasoning and a religious framework in which kinds have a purpose and divinely-given essence (Diesendruck & Haber, 2009), it may be that by adolescence this conceptual overlap is better captured by different measures, such as reported belief in a higher power. Consistent with this interpretation, some of the correlations between these measures of cognitive variation and the partial mediators in the Mediation Model are in the predicted direction. However, this pattern is inconsistent and many of these correlations are close to zero. Therefore, research and theory that places cognition at the center of the development of creation belief in childhood (e.g., Kelemen, 2004; Kelemen & DiYanni, 2005), even if culturally-modified (Diesendruck & Haber, 2009) needs to explore the relationship of cognitive variation to the factors that explain creation belief into adolescence.

Finally, the third research question examined in this study concerned understanding what variables explained, or mediated, the relationship between culture and evolutionary knowledge. The results suggested that Chinese adolescents demonstrated sophisticated evolutionary knowledge, a variational understanding of evolution, at higher mean levels than American adolescents (Hypothesis 1.2). This finding about variational reasoning has two levels of interpretation: standard comparisons and relative differences.

Although the results indicated that Chinese adolescents were more knowledgeable than American adolescents, these relative differences do not suggest that either cultural group performed particularly well. If the performance of either group were compared against a standard measure of success, such as a 70% rate (i.e., a passing grade), the mean scores of both cultural groups would represent failure. Considerably less strict standards would not provide any more optimistic findings as means for both cultural groups were under a 10% rate. Therefore, an investigation of the factors that contribute to evolutionary knowledge and the comparison of the relative differences between the cultural groups should be considered as factors that explain minimal variation in overall low levels of evolutionary knowledge.

Hypothesis 3.1 predicted that the cultural differences evolutionary knowledge would be explained by science exposure. However, as discussed in Chapter 2, it was not possible to directly measure science exposure; Hypothesis 3.1 and 3.2 were thus examined using three measures of science preference. That there was no relationship between these measures of science preference and evolutionary knowledge is interesting,

but reflect a considerable limitation of this research. Although there is sufficient documentation suggesting that evolutionary misconceptions persist after science exposure in Western contexts (Banet & Ayuso, 2003; Bishop & Anderson, 1990; Bizzo, 1994; Lawson & Worsnop, 1992; Sandoval & Morrison, 2003; Settlage, 1994), the possibility that science exposure and training may reduce evolutionary misconceptions in a culture in which scientific explanations are culturally dominant was not able to be tested. This limitation will be discussed in more detail below.

Future research needs to better measure and account for past and current science exposure as it is possible that exposure does translate into understanding when the broader cultural environment, including normative cultural beliefs, supports the content learned. Research should also evaluate the possibility that scientific content and methods for teaching may be sufficiently different cross-culturally accounting for, in part, the relative cultural differences in evolutionary knowledge. Organizations like ASCD (formerly Association for Supervision and Curriculum Design) and the Organisation for the Economic Co-operation and Development attempt to do this, hosting international conferences for excellence in teaching, including teaching in STEM fields.

Measures of science preference indicated that although Chinese adolescents tended to feel more strongly about science than American adolescents, listing it more frequently as a favorite or least favorite subject (indirect test of Hypothesis 3.2), this difference did not result in any reliable differences in evolutionary knowledge. Moreover, Chinese and American adolescents did not differ in their overall liking of

biology compared to other subjects (indirect test of Hypothesis 3.2) and individual variation in liking of biology also did not predict evolutionary knowledge.

Interestingly, age was related to science preference such that younger adolescents tended to more frequently list a science as their favorite subject and they tended to favor biology compared to other subjects more than older adolescents. Although not in the hypothesized direction, this difference did not result in a significant correlation between age and evolutionary knowledge (Hypothesis 3.3). Although participants' amount of science exposure is unknown, the finding that science preference was unrelated to knowledge is consistent with research suggesting that evolutionary misconceptions persist after specific and general biology instruction in high school, college, among medical students, and college graduates (Banet & Ayuso, 2003; Bishop & Anderson, 1990; Bizzo, 1994; Brumby, 1984; Dagher & BouJaoude, 1997; Ferrari & Chi, 1998; Larreamendy-Joerns & Ohlsson, 1995; Lawson & Worsnop, 1992; Sandoval & Morrison, 2003; Settlage, 1994; Shtulman, 2006; Shtulman & Schulz, 2008; Sinatra et al., 2003).

One surprising aspect of this finding came after a comparison of the codes the author gave for the evolutionary questions and the codes of several undergraduate students (not used in the reported analyses). These undergraduate students, many of whom fit the category of not demonstrating a variational knowledge of evolution, gave codes that reflected higher scores on evolutionary knowledge for both Chinese and American adolescents. However, the higher scores were not evenly distributed; the codes from undergraduates boosted mean variational scores for Chinese adolescents considerably more than for American adolescents.

An inspection of the differences in the codes that led to this discrepancy indicated that Chinese adolescents often knew (and used) scientific key terms, which the undergraduates mistakenly interpreted as scientific knowledge. Thus, science preference, either extreme like or dislike, may predict variables such as use of scientific vocabulary without actually predicting knowledge and understanding, as examined in the reported coding and analyses. A revision of the initial undergraduate coding will be conducted to more directly examine this possibility.

The data indicated that of all the variables examined, only the two measures of psychological essentialism examined in Chapter 4 met the requirements for potential mediation. Furthermore, the Mediation Model indicated that only one of these variables, possible variation, was a partial mediator. That is, there was a 15% reduction in the explanatory power of culture once possible variation was included suggesting that possible variation at least partially explained some of the relationship between culture and evolutionary knowledge. Across the various measures of psychological essentialism, Chinese adolescents were consistently less essentialist in their thinking than American adolescents.

The finding that one of the measures of psychological essentialism partially explained the relationship between cultural membership and evolutionary knowledge is consistent with previous research. For example, an appreciation for the possibility of within species-variation, a non-essentialist framework, was related to increased evolutionary knowledge (Shtulman & Schulz, 2008). In the current data, Chinese adolescents expressed an appreciation for this possibility, at least partially explaining

their higher rates of evolutionary knowledge compared to American adolescents; a decreased reliance on essentialist reasoning was predictive of higher rates of evolutionary understanding. In the current research, the reduced reliance on essentialist thinking for Chinese adolescents was the only cultural difference that explained the cultural differences in evolutionary knowledge.

As expected, these measures of psychological essentialism, actual and possible variation, were highly correlated yet they evoked differing levels of essentialist reasoning from participants. Participants were less essentialist when reasoning about possible variation than actual variation; they were more likely to grant that within-species might occur than that it actually did occur. As expected, measures of participants' agreement that within-species variation actually occurred was a more stringent measure of psychological essentialism, evoking stronger essentialist responses from participants. Interestingly, this more stringent measure of psychological essentialism, actual variation, did not mediate the relationship between culture and evolutionary knowledge, only the less stringent measure demonstrated to be a significant partial mediator. These findings do not suggest that the more stringent measures of psychological essentialism was unrelated to evolutionary knowledge as both measures of possible and actual variation were negatively correlated with evolutionary knowledge at significant levels. What these findings suggest is that the adolescents who performed the best on measures of evolutionary knowledge may have thought about evolution at least partially consistent with a psychological essentialist framework as captured by the more stringent actual variation measure. This interpretation is consistent with the overall low levels of

evolutionary knowledge demonstrated within both cultural samples. In a sample with more diversity of evolutionary knowledge, measures of actual variation may have more variation. Increased variability in measures of evolutionary knowledge and actual variation may provide the statistical base necessary to significantly predict evolutionary knowledge from actual variation, a more stringent measure of psychological essentialism.

Interestingly, teleological preference for natural kinds did not meet the criteria for inclusion in the mediation analyses as it was not significantly correlated with evolutionary knowledge. The direction of correlation was, however, in the expected direction. Although teleological preference for natural kinds did not explain between culture variation in evolutionary knowledge, future analyses will examine the possibility that within culture variation in teleology may explain differences in evolutionary knowledge.

That evolutionary knowledge was predicted after controlling for culture only by the less stringent measure of the two measures of psychological essentialism suggests the importance of designing science curriculum to teach science content that can build on or reshape the standard operation of cognitive constraints. The direction of the relationships between culture, teleological reasoning, and evolutionary knowledge also supports this conclusion. This suggestion has been given elsewhere (e.g., Evans, Legare, & Rosengren, 2011; Tare, French, Frazier, Diamond, & Evans, in press). However, two recommendations for curriculum development are worth revisiting here in relation to the current findings about the relationship between basic cognitive constraints and evolutionary knowledge.

First, although cognitive constraints are related to both creation belief in younger participants (e.g., Diesendruck & Haber, 2009; Kelemen & DiYanni, 2005) and evolutionary knowledge (e.g., this data; Shtulman & Schulz, 2008), science curriculum during the adolescent period should focus on knowledge rather than belief. One need not "believe" in common descent to understand the evolutionary processes involved. This is important because understanding evolutionary processes may influence decisions about a wide variety of topics, such as the safety of genetically engineered food and the implications of one's decision of whether or not to vaccinate their child. These decisions may be reached from one's knowledge of evolutionary processes regardless of whether one believes in (e.g., accepts to be true) evolution or creation.

This proposition, that some decisions can be derived from knowledge regardless of belief, assumes that some decisions may be reached primarily based on the assessment of the conflict between specific aspects of knowledge and belief; that analytic cognition can override intuitive cognition when it conflicts with science. For example, in understanding the micro-evolutionary processes involved in genetically modifying food, one may come to the conclusion that it is safe to consume. Even if one believes in creation, the micro-evolutionary processes involved in genetically modifying food do not conflict with most versions of creation . Understanding and applying the principles of microevolution to the problem of whether or not to consume genetically modified food does not violate one's beliefs about creation because microevolution does not speak to the evolution of different species or the timeline of origins.

