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Chapter 7

Accepting Evolution or Creation in People, Critters, Plants, and Classrooms

The Maelstrom of American Cognition about Biological Change

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Introduction

Early in our joint investigations of individuals' cognitions about evolution, a Japanese visiting professor asked a wide-eyed question during a lab meeting: "Excuse me, but did you say that some Americans do *not* believe in evolution?" His amazement was infectious. When we asserted that somewhat less than 50% of U.S. adults accept evolution (