However, this logic may not accurately describe the nature of decision-making. The logic in this example assumes that the assessment of the direct conflict of relevant knowledge (e.g., micro-evolutionary processes) and belief are the sole determinant of this kind of decision. Yet deeming micro-evolutionary processes, which are part of a larger theory of evolution, and creation belief as compatible may not be the only or the primary information used by individuals in their decisions about problems such as whether or not to consume genetically modified food. Furthermore, according to Francis Collins (2006), this proposition would actually require a misrepresentation of evolutionary knowledge as it denies the arbitrary distinction between macro- and micro-evolutionary processes. Although it may be possible to selectively reason from scientific knowledge regardless of one's beliefs, it is necessary for future research to establish what kinds of problems are approached from one's knowledge, what kinds of problems are approached from one's beliefs, how individual differences in intuitive and analytic cognition influences this process. Understanding these questions are particularly relevant when knowledge and belief conflict.

A second starting point for instruction is directly related to the claim that one need not "believe" in common descent. Within an American context where evolution is highly controversial in the classroom (e.g., Berkman & Plutzer, 2011), the nature of science, what science can and cannot say, an understanding of scientific methods, and how scientific claims are validated, needs to be addressed early and frequently in science education. Future research should extend measures of epistemology to include participants' understanding about what science can and cannot claim, as well as how

those claims are made, supported, and turned from hypotheses into scientific theories. Developing this type of reasoning may be the key to using scientific knowledge that conflicts with beliefs in real-world decisions, such as consuming genetically modified food in the above example. A call toward systematic, educational focus on the nature of science echoes the frustrated call of many scientists who often hear retorts to evolution in the ilk of "it is only a theory."

The educational models in the United States and China are traditionally quite different. However, adolescents from both cultural groups demonstrated a limited ability to grasp evolutionary content. These results reiterate the importance of testing the effectiveness of science curriculum in teaching the intended content and engaging students. These results indicated that cognitive constraints such as psychological essentialism are still operative in adolescence and influence adolescents' ability to learn and accurately describe evolutionary theory.

Future research investigating creation beliefs and evolutionary knowledge can extend this research by using a non-questionnaire format. A survey format may not be able to fully capture the intricacies and nuances of the underlying cultural processes that contribute to the expression of these beliefs and knowledge. Thus, although this research offers a significant and much needed assessment of the between-culture differences and similarities in creation belief, evolutionary understanding, and some of the relevant variables that mediate the relationship between culture and creation belief/evolutionary knowledge, an important next step will be to examine these variables in alternate formats.

One study currently in the planning phases will bring parent-child dyads into a laboratory setting to discuss artwork/storybooks aimed to evoke discussion about religious and scientific topics. Special attention will be given to how parents frame these discussions, especially for artwork/storybooks that could lead to either a scientific or a religious discussion, and how this relates to children's beliefs, natural history knowledge, and expression of essentialism and teleology. Additional research should attempt to include data collected in science classrooms, religious services, as well as from peer discussions and family interactions across developmental periods. Allowing participants the opportunity to reason about issues of religion, science, and epistemology in a verbal format may provide insight into the cognitive process that results in the types of responses collected in a written survey. A multi-layered, multi-method approach will enable not only a better understanding of these phenomena, but also the developmental and cultural processes that underlie them.

Limitations

Four types of limitations of this research will be discussed. These pertain to the method of study, examination of developmental processes, examination of cultural processes especially as they relate to evolution instruction and religion, and coding of creation belief and evolutionary knowledge.

Regarding the method of study, a questionnaire does not allow for assessing thought processes, which was one of the aims of the current study. This method was chosen for two reasons. First, questionnaires make gathering large amounts of data in a relatively short period of time possible. Second, the school administrators in both

locations requested a questionnaire method instead of the more time-consuming one-on-one interviews.

Despite these benefits to a using a questionnaire to gather data, participants' responses to the questions represent a single outcome of the process of thinking; this type of data does not permit an examination of the process by which this outcome was reached (Spector, 1994). For example, participants evaluated conflicting opinions about the origin of species, one religious and one scientific. One option was for participants to choose that both opinions were good but one was better. These participants were judged to have a more advanced understanding of knowledge than those who selected the response that only one could be correct (Kuhn et al., 2000). However, these data cannot address whether the reasoning process behind these selections was different.

Because of this limitation, inferences from the finding that epistemological stance for the origin of the universe mediated the relationship between culture and belief in creation are limited. Chinese adolescents had more sophisticated stances toward knowledge and lower creation belief than American adolescents. If the assumption that measurements of epistemological stance represents differences in the underlying reasoning process is not accurate, these data would require an explanation for why similar processes result in different epistemological stances, how these processes relate to epistemological stance, and how both the process of thinking and epistemological stance are related to reports of creation belief.

In the case of epistemological reasoning, it may be that adolescents who agree that "both opinions are good but one is better" actually have equally sophisticated

reasoning skills as the adolescents who agreed to the less sophisticated stance that "only one opinion can be correct." Differences in the selection of a specific epistemological stance may be based on a difference in a third variable. A likely candidate for this third variable is religious belief. The view that only one opinion is correct is consistent with a belief that knowledge is directly knowable and absolute; this is highly consistent with at least a Christian religious perspective (Driscoll & Breshears, 2010; Enns, 2005). This interpretation is consistent with these data: the more religious American adolescents had less sophisticated views toward knowledge and higher creation belief than the less religious Chinese adolescents. However, because the current data do not examine the thinking behind the selection of an epistemological stance, these data cannot distinguish between this third variable interpretation and the interpretation proposed elsewhere in this chapter. The third variable interpretation would suggest that religious belief promotes the endorsement of specific epistemological stances without influencing the underlying process. An alternate possibility has been suggested elsewhere in this chapter, that less sophisticated epistemological stances represent less sophisticated reasoning about knowledge which results in increased creation belief. Epistemological stance was only one variable in this research that was assumed to represent underlying processes. Future research into this topic should take a process-oriented approach, using non-questionnaire methods such as one-on-one interviews with open-ended questions and observational methods.

The second and third limitations concern the measurement of developmental and cultural processes. These limitations occurred partially as a result of how development,

developmental processes, culture, and cultural processes were operationalized and measured, and reflect the lack of consensus as to how development and culture are best conceptualized, defined, operationalized, and measured (see Cole, 2005 for a summary of some of these different conceptualizations). How the limitations concerning development and culture influence the interpretation of the current data are each discussed in turn.

Related to measuring developmental processes, the current research operationalized development by focusing primarily on age. Although age is a common variable in developmental research, it is used as a proxy for the types of processes Whiting (1975) discussed in relation to the packaged variable problem. Age represents a set of variables, such as experience in school, physical maturation, changes in societal and familial expectations, etc., that may influence the dependent variables in question. The problem is that when age is significantly related to the dependent variable, the researcher cannot identify what about age is responsible for the finding.

In this research, age was not significantly related to creation belief or evolutionary knowledge. The lack of a significant relationship suggests that understanding developmental change in creation belief and evolutionary knowledge may require an examination of additional developmental periods. For example, previous research has documented a shift in beliefs about origins in late childhood such that between the ages of 10 and 12 children were more likely to report beliefs similar to their parents (Evans, 2001). In order to capture an effect of age, it may be necessary to include specific developmental periods of transition, such as the transition between childhood and

adolescence or even the transition between adolescence and young adulthood. The period of adolescence captured in this research, high school students between 14 and 18 years, may be a time during which many adolescents are in foreclosure about their religious beliefs in that they are committed to them without exploration (Kroger, Martinussen, & Marcia, 2010). Kroger and colleagues' (2010) meta-analysis suggested that individuals' were likely to shift from identity foreclosure to identity achievement during the transition from adolescence to adulthood. This transition is often accompanied with moving out of the parents' home, which may promote exploration, specifically with regard to religious belief. This interpretation is consistent with research documenting a notable decline in religious attendance for many young adults, at least in America (e.g., McConnell, 2007).

Besides age, the current research included two measures of epistemological sophistication to examine how developmental processes may influence creation belief and/or evolutionary knowledge. Previous research has suggested a link between age and the development of epistemological reasoning as a result of specific age-related experiences such as formal education and others' talk about mental states such as knowing, believing, and feeling (Kuhn et al., 2000). Furthermore, there is evidence that epistemological reasoning influences beliefs about origins such that less sophisticated views of knowledge are related to the rejection of human evolution (e.g., Sinatra et al., 2003). In the current study, although epistemological stances were unrelated to age, more sophisticated epistemological stances were predictive of lower mean levels of creation

belief. Yet, epistemological stance is not likely to be the only developmental factor influencing creation belief.

Understanding if and how other developmental changes, such as increased responsibility in family/household duties (e.g., Bourdillon, 2011; Munroe, Munroe, & Shimmin, 1984; White & Brinkerhoff, 1981) or the increasing importance of the adolescents' peer group (e.g., Brown & Larson, 2002; Meeus & Deković, 1995), influence creation belief is important in understanding the underlying developmental processes. Measurement of these and other developmental variables with multiple methods may clarify how and why creation belief and evolutionary knowledge change or stay the same across developmental periods. Increased household responsibility may increase adolescents' solidarity with their parents, especially in the elder-directed Chinese cultural context (e.g., filial piety, Kim et al., 1999). This increased harmony may promote consistency in adolescents' beliefs to that of their parents. In this circumstance, creation belief would be related to the developmental process of family cohesion as a function of increased household responsibility.

Alternatively, when paired with the increased importance of adolescents' peer group, increased household responsibility may strain the relationship between adolescents and their parents causing adolescents to look to their peers for acceptable beliefs and activities. Relative to understanding the relationship between adolescents' beliefs and that of their parents and peers, these data suggest high, positive correlations between adolescents' beliefs about how the origin of the natural world should be explained and their perceptions of how their parents and peers explain the origin of the natural world.

However, these data do not allow for examining the accuracy of adolescents' perceptions or why this pattern of correlations exists (e.g., does increased responsibility in the home promote family cohesion, including consistency of beliefs?). Additional research combining the use of self- and other-report, as well as direct observations would be necessary to address these possibilities.

A third limitation of this research is that these data cannot address how cultural processes currently influence or have influenced creation belief and evolutionary knowledge over the course of development. Culture was defined in this research as the patterns of behavior and social interactions that are passed from one generation to the next (Cole, 2005; Gauvain, 2008). Although questions included in the questionnaire asked participants to consider these patterns of interactions (e.g., "How [does your mother] explain the beginning and continuation of the natural world?"), these data reflect adolescents' perceptions of these interactions. Thus, these data cannot address the possibility that adolescents' perceptions are different from what would be discovered in an independent observation of these interactions.

Direct observations and measurements are vital to understanding the process by which adolescents' perceptions are formed and how these perceptions subsequently influence adolescent's own beliefs. The cultural differences in adolescents' own reports and their reports of others' explanations of the origin of the natural world may be related to cultural patterns and differences. Directly observing and measuring how Chinese and American adolescents' parents explain the origin of the natural world in everyday situations may elucidate these patterns. For example, increased conformity to norms and

patterns of filial piety among Chinese adolescents compared to American adolescents (Kim et al., 1999) may promote a higher consistency between adolescents' beliefs and their perceptions of their parents' beliefs, as discussed above. American adolescents may, alternatively, be more willing to express when their beliefs are different from their perception of the beliefs of others with regard to explanations of the origin of the natural world as a result of higher levels of individualism than their Chinese counterparts (Oysermann, Coon, & Kemmelmeir, 2002). Although a questionnaire format can confirm cultural differences in adolescents' perceptions and cultural interdependence, it cannot address the processes by which these differences originated.

There were two additional instances of how these data are limited in examining cultural processes related to exposure to teaching about evolution and religion. First, the questionnaire was not properly designed to explore how cultural differences in instruction about evolution influenced evolutionary knowledge and creation belief for Chinese and American adolescents. Science instruction was hypothesized to explain the largest portion of variance in the relationship between culture and evolutionary knowledge. This hypothesis was based on data suggesting Chinese adolescents have more science education, including biology, than American adolescents (i.e., number of specific science classes and length/frequency of exposure; Asia Society, 2006). However, given the poor wording, participants' responses to questions about previous science exposure were uninterruptable.

Given that these data cannot explore the role of previous biology and evolution instruction, the finding that participants' beliefs that specific traits for members of the

same species could not vary partially mediated the relationship between culture and evolutionary knowledge should be interpreted cautiously. Because the concept of within-species variation is central to an accurate understanding of evolutionary theory, proclivities toward the belief that members of the same species do not vary may have been reduced as a function of increased evolution instruction. Teachers' non-essentialist language, repetition of the existence of within-species variation during instruction, and increased exposure to how the driving force of evolution is random, within-species variation may fully account for the relationship between culture, an appreciation for within-species variation, and evolutionary knowledge. Given that this construct is complex, draws on ideas that many students find challenging (e.g., randomness), and is in some ways counter-intuitive, formal instruction may be critical to its understanding. The current data are limited in that they cannot address whether previous science instruction accounts for these relationships.

An additional piece of cultural variation that was anticipated to explain the relationship between culture and creation belief was religious belief. As with variables of culture and development, defining the supernatural, religion, and religious belief is difficult and highly variable across disciplines and researchers (e.g., Atran & Norenzayan, 2004; Geertz, 2008; Legare et al., in press). The current research operationalized religious belief as belief in a higher power. In these data, belief in a higher power was a partial mediator of the relationship between culture and creation belief. However, belief in a higher power is only one aspect of religious belief; thus, the

influence of belief in a higher power may only explain one part of how religious belief influences creation belief.

These data cannot address the nature of the religious instruction participants received, specifically as related to origins, nor can they address how variation in specific religious practices may relate to variation in creation belief. However, these data indicated that the relationship between culture and creation belief was partially mediated by belief in a higher power. Although this measure was relatively general, that it partially explained some of the relationship between culture and creation belief suggests that religious belief and the cultural processes that support it are necessary to consider in more detail in future research. The current data are limited in their ability to consider the role of religious exposure, instruction, and belief in creation belief.

The final limitation is that the current research analyzed and reported only on two aspects of the measured dependent variables. Beliefs about the origin of species were coded to examine whether participants reported creation as the best of several possible explanations for origins. Evolutionary understanding was coded to examine whether or not participants reported a correct understanding of evolution.

Participants' reported beliefs about the origin of species were coded as the proportion of questions for which creation was selected as the best explanation for origins. This coding allowed for examining the factors that explained cultural differences in participants' preference for a creation explanation over other explanations of origins, specifically how differences between Chinese and American adolescents may explain the relationship between culture and creation belief. However, this method left several

aspects relevant to understanding beliefs about origins unanswered, specifically how religious explanations may coexist with scientific explanations (e.g., Legare et al., in press).

Beliefs about the origin of species are more diverse than whether an individual selects creation as the best explanation or not. Two individuals who selected creation may have had very different models of creation (e.g., a seven-day Genesis creation model versus a theistic evolutionary model), and they may have differed in their flexibility toward other explanations (e.g., creation is not just the best, but the only explanation for origins versus creation being only marginally better than alternate explanations). These data are unable to address the nature of adolescents' creationist models. Research currently being planned will examine adolescents' ranking of creation as the best explanation for origins relative to a reincarnation religious explanation, an evolutionary explanation, and a spontaneous generation explanation that is non-religious and also non-evolutionary.

The coding of participants' evolutionary understanding was also restricted; codes were based on whether or not adolescents demonstrated a sophisticated, accurate understanding of evolutionary theory. This coding provided a means of examining what factors were related to sophisticated reasoning about evolutionary processes. However, the coding limited the possibility of examining the roots of and explanations for misunderstandings about evolutionary processes. Research into conceptual change as related to the development of evolutionary knowledge has suggested that some forms of evolutionary misconceptions may serve as a better starting point for transition toward

evolutionary knowledge more than other misconceptions (e.g., Evans et al., 2011). Future research will examine these data recoded to examine the full range of evolutionary knowledge and categories of misconceptions. Examining evolutionary knowledge and misconceptions together may reveal more marked differences between Chinese and American adolescents. As in the data are reported here, Chinese adolescents had significantly more evolutionary knowledge than American adolescents, yet overall both groups performed quite poorly. Recoding these data to explore evolutionary misconceptions as well as accurate evolutionary knowledge may reveal more significant and meaningful differences between Chinese and American adolescents. Despite adolescents' low levels of evolutionary knowledge, an analysis of types of misconceptions may reveal that Chinese adolescents are conceptually closer to an accurate understanding of evolution compared to American adolescents.

Conclusions

One of the underlying questions of this research and other research like it is whether creation beliefs are a "special" kind of belief. Other researchers have made claims that it may be (Kelemen, 2004), resulting from the way cognitive constraints of psychological essentialism and teleological reasoning promote understanding of the world around us (e.g., Kelemen & DiYanni, 2005). However, the research behind these claims generally fails to account for the role of culture. Furthermore, the role of cognitive constraints in the development and maintenance of these beliefs beyond childhood is not well understood. Addressing these shortcomings is one of the primary strengths of the current research. One of the main findings of the current research is that

part of the between-culture differences in creation belief are the result of between-culture differences in epistemology, religious belief, and explicit measures examining whether participants prefer religious or scientific explanations for origins. Less sophisticated epistemology, higher religious belief, and a preference for religious explanations for origins partially explained why American adolescents were more creationist; compared to Chinese adolescents, American adolescents were more likely to have less sophisticated epistemology, higher religious belief, and a preference for more religious explanations.

The strengths of this research equally apply to the investigation of the development of evolutionary knowledge. Specifically, this research suggested that cultural differences in evolutionary knowledge are at least partially explained by differences in measures of psychological essentialism. Despite the possible influence of a myriad of variables on evolutionary knowledge, such as religious beliefs, science preference, and age, the cognitive constraints that are operative from an early age are the strongest predictors of evolutionary knowledge. Specifically, the participants who struggled to override these constraints performed the worst on measures of evolutionary knowledge. Between-culture differences suggest that Chinese adolescents were, overall, less essentialist in their reasoning.

To summarize, these data offer three key suggestions for future research and theory. First, although the Mediation Models suggest variables that partially explain the relationship between culture and creation belief/evolutionary knowledge, there is considerable work left to be done in delineating the aspects of culture that can be used to understand these variables. Although the cultures and the variables selected for

examination in this research were selected based on their theoretical relevance as is necessary for cultural research, many meaningful aspects of culture were nonetheless excluded (Gauvain et al., 2011). This exclusion was, in part, the direct result of the survey methodology. It will be vital for future research to expand the scope of investigation to consider cultural and developmental processes.

The second suggestion, consistent with the first, is that future research and theory into the development of creation beliefs needs to carefully consider the packaged variable problem (Whiting, 1975). In this data, the three partial mediators of the relationship between culture and creation belief all represent packaged variables; variables that represent many other experiences, including psychological experiences related to religious experience and teaching.

The final suggestion concerns the factors that influenced evolutionary reasoning in these data. Although possible variation partially mediated the relationship between culture and evolutionary knowledge, consistent with previous research, this leaves open the question about what positively predicts evolutionary knowledge. Uncovering this constellation of variables and intervention techniques will prove vital to science educators and science learners alike.

To conclude, the psychological processes contributing to beliefs about and scientific explanations for origins are likely to vary not just across culture, but also across individual people and settings. For some people, at some times, they may be non-overlapping magesteria, for others, they are one in the same, both representing a quest for ultimate truth or understanding. In any of these circumstances, investigating these

important developmental and cultural issues questions with respect and honesty will be the best way to fully understand these phenomena and to better understand the nature of humans' cognition.

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Appendix A
Summary of variable names and coding

Dependent Variables	**Variable coding/creation**	**Survey Location**: *Section.Number*
Demographics		
Cultural group	Chinese (0), American (1)	
Gender	Male (0), Female (1)	1.2
Age	Continuous variable calculated from date of birth and date of survey administration	1.1
Science Preference		Chinese/US survey questions
Favorite Science	Categorical coding from open-ended responses: Non-science (0), Science (1)	1.6/1.9
Least favorite science	Categorical coding from open-ended responses: Non-science (0), Science (1)	1.7/1.10
Liking of biology	5-point scale: -2 (likes biology much less than most other subjects) to +2 (likes biology much more than most other subjects)	1.8/1.11
Cultural interdependence		
Conformity to norms[1]	5-point scale: -2 (strongly disagree) to +2 (strongly agree)	1.16/1.19
Family recognition through achievement[1]	5-point scale: -2 (strongly agree) to +2 (strongly disagree); reverse-coded	1.17/1.20
Emotional self-control[1]	5-point scale: -2 (strongly disagree) to +2 (strongly agree)	1.18/1.21
Collectivism[1]	5-point scale: -2 (strongly disagree) to +2 (strongly agree)	1.19/1.22
Humility[1]	5-point scale: -2 (strongly disagree) to +2 (strongly agree)	1.20/1.23
Filial piety[1]	5-point scale: -2 (strongly disagree) to +2 (strongly agree)	1.21/1.24
Average cultural interdependence[1]	6 questions summed and divided by 6	
Academic choice	3-point scale: -1 (parents make these choices independent of adolescent) to +1 (adolescents make these choices independent of parents)	1.14/1.17
Social choice	3-point scale: -1 (parents make these choices independent of adolescent) to +1 (adolescents make these choices independent of parents)	1.15/1.18

Epistemology		Universe/Species
Religious agreement	5-point scale: -2 (strongly disagree) to +2 (strongly agree)	3.1/3.7
Scientific agreement	5-point scale: -2 (strongly disagree) to +2 (strongly agree)	3.2/3.6
Reconciliation	Categorical: Yes (1) or No (0)	3.3/3.8
Epistemological stance[2]	3-point scale: Absolutist (+1), Multiplist (+2), Evaluativist (+3)	3.5/3.10
Cognition		
Teleological reasoning		
Teleological preference-Biological kinds[3]	Composite: Teleological (social or mechanistic; +1), Natural (+0). Maximum +4, Minimum +0	5.1 + 5.4 + 5.7 + 5.8
Teleological preference-Natural kinds[3]	Composite: Teleological (social or mechanistic; +1), Natural (+0). Maximum +2, Minimum +0	5.5 + 5.8
Teleological comparison-Biological kinds[3]	Composite: Teleological mechanistic (+0), Teleological Social (+1). Maximum +4, Minimum +0.	5.1 + 5.4 + 5.7 + 5.8
Teleological comparison - Natural kinds[3]	Composite: Teleological mechanistic (+0), Teleological Social (+1). Maximum +2, Minimum +0.	5.5 + 5.8
Psychological essentialism		
Differences in individual species	Yes (1) No (0)-nominal. Open-ended justification coding: (1) genetics, biology, internal essences, (2) personality, preferences, experiences, (3) phenotypes, physical differences, (4) gender, age, (5) unable to be coded, species-level differences	2.7a, b
Possible variation[4]	Composite: Maximum +2 (variation is not possible; full-essentialist framework), Minimum +0 (variation is possible, non-essentialist framework)	5.3 + 5.9
Actual variation[4]	Composite: Maximum +2 (variation occurs; full-essentialist framework), Minimum +0 (variation does not occur, non-essentialist framework)	5.2 + 5.8
Localized view of essences[5]	Mean agreement: -2 (strongly disagree) to +2 (strongly agree)	5.14
Distributed view of essences[5]	Mean agreement: -2 (strongly disagree) to +2 (strongly agree)	5.13
Internal sample	Mean agreement: -2 (strongly disagree) to +2 (strongly agree)	5.15

Best "stay together" explanation[6]	Categorical: Essentialist (+1), Teleological (+2), Intentional (+3)	5.6
Worst "stay together" explanation[6]	Categorical: Essentialist (+1), Teleological (+2), Intentional (+3)	5.12
Beliefs of others	Measured for self, mother, father, close friends, teachers	
Preferred method of explanation	Mean agreement: Primarily scientific explanations (-1), Scientific and religious explanations (+0), Primarily religious explanations (+1); Participants who selected "I don't talk to this person about this" were excluded from the analyses. Although participants only saw "explanations of higher power," throughout this paper they are referred to as religious explanations	6.1
Opinions toward scientific explanations	Mean agreement: Mostly negative (-1), Neutral (+0), Mostly positive (+1)	6.2
Opinions toward religious explanations	Mean agreement: Mostly negative (-1), Neutral (+0), Mostly positive (+1)	6.4
Scientific disappointment	Mean agreement: Disappointed (-1), Neutral (+0), Not disappointed (+1)	6.8
Religious disappointment	Mean agreement: Disappointed (-1), Neutral (+0), Not disappointed (+1)	6.9
Overall view of religious explanations	Composite: Sum of *opinions toward scientific explanations* reverse coded), *opinions toward explanations of higher power*, *scientific disappointment* (reverse coded), and *religious disappointment.* Maximum +4 (higher opinion religious explanations than scientific explanations); Minimum -4 (higher opinion scientific explanations than religious explanations). Scores of 0 represent equal opinions of religious and scientific explanations.	
Most scientific talk	Categories coded from open-ended responses: Family (+1), Friend (+2), School teachers (+3), Religious leaders (+4), Other (+5)	6.3
Least scientific talk	Categories coded from open-ended responses: Family (+1), Friend (+2), School teachers (+3), Religious leaders (+4), Other (+5)	6.4
Most religious talk	Categories coded from open-ended responses: Family (+1), Friend (+2), School teachers (+3), Religious leaders (+4), Other (+5)	6.6
Least religious talk	Categories coded from open-ended responses: Family (+1), Friend (+2), School teachers (+3), Religious leaders (+4), Other (+5)	6.7

Stereotype variables		
Average scientific stereotype	Average of composite: 11 traits; +1 (positive attribute), +0 (neither attribute more similar), -1 (negative attribute). Maximum +1, Minimum -1.	6.11
Average religious stereotype	Average of composite: 11 traits; +1 (positive attribute), +0 neither attribute more similar, -1 (negative attribute). Maximum +1, Minimum -1.	6.14
Spiritual, Religious, Want to be Friends with	Selection of these traits were scored as the endorsement of positive traits (+1). Paired opposite endorsement (secular, irreligious, and wouldn't want to be friends with) scored as negative traits (-1). Neither more likely scored as +0.	6.11 (science), 6.14 (religious)
Religious beliefs		
Ever attended	Categorical: Yes (1) No (0)	7.1a
Currently attend	Categorical: Yes (1) No (0)	7.2a
Religious affiliation	Categorical, multiple codes possible: Catholicism (+1), Protestantism (+2), Buddhism (+3), Islam (+4), Daoism (+5), and Other (+6).	7.1b (ever attended); 7.2b (currently attend)
Frequency of attendance	7-point scale: Once a year +1, Once a month +3, Several times a week +6. Participants who responded they have never attended a religious service were coded as never +0.	7.2c
Attend with	If participants reported currently attending, they were given categorical for who they attended with: father (+1), mother (+2), both parents (+3; if father and mother options were both circled), other family member (+4), friend (+5), other (+6), multiple (+7; unless participants only circled mother and father; this was coded as a +3).	7.2d
Thought about attending	Categorical: Yes(+1) no (+0)	7.3a
Belief in a higher power	3-point scale: No -1, Not sure +0, Yes +1.	7.4

Independent Variables		
Creation belief		
Exemplars[7,8]: Fish, chair, tree, plankton, ape, rock, dog, Neandertal (cave man), and human	Ranked explanations were coded for which explanation was the best explanation: Creation (1) Other (0)	2.8-2.16
Creation proportion/creation belief	Number of best-creation responses (1) divided by total number of questions answered (maximum 8, minimum 1)	2.8, 2.10-2.16
Evolutionary knowledge		
Individual questions[9]: woodpecker, basketball, moth, common ancestor, chimpanzees, bacteria	Coding fully described in Appendix C. Variational, +1; Ambiguous, +0; Transformational, -1	4.1-4.6
Variational proportion/evolutionary knowledge	Number of variational codes (+1) divided by total number of questions given a code (maximum 6, minimum 1)	4.1-4.6

Note 1. Differences in the question numbers between the Chinese and American participants in the demographic section (section 1) resulted from the American participants being asked three additional questions to establish generational status.
Note 2. Superscript numbers represent variables created by replicating or adapting questions used in previous research:
1. Kim et al., 1999
2. Kuhn et al., 2000
3. Kelemen 1999
4. Shtulman & Schulz, 2008
5. Newman & Keil, 2008
6. Evans & Poling, 2002
7. Evans, 2001
8. Smith & Richert, 2011b
9. Shtulman, 2006, Shtulman & Schulz, 2008

Appendix B
Full Survey Text Given to American Adolescents

Opinions Survey

This survey will take about 20 minutes to complete. You do not have to participate, this is not a school project. If you choose to complete this survey there are several things that you should know. First, your answers are strictly anonymous and will not be shared with anyone. Please do not write your name on this survey. Second, there are no right or wrong answers. If you don't know how to answer a question, just put what you think or believe. Please answer as honestly as possible. Third, you do not have to answer any question that you do not want to and you may stop participating at any time. Your participation is completely voluntary, and your decision to participate or not will not influence your relationship with your school, or any of your teachers. If you do not want to participate, please continue working on your school work quietly and return this survey. If you decide to participate in this research project, please do so quietly on your own. If you have any questions about the survey, please raise your hand.

Section 1: Please provide us with some information about yourself.

1. What is your date of birth? _____

2. What is your gender? Male Female

3a. What is your ethnicity?
___ African American or Black
___ American Indian or Alaska Native
___ Asian (please specify) _____
___ Caucasian or White, not of Hispanic origin
___ Hispanic (please specify) _____
___ Native Hawaiian or other Pacific Islander
___ Other (please specify) _____

4. Were you born in the United States? Yes No (if no, please answer 4a-4d)
4a. What country were you born in? _____
4b. What city/region and country did you primarily live in or grow up in before coming to the U.S.? City _____ Country _____
4c. How old were you when you came to live in the U.S.? _____
4d. Did you attend school outside of the U.S.? Yes No

5. Was your mother born in the United States? Yes No (if no, please answer 5a-5c)
5a. What country was she born in? _____
5b. What city/region and country did she primarily live in before coming to the U.S.? City _____ Country _____
5c. How old was she when she came to live in the U.S.? _____

6. Was your father born in the United States? Yes No (if no, please answer 6a-6c)

6a. What country was he born in? _____

6b. What city/region and country did he primarily live in before coming to the U.S.?
City _____ Country _____

6c. How old was he when he came to live in the U.S.? _____ years old.

7. Do both of your parents currently live in the house that you live in?

Just my mother lives in the house where I live	Just my father lives in the house where I live	Both of my parents live in the house where I live	We have another living arrangement. Please explain:

8a. Do you have any brothers or sisters? Yes No

8b. If yes, how many? Please list your siblings' ages and genders.

9. What is your favorite school subject? _____

10. What is your least favorite school subject? _____

11. How much do you like the subject of biology compared to all other school subjects?

Less than all other subjects	Less than most other subjects	About the same as most other subjects	More than most other subjects	More than all other subjects

12. How many biology classes have you taken? Please list the total number of classes and the approximate length of each class (in months).

13a. Are you taking a science class right now? Yes No

13b. If yes, what kind of science are you taking? (for example: biology, physics, chemistry, etc.)

14. Do you plan to go to college? Yes No

15. If you were able to go to college, what do you think you would want to study/major in? Please be as specific as you can and list your top three interests for study:

16. What type of job do you want to have as an adult? _____

17. How much choice do you have in your current academic activities (choice of classes, when to complete homework, amount of effort, extracurricular academic activities, etc.)?

My parents make most of these choices independently of what I think	My parents and I make these choices together	I make most of these choices independently of what my parents think

18. How much choice do you have in your current social activities (choice of friends, what you do in your free time, non-academic extracurricular activities, etc.)?

My parents make most of these choices independently of what I think	My parents and I make these choices together	I make most of these choices independently of what my parents think

Please rate how much you agree with the following statements using the following scale.

1	2	3	4	5
Strongly disagree	Disagree somewhat	Neither Agree nor disagree	Agree somewhat	Strongly agree

Statement	**Number**
19. It is important to follow family and societal expectations.	
20. My family would not be ashamed of me if I failed at my occupation.	
21. The ability to control one's emotions is a sign of strength.	
22. Parental love should be understood and not openly expressed.	
23. The needs of others in my group should be put before my needs.	
24. My family should be my main source of trust and dependence.	

Section 2:

1.Who first taught you about evolution?

A family member	A school teacher	Other (please list):

2. How old (in years) were you when you first learned about evolution from a family member?

3. How old were you (in years) when you first learned about evolution from a school teacher?

4. When you learned about evolution for the first time, did it change what you believed about why so many different types of animals live on earth? Yes No

5. When you learned about evolution for the first time, did it change what you believed about how the human species came to be? Yes No

7a. Are individual members of the same species different from one another? Yes No

7b. Why or why not?

8a. Has anyone taught you about creation of the species by a higher power? Yes No

8b. If yes, who first taught you?

A family member	A school teacher	Other (please list):

8c. If yes, how old were you? _____

Sometimes, even when people understand what they are taught they may not believe all of it. Answer the next questions about what you believe about how the following things came to be. Each question provides 5 options. For each question, rank the five explanations from best (1) to worst (5) to explain how the thing came to be.

8. Where did the very first fish on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

9. Where did the very first chair on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

10. Where did the very first tree on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

11. Where did the very first plankton on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

12. Where did the very first ape on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

13. Where did the very first rock on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

14. Where did the very first dog on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

15. Where did the very first Neandertal (cave man) on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

16. Where did the very first human on earth come from?

	It emerged over a very long time from a different kind of thing on earth
	It was something that was reborn as a fish
	It just appeared
	A person made it and put it here on earth
	It was made by a higher power

Section 3: Consider the arguments presented below.
Some days ago Chris and Sam were talking about how they thought the universe came to be. Chris said that some higher power created the universe. Sam said that the universe just appeared and evolved into its current form.

1. Do you agree with Chris's argument that some higher power created the universe?

I am certain Chris is wrong	Chris is probably wrong	I'm not sure	Chris is probably right	I am certain Chris is right

2. Do you agree with Sam's argument that the universe just appeared and evolved into its current form?

I am certain Sam is wrong	Sam is probably wrong	I'm not sure	Sam is probably right	I am certain Sam is right

3. Can Chris and Sam's opinions be reconciled (can they both be right)? Yes No

4. Please explain why you think Chris and Sam's opinions CAN or CANNOT be reconciled:

5. Now consider the disagreement in general. Please choose one of the following judgments about the disagreement between Chris and Sam:

Only one opinion is correct	Each opinion has some good points, and it is impossible to choose between them	Each opinion has some good points, but one has better arguments than the other

Some days ago John and Alex were talking about what they believed about how different species originated. John said that he believed that new species appeared over millions of years as the result of natural selection and evolutionary adaptation. Alex said that he believed that species can evolve and change, but that they cannot become new species by natural processes. He said that all species were at some point created by a higher power.

6. Do you agree with John's argument that new species appeared over millions of years as the result of evolution?

I am certain John is wrong	John is probably wrong	I'm not sure	John is probably right	I am certain John is right

7. Do you agree with Alex's argument that species were created by a higher power and cannot change by natural processes into different species?

I am certain Alex is wrong	Alex is probably wrong	I'm not sure	Alex is probably right	I am certain Alex is right

8. Can John and Alex's opinions be reconciled (can they both be right)? Yes No

9. Please explain why you think John and Alex's opinions CAN or CANNOT be reconciled:

10. Now consider the disagreement in general. Please choose one of the following judgments about the disagreement between John and Alex:

Only one opinion is correct	Each opinion has some good points, and it is impossible to choose between them	Each opinion has some good points, but one has better arguments than the other

Section 4: Please answer the following questions according to what you know to be true of the Darwinian theory of evolution.

1a. A species of woodpecker lives in isolation on a secluded island. These woodpeckers have, on average, a three centimeter beak, and their only food source is a tree-dwelling insect that lives, on average, four-and-a-half centimeters under the tree bark. Compared to its parents, the offspring of any two woodpeckers on the island should develop which of the following features?

A longer beak	A shorter beak	Either a longer beak or a shorter beak; neither feature is more likely

1b. Please explain your answer.

2a. A youth basketball team scores more points per game this season than they did the previous season. Which explanation is an analogy for a Darwinian explanation for the adaptation of species?

Each returning team member grew taller over the summer	Any athlete who participates in a sport for more than one season will improve at that sport	More people tried out for the same number of spots this year	On average, each team member practices harder this season

2b. Please explain your answer.

3. During the 19th century, England underwent an Industrial Revolution that resulted in the unfortunate side effect of covering the English countryside in soot and ash. During this same period of time, the members of England's native moth species became, on average, darker in color. Assuming that darker coloration was adaptive, how might a change in the moths' environment brought about a change in the moths' color?

4. Indicate which of the following organisms share a common ancestor with humans:

Elephants	Lemurs	Lizards	Sparrows	Bees	Jellyfish	Algae	Daffodils	Brontasauruses

5a. As chimpanzees continue to evolve, they will become which of the following?

More similar to modern day humans	Less similar to modern day humans	Either more or less similar to modern day humans; neither outcome is more likely

5b. Please explain your answer.

6a. Compared to the number of living bacteria species, the number of extinct bacteria species is which of the following?

Greater	Smaller	Either greater or smaller; neither situation is more likely

6b.Please explain your answer.

7. Please briefly explain the Darwinian theory of natural selection.

Section 5:

Cryptoclidus were prehistoric aquatic reptile. They spent a lot of time in the water, but some time out of the water too. Cryptoclidus had very long necks and lived in herds. Near where Cryptoclidus lived, there were many very pointy rocks.

1. Why do you think Cryptoclidus had such long necks?

They had long necks because the stuff inside got all stretched out and curved	They had long necks so that they could grab at fish and feed on them	They had long necks so that they could hold up their friends when they got tired swimming	Other (please explain):

2. Do you think all Cryptoclidus have long necks? Yes No

3. Do you think a Cryptoclidus could be born with a short neck? Yes No

4. Why do you think Cryptoclidus' neck swayed from side to side when they moved?

Their necks swayed because of the way their bones fit inside their bodies	Their necks swayed so that they could move quickly through the water	Their necks swayed so they could soothe their children to sleep	Other (please explain):

5. Why do you think the rocks were so pointy near where the Cryptoclidus lived?

They were pointy because little bits of stuff (little rocks, sand, etc.) broke away naturally over a long time	They were pointy so that animals wouldn't sit on them and smash them	They were pointy so that animals like Cryptoclidus could scratch on them when they got itchy	Other (please explain):

6. Of the following, what is the **best** explanation for why so many Cryptoclidus stayed together?

They stay together because they liked each other	They stay together because being together can ensure their safety	They stay together because they have the same things inside their bodies

Mononykus was a prehistoric terrestrial bird. Mononykus had soft feathers and when they sat down their feathers puffed out from their body. Also, Mononykus birds lived together in large nests. Near where the Mononykus lived there was the rough, grainy sand.

7. Why do you think Mononykus had such soft feathers?

They had soft feathers so that other tiny animals could crawl under them and stay warm and protected	They had soft feathers so that they could look like leaves on trees and stay hidden	They had soft feathers because furry stuff got built up all over them and pressed together in a certain way	Other (please explain):

8. Do you think all Mononykus had soft feathers? Yes No

9. Do you think a Mononykus could be born with feathers that were not soft? Yes No

10. Why do you think Mononykus' feathers puffed out from their body when they sat down?

Their feathers puffed out so that their friends would know they were asleep and would get mad at them if they were woken up	Their feathers puffed out so they could stay warm while they were not moving	Their feathers puffed out because of the way their bodies changed position when they weren't standing up	Other (please explain):

11. Why do you think the sand was so rough and grainy near where the Mononykus lived?

It was grainy so that animals like Mononykus could easily bury their eggs in it	It was grainy so that it wouldn't get blown away and scattered by the wind	It was grainy because bits of shells got broken up and mixed up making it that way	Other (please explain):

12. Of the following, what is the **worst** explanation for why so many Mononykus stayed together?

They stay together because they liked each other	They stay together because being together can ensure their safety	They stay together because they have the same things inside their bodies

Many years ago, while a giant glacier moved across the land, it froze some things inside. A group of scientists discover the glacier and they notice that a large animal is frozen inside. They want to know what kind of animal it is. The scientists decide that they will take really tiny samples from the inside of the animal. Each sample will be the size of a pea, and then the scientists will use all their tools and technology to look at these tiny samples, and they will be able to see everything that is inside each sample.

13. It doesn't matter where they take the samples from, any sample will be able to tell them what kind of animal it is.

Strongly disagree	Disagree somewhat	Neither agree nor disagree	Agree somewhat	Strongly agree

14. There is only one special sample that will tell them what kind of animal it is.

Strongly disagree	Disagree somewhat	Neither agree nor disagree	Agree somewhat	Strongly agree

15. Taking a sample from the inside of the animal is a good way to determine what kind of animal it is.

Strongly disagree	Disagree somewhat	Neither agree nor disagree	Agree somewhat	Strongly agree

16. Why do you think this is or is not a good way to determine what kind of animal it is?

Section 6: Just a few more questions. Remember you may skip any question you do not wish to answer, and you may stop filling out this survey at any time. For the next few questions, please use the following definitions:

Natural world: The physical world, and the living and non-living things that make up the world. Includes biological processes (e.g., photosynthesis, reproduction), non-biological kinds (e.g., rocks, the atmosphere), and non-biological processes (e.g., tornados, tsunamis). The natural world does not include man-made things or technology.

Scientific explanations: Explanations derived from the scientific method. The scientific method is a set of techniques used to test hypotheses; it involves gathering data (evidence) through observation and experimentation.

Explanations of higher power: Explanations and claims that invoke reference to one or many higher powers with supernatural abilities.

People have differing opinions about the usefulness of scientific explanations and explanations of higher power for explaining the natural world. For the next questions, we would like you to reflect on your opinions about these explanations for the natural world.

1. How do the following people explain the beginning and continuation of the natural world?

	Mostly scientific explanations	Both scientific explanations and explanations of higher power	Mostly explanations of higher power	I don't talk with this person about this
You				
Your Mother				
Your Father				
Your close friends				
Your teachers				

2. What are the opinions of the following people toward scientific explanations of the origin and continuation of the natural world:

	Mostly Positive	I'm not sure/neutral	Mostly Negative
You			
Your Mother			
Your Father			
Your close friends			
Your teachers			

3. Who do you talk with the **most** about scientific explanations for the natural world?

4. Who do you talk with the **least** about scientific explanations for the natural world?

5. What are the opinions of the following people toward explanations of higher power for the origin and continuation of the natural world:

	Mostly Positive	I'm not sure/neutral	Mostly Negative
You			
Your Mother			
Your Father			
Your close friends			
Your teachers			

6. Who do you talk with the **most** about explanations of higher power for the natural world?

7. Who do you talk with the **least** about explanations of higher power for the natural world?

8. If you were to explain how the natural world came to be and how it continues today with scientific explanations, would the following people feel disappointed?

	Yes, disappointed	I don't know/neutral	No, not disappointed
You			
Your Mother			
Your Father			
Your close friends			
Your teachers			

9. If you were to explain how the natural world came to be and how it continues today with explanations of higher power, would the following people feel disappointed?

	Yes, disappointed	I don't know/neutral	No, not disappointed
You			
Your Mother			
Your Father			
Your close friends			
Your teachers			

Imagine someone who only used <u>scientific explanations</u> to describe how the natural world came to be and how it continues today.

Do you think type of person is more likely to be:

10a.	Male	Female	Either male or female
10b.	Young	Old	Either young or old

11. Circle the number that represents what characteristics you would expect of this type of person, compared to the average person.

1	2	3
The characteristic on the left is much more descriptive of this type of person than the characteristic on the right, compared to the average person	**Each characteristic is equally descriptive**; this type of person is similar to the average person on this characteristics	**The characteristic on the right is much more descriptive** of this type of person than the characteristic on the left, compared to the average person

Smart	1	2	3	Dumb
Dull	1	2	3	Funny
Selfish	1	2	3	Generous
Considerate	1	2	3	Inconsiderate
Untrustworthy	1	2	3	Trustworthy
Outgoing	1	2	3	Shy
Wealthy	1	2	3	Poor
Weird/Odd	1	2	3	Normal
Good-looking	1	2	3	Ugly
Mean	1	2	3	Nice
Spiritual	1	2	3	Secular
Irreligious	1	2	3	Religious
Has lots of friends	1	2	3	Has very few friends
Someone you would want to be friends with	1	2	3	Someone you would not want to be friends with

12. Would you expect anything else about this type of person?

Imagine someone who only used <u>explanations of higher power</u> to describe how the natural world came to be and how it continues today.

Do you think type of person is more likely to be:

13a.	Male	Female	Either male or female
13b.	Young	Old	Either young or old

14. Circle the number that represents what characteristics you would expect of this type of person, compared to the average person.

1	2	3
The characteristic on the left is much more descriptive of this type of person than the characteristic on the right, compared to the average person	**Each characteristic is equally descriptive**; this type of person is similar to the average person on this characteristics	**The characteristic on the right is much more descriptive** of this type of person than the characteristic on the left, compared to the average person

Smart	1	2	3	Dumb
Dull	1	2	3	Funny
Selfish	1	2	3	Generous
Considerate	1	2	3	Inconsiderate
Untrustworthy	1	2	3	Trustworthy
Outgoing	1	2	3	Shy
Wealthy	1	2	3	Poor
Weird/Odd	1	2	3	Normal
Good-looking	1	2	3	Ugly
Mean	1	2	3	Nice
Spiritual	1	2	3	Secular
Irreligious	1	2	3	Religious
Has lots of friends	1	2	3	Has very few friends
Someone you would want to be friends with	1	2	3	Someone you would not want to be friends with

15. Would you expect anything else about this type of person?

Section 7

1a. Have you <u>ever</u> attended a religious service? Yes No

1b. If yes, what religious affiliation? (Circle all that apply)

Catholicism	Protestantism	Buddhism	Islam	Daoism	Other (please list):

2a. Do you <u>currently</u> attend any religious services? Yes No

2b. If yes, what religious affiliation?

Catholicism	Protestantism	Buddhism	Islam	Daoism	Other (please list):

2c. If yes, how often do you attend?

Once a year	Several times a year	Once a month	A few times a month	Once a week	Several times a week

2d. If yes, who do you attend with? (Circle all that apply)

Father	Mother	Other family member	Friend	Other (please explain)

3a. If you have <u>never</u> attended a religious service, have you ever thought about attending? Yes No

3b. Why or why not?

4. Do you believe in a higher power? Yes No I don't know

If you have anything else you would like to tell us related to the questions in this survey, please use the space below or on the back of this page. **Thank you for your participation!**

Appendix C
Evolutionary Knowledge Coding

1a. A species of woodpecker lives in isolation on a secluded island. These woodpeckers have, on average, a three centimeter beak, and their only food source is a tree-dwelling insect that lives, on average, four-and-a-half centimeters under the tree bark. Compared to its parents, the offspring of any two woodpeckers on the island should develop which of the following features?

A longer beak	A shorter beak	Either a longer beak or a shorter beak; neither feature is likely

1b. Please explain your answer.

Variational Responses (scored +1): *Either a longer beak or a shorter beak* because offspring vary randomly from their parents; because the environment does not determine direction of mutations (e.g., "They have inherited different genes from their parents, which resulted different outcomes." Participant 32)

Transformational Responses (scored -1): *A longer beak* because it is necessary for survival (e.g., "so it will be able to get food and survive" Participant 68). *A shorter beak* because of adaptation (e.g., "Because every creature evolves from simple to complex" Participant 45). *Longer or shorter beak* because evolution takes more than one generation (e.g., "As time elapses, woodpeckers would probably evolve." Participant 60).

2a. A youth basketball team scores more points per game this season than they did the previous season. Which explanation is an analogy for a Darwinian explanation for the adaptation of species?

Each returning team member grew taller over the summer	Any athlete who participates in a sport for more than one season will improve at that sport	More people tried out for the same number of spots this year	On average, ea member practi harder this sea

2b. Please explain your answer.

Variational Responses (scored +1): *More people tried out,* selection analogy (e.g., "More people have tried out, the bad (weak) players will be eliminated. Survival of the fittest" Participant 153).

Transformational Responses (scored -1): *Each returning team member grew taller,* growth analogy (e.g., "When playing basketball, players need enough height. If comparing to the "adaptation of species" explanation, member grew taller would be the best analogy, because it is a physiological phenomenon." Participant 135); *athletes will improve,* force

analogy (e.g., “As an athlete that practices, they learn from their mistakes and grow more every time. They evolve into better players.” Participant 251); *team members practice harder,* intention analogy (e.g., “If that team have been practicing hard normally, then every player will improve.” Participant 231).

3. During the 19th century, England underwent an Industrial Revolution that resulted in the unfortunate side effect of covering the English countryside in soot and ash. During this same period of time, the members of England’s native moth species became, on average, darker in color. Assuming that darker coloration was adaptive, how might a change in the moths’ environment brought about a change in the moths’ color?

Variational Responses (scored +1): Referenced individual differences (e.g., “Moths with the lighter color will be easily detected by predators and be eaton (sic). Therefore, it is easier for moths with the darker color to survive; so will their offsprings (sic). During evolution, moths with the darker color will have an advantage.” Participant 134).

Transformational Responses (scored -1): Referenced needs or characteristics of the species population (e.g., “Moths darken their colors to aid them in hiding.” Participant 209).

4. Indicate which of the following organisms share a common ancestor with humans:

Elephants	Lemurs	Lizards	Sparrows	Bees	Jellyfish	Algae	Daffodils	Brontasauruses

Variational Responses (scored +1): All 9 species were selected indicating all share a common ancestor.

Transformational Responses (scored -1): None of the 9 species were selected, indicating none share a common ancestor.

5a. As chimpanzees continue to evolve, they will become which of the following?

More similar to modern day humans	Less similar to modern day humans	Either more or less similar to modern day humans; neither outcome is more likely

5b. Please explain your answer.

Variational Responses (scored +1): *Either more or less similar* because each species changed because of different selection pressures; because evolution continued after the species diverged (e.g., “Humans are also evolved from apes; however, the living environment now is different compared to the living environment in the past. Thus, chimpanzees' evolution will probably be different than humans'.” Participant 93).

Transformational Responses (scored -1): *More similar* because chimpanzees evolved from the same earlier species as humans (e.g., "Because as earth changes gradually, chimpanzees will change as well in order to avoid from being eliminated. Human and chimpanzee live on the same planet, therefore the environment is the same, furthermore human evolved from monkey-type creature, it will change as the Earth is changing." Participant 63); *Less similar* because chimpanzees are less evolved than humans/humans alone continued to evolve (e.g., "Chimpanzees will not become as humans because they will probably stay the same" Participant 468).

6a. Compared to the number of living bacteria species, the number of extinct bacteria species is which of the following?

Greater	Smaller	Either greater or smaller; neither situation is mc

6b.Please explain your answer.

Variational Responses (scored +1): *Greater* because it's easier to go extinct than to adapt; because of the length of time bacteria has existed (e.g., "We have a very long history in the past, therefore the numbers of extinction must be greater than the ones still alive." Participant 64).

Transformational Responses (scored -1): *Smaller* because each species gives rise to many new ones (e.g., "The more species, the more bacterias." Participant 120); *Greater or smaller* because evolution is random (e.g., "It's hard to say, you guess." Participant 178).

Note. Ambiguous responses (scored +0) were given to uninterruptable responses, responses that required an open-ended justification that was left blank, and responses that reflected both a variational and a transformational framework.

Appendix D
Correlation Matrix for Variables Examined in Chapter 4

	1.	2.	3.	4.	5.	6.	7.	8.
	Culture	Creation Belief	Evolutionary Knowledge	Gender	Age	Favorite Science	Least Favorite Science	Liking of Biology
1.	--	.405***	-.220***	-.163***	-.052	-.085+	-.252***	-.043
2.		--	-.015	-.011	-.061	-.066	-.125*	-.077
3.			--	.081+	.066	-.028	.051	.040
4.				--	-.118**	-.009	.180***	-.061
5.					--	-.124**	-.009	-.176***
6.						--	-.170***	.335***
7.							--	-.241***

Note. $^{+}p < .10$, $*p < .05$, $**p < .01$, $***p < .001$

	9.	10.	11.	12.	13.	14.
	Cultural Interdependence	Species Epistemological Stance	Universe Epistemological Stance	Teleological Preference-Biological Kinds	Teleological Preference-Natural Kinds	Actual Variation
1.	-.286***	-.136**	-.242***	-.005	-.119*	.255***
2.	-.111*	-.063	-.199***	-.041	-.035	.062
3.	-.006	-.042	.093+	-.040	-.104+	-.121*
4.	.051	.184***	.135**	.016	-.075	-.055
5.	.043	.010	.023	-.034	-.044	.098+
6.	-.031	.084+	.055	.068	-.019	-.030
7.	.082+	.083+	.044	.022	-.095+	-.067
8.	.017	.048	.055	.002	.013	-.001
9.	--	.056	.076	-.109+	.039	-.005
10.		--	.447***	.028	-.017	-.002
11.			--	-.048	.082	-.146***
12.				--	.086	-.040
13.					--	-.041
14.						--

Note. $^{+}p < .10$, $*p < .05$, $**p < .01$, $***p < .001$

	15.	16.	17.	18.	19.
	Possible Variation	Belief in a higher power	Self Preferred Explanation	Science Stereotype	Religious Stereotype
1.	.156**	.237***	.386***	-.250***	.073
2.	.048	.266***	.388***	-.080	.057
3.	-.163**	-.086+	-.058	.046	.086
4.	-.055	-.006	-.036	.025	.004
5.	.076	-.070	-.072	-.002	-.112+
6.	-.026	-.093+	.051	.106+	.043
7.	-.053	-.021	-.196**	.103	-.085
8.	-.064	-.089+	-.013	.016	-.044
9.	.023	-.056	-.152*	.182**	.070
10.	-.023	-.094+	-.034	.118+	-.019
11.	-.054	-.077	-.201**	.073	-.087
12.	.007	-.002	.077	.130+	.050
13.	-.023	.017	.004	.109	.122+
14.	.354***	.130*	.165**	.040	.036
15.	--	-.005	.069	-.106	-.113
16.		--	.434**	-.099	.083
17.			--	-.201**	.164*
18.				--	.197**

Note. $^{+}p < .10$, $*p < .05$, $**p < .01$, $***p < .001$

Appendix E

Percentage of Participants' Ranking of Responses for Each Exemplar by Culture

	Evolution		Reincarnation		Spontaneous Generation		Artificialist		Creation	
Rank	Chinese	US	Chinese	US	Chinese	US	Chinese	US	Chinese	US
Fish (Chinese: *n* = 166; American: *n* = 118)										
1	81.9	33.1	3.0	6.8	7.8	6.8	1.2	11.9	6.0	41.5
2	9.6	30.5	12.7	25.4	47.6	13.6	7.2	14.4	23.5	16.1
3	3.6	13.6	26.5	39.8	25.3	19.5	21.1	13.6	23.5	13.6
4	1.2	11.0	24.7	23.7	12.0	24.6	33.7	30.5	27.7	10.2
5	3.6	11.9	33.1	4.2	7.2	35.6	36.7	29.7	19.3	18.6
Chair (Chinese: *n* = 163; American: *n* = 113)										
1	9.2	10.6	3.1	6.2	3.7	3.5	77.3	65.5	7.4	14.2
2	20.2	17.7	1.8	9.7	38.7	16.8	10.4	11.5	28.8	44.2
3	28.8	28.3	14.7	15.9	34.4	33.6	3.7	4.4	18.4	17.7
4	27.0	28.3	23.9	24.8	16.0	27.4	4.3	4.4	28.2	15.0
5	14.7	15.0	56.4	43.4	7.4	18.6	4.3	14.2	17.2	8.8
Tree (Chinese: *n* = 162; American: *n* = 110)										
1	41.4	33.6	3.7	6.4	42.6	15.5	3.1	9.1	9.3	36.0
2	30.9	30.0	6.8	10.0	29.6	19.1	10.5	21.8	22.2	18.0
3	14.2	15.5	20.4	10.9	14.8	25.5	23.5	30.9	27.2	17.1
4	7.4	7.3	21.6	23.6	9.9	22.7	34.6	31.8	26.5	15.3
5	6.2	13.6	47.5	49.1	3.1	17.3	28.4	6.4	14.8	13.5
Plankton (Chinese: *n* = 167; American: *n* = 112)										
1	67.7	35.7	6.6	12.5	19.2	20.5	2.4	8.0	4.2	23.2
2	14.4	25.0	17.4	21.4	47.9	15.2	4.2	17.0	16.2	21.4
3	8.4	13.4	26.3	24.1	16.8	27.7	19.8	16.1	28.1	17.9
4	3.6	13.4	14.4	17.9	10.8	17.9	41.3	36.6	29.9	14.3
5	6.0	12.5	35.3	23.2	5.4	18.8	32.3	22.3	21.6	23.2
Ape (Chinese: *n* = 163; American: *n* = 112)										
1	74.2	35.7	7.4	8.9	7.4	9.8	1.2	7.1	9.2	38.4
2	9.2	24.1	26.4	16.1	39.3	20.5	8.0	17.9	17.8	22.3
3	7.4	13.4	27.0	21.4	28.8	25.9	18.4	24.1	19.0	14.3
4	4.3	10.7	10.4	20.5	16.0	25.0	36.2	31.3	33.1	12.5
5	4.9	16.1	28.8	33.0	8.6	18.8	36.2	19.6	20.9	12.5

Cont.	Evolution		Reincarnation		Spontaneous Generation		Artificialist		Creation	
Rank	Chinese	US	Chinese	US	Chinese	US	Chinese	US	Chinese	US
Rock (Chinese: *n* = 162; American: *n* = 103)										
1	27.2	34.0	2.5	10.7	54.3	28.2	0.6	4.9	15.4	23.3
2	32.1	29.1	1.9	13.6	27.2	19.4	13.6	17.5	25.3	21.4
3	19.1	11.7	17.3	13.6	11.1	24.3	22.2	32.0	30.2	17.5
4	16.7	11.7	20.4	21.4	5.6	14.6	42.0	31.1	15.4	19.4
5	4.9	13.6	58.0	40.8	1.9	13.6	21.6	14.6	13.6	18.4
Dog (Chinese: *n* = 163; American: *n* = 101)										
1	71.2	34.3	13.5	13.7	6.1	8.8	3.7	5.9	5.5	37.3
2	15.3	25.5	30.7	9.8	31.9	21.6	8.0	22.5	14.7	20.6
3	6.7	13.7	14.1	16.7	33.1	31.4	20.2	24.5	25.8	12.7
4	3.1	11.8	11.7	23.5	14.7	21.6	39.3	29.4	31.3	13.7
5	3.7	14.7	30.1	36.3	14.1	16.7	28.8	17.6	22.7	14.7
Neandertal (Chinese: *n* = 161; American: *n* = 102)										
1	72.7	41.6	7.5	6.9	13.0	8.9	3.1	6.9	3.7	34.7
2	15.5	18.8	33.5	14.9	26.1	27.7	6.8	18.8	18.0	20.8
3	5.0	11.9	19.9	13.9	34.2	28.7	18.6	28.7	22.4	16.8
4	3.1	12.9	13.0	22.8	15.5	21.8	39.1	27.7	29.2	14.9
5	3.7	14.9	26.1	41.6	11.2	12.9	32.3	17.8	26.7	12.9
Human Being (Chinese: *n* = 161; American: *n* = 105)										
1	77.0	38.1	5.6	10.5	6.2	5.7	6.2	7.6	6.2	38.1
2	11.2	21.9	34.2	11.4	27.3	22.9	9.9	24.8	17.4	19.0
3	3.1	16.2	23.6	14.3	34.8	35.2	19.3	21.9	18.6	13.3
4	4.3	10.5	9.9	19.0	19.3	26.7	32.9	28.6	32.9	15.2
5	4.3	13.3	26.7	44.8	12.4	9.5	31.7	17.1	24.8	14.3

Appendix F

Creation belief proportion: A comparison of participants who answered origin belief questions and those who did not

Variable	Test Description and Results
Culture*	A 2 (missingness) x 2 (cultural group) chi-square indicated a significant relationship between missingness and cultural membership, χ^2 (1) = 44.41, $p < .001$, $\phi = .29$. Significantly more Americans (92.3%, $n = 60$) than Chinese (7.7%, $n = 5$) contributed to the group of missing data participants.
Gender	A 2 (missingness) x 2 (gender) chi-square indicated no significant relationship between missingness and gender. Males (45.9%, $n = 28$) and females (54.1%, $n = 33$) were equally likely to be participants missing data.
Age	A logistic regression indicated that age was not a significant predictor of whether participants were in the missing data category or not.
Cultural interdependence*	An independent samples *t*-test indicated a mean difference between the missing data participants ($M = .50$, $SD = .69$, $n = 46$) and the full data participants ($M = .69$, $SD = .58$, $n = 430$; t (474) = 2.19, $p < .05$).
Favorite science	A 2 (missingness) x 2 (favorite science) chi-square indicated no significant relationship between missingness and the listing of a science as a favorite subject. Although 88.7% ($n = 55$) of the missing data participants reported a non-science (compared to only 11.3%, $n = 7$ reporting a science) as their favorite subject, this difference was no significantly different than the expected counts.
Least science	A 2 (missingness) x 2 (least science) chi-square indicated no significant relationship between missingness and the listing of a science as a least favorite subject. Similar to favorite science, although 83.9% ($n = 47$) of the missing data participants reported a non-science (compared to 16.1%, $n = 9$, listing a science) as their favorite subject, this difference was not significantly different from the expected counts.
Liking of biology	Independent samples *t*-tests indicated no mean differences in participants liking of biology based on if they belonged to the missing data participant group ($M = -.18$, $SD = 1.19$, $n = 55$) or if they did not ($M = -.01$, $SD = .97$, $n = 419$).

Teleological Preference	Independent samples *t*-tests indicated no mean differences in participants teleological preference for biological kinds based on if they belonged to the missing data participant group (M = 3.30, SD = .86, n = 20) or if they did not (M = 3.09, SD = .92, n = 307). There was also no difference in teleological preference for natural kinds based on if they belonged to the missing data participant group (M = 1.35, SD = .71, n = 23) or if they did not (M = 1.21, SD = .70, n = 332).
Essentialist Reasoning	Independent samples *t*-tests indicated no mean differences in participants actual variation scores based on if participants were missing data participants (M = 1.17, SD = .87, n = 24) or full data participants (M = 1.01, SD = .86, n = 356). There was also no difference in possible variation based on if they belonged to the missing data participant group (M = .71, SD = .69, n = 24) or if they did not (M = .57, SD = .74, n = 357).
Epistemological Stance	Independent samples *t*-tests indicated no mean differences in participants universe epistemological stance based on if they belonged to the missing data participant group (M = 2.13, SD = .67, n = 31) or if they did not (M = 2.19, SD = .73, n = 413). There was also no difference in species epistemological stance based on if they belonged to the missing data participant group (M = 2.16, SD = .69, n = 31) or if they did not (M = 2.04, SD = .78, n = 415).
Previous religious attendance	A 2 (missingness) x 2 (previous religious attendance) chi-square indicated no significant relationship between missingness and previous religious attendance. Just under one-third (28.9%, n = 11) of the missing data participants had never attended a religious service which was not statistically different from the 40.4% (n = 158) full data participants who had also never attended a religious service.
Current religious attendance	A 2 (missingness) x 2 (current religious attendance) chi-square indicated no significant relationship between missingness and current religious attendance. Half of the participants in the missing participants category reported they did not currently attend religious services (50.0%, n = 18) which was not significantly different from the 58.2% (n = 228) of the full data participants who did not currently attend religious services.
Belief in a higher power	Independent samples *t*-tests indicated no mean differences in participants' belief in a higher power based on if they belonged to the missing data participant group (M = 1.41, SD = .69, n = 37) or if they did not (M = 1.23, SD = .71, n = 385).

Average stereotypes	Independent samples *t*-tests indicated no mean differences in the average stereotypes of individuals who use explanations of higher power for the missing data participants (M = .13, SD = .35, n = 17) and the full data participants (M = .21, SD = .35, n = 224). Similarly, there was no difference in the average stereotyping of individuals who use scientific explanations between the missing (M = .14, SD = .30, n = 16) and the full (M = .25, SD = .34, n = 234) data participants.

Note. *$p < .05$.

Appendix G

Evolutionary knowledge: A comparison of participants who answered the evolutionary knowledge questions and those who did not

Variable	Test Description and Results
Culture*	A 2 (missingness) x 2 (cultural group) chi-square indicated a significant relationship between missingness and cultural membership, χ^2 (1) = 58.62, $p < .001$, $\phi = .34$. Significantly more Americans (98.4%, $n = 63$) than Chinese (1.6%, $n = 1$) contributed to the group of missing data participants.
Gender	A 2 (missingness) x 2 (gender) chi-square indicated no significant relationship between missingness and gender. Males (55.0%, $n = 33$) and females (45.9%, $n = 27$) were equally likely to be participants missing data.
Age	A logistic regression indicated that age significantly predicted missingness ($\beta = .30$, Wald $\chi^2 = 4.52$, $p < .05$). The odds ratio indicated that older adolescents were 1.35 times more likely to contribute to the missing data participants than younger adolescents.
Cultural interdependence+	An independent samples *t*-test indicated a marginal mean difference between the missing data participants ($M = .50$, $SD = .60$, $n = 42$) and the full data participants ($M = .68$, $SD = .58$, $n = 434$; t (474) = 1.91, $p = .06$).
Favorite science+	A 2 (missingness) x 2 (favorite science) chi-square indicated a marginal relationship between missingness and the listing of a science as a favorite subject, χ^2 (1) = 3.31, $p = .07$, $\phi = -.08$. 91.2% ($n = 52$) of the missing data participants listed a non-science as their favorite subject whereas only 8.8% ($n = 5$) of these participants who listed a science.
Least science*	A 2 (missingness) x 2 (least science) chi-square indicated a significant relationship between missingness and the listing of a science as a least favorite subject, χ^2 (1) = 6.02, $p < .05$, $\phi = -.11$. 94.7% ($n = 54$) of the missing data participants listed a non-science as their least favorite subject whereas only 5.3% ($n = 3$) listed a science as their least favorite subject.
Liking of biology	Independent samples *t*-tests indicated no mean differences in participants liking of biology based on if they belonged to the missing data participant group ($M = -.21$, $SD = 1.13$, $n = 52$) or if they did not ($M = -.01$, $SD = .98$, $n = 422$).

Teleological Preference	Independent samples *t*-tests indicated no mean differences in participants teleological preference for biological kinds based on if they belonged to the missing data participant group (M = 2.50, SD = .58, n = 4) or if they did not (M = 3.11, SD = .91, n = 322). There was also no difference in teleological preference for natural kinds based on if they belonged to the missing data participant group (M = 1.40, SD = .55, n = 5) or if they did not (M = 1.22, SD = .70, n = 350).
Essentialist Reasoning^{+}	Independent samples *t*-tests indicated a marginal mean differences in participants actual variation scores, t (378) = 1.71, p = .09. The missing data participants tended to have higher average scores reflecting more essentialist reasoning (M = 1.75, SD = .50, n = 4) compared to the full data participants (M = 1.02, SD = .86, n = 376). There was no difference in possible variation based on if they belonged to the missing data participant group (M = .50, SD = .58, n = 5) or if they did not (M = .58, SD = .74, n = 377).
Epistemological Stance	Independent samples *t*-tests indicated no mean differences in participants universe epistemological stance based on if they belonged to the missing data participant group (M = 1.96, SD = .62, n = 24) or if they did not (M = 2.20, SD = .73, n = 420). There was also no difference in species epistemological stance based on if they belonged to the missing data participant group (M = 1.86, SD = .73, n = 21) or if they did not (M = 2.06, SD = .77, n = 425).
Previous religious attendance*	A 2 (missingness) x 2 (previous religious attendance) chi-square indicated a significant relationship between missingness and previous religious attendance, χ^2 (1) = 9.00, p < .01, ϕ = .15. 11.5% (n = 3) of the missing data participants reported having never attended a religious service whereas 88.5% (n =23) reported having previously attended a religious service of some kind.
Current religious attendance	A 2 (missingness) x 2 (current religious attendance) chi-square indicated no significant relationship between missingness and current religious attendance. Half of the participants in the missing participants category reported they did not currently attend religious services (48.0%, n = 12) which was not significantly different from the 58.1% (n = 234) of the full data participants who did not currently attend religious services.
Belief in a higher power*	Independent samples *t*-tests indicated a significant difference in participants' belief in a higher power; missing data participants had higher mean levels of belief (M = 1.52, SD = .59, n = 25) than the full data participants (M = 1.23, SD = .71, n = 397; t (420) = 1.99, p <.05).

Average stereotypes	Independent samples *t*-tests indicated no mean differences in the average stereotypes of individuals who use explanations of higher power for the missing data participants (M = .36, SD = .46, n = 10) and the full data participants (M = .20, SD = .34, n = 231). Similarly, there was no difference in the average stereotyping of individuals who use scientific explanations between the missing (M = .22, SD = .55, n = 9) and the full (M = .24, SD = .33, n = 241) data participants.

Note. $^{+}$ $p < .10$, $^{*}p < .05$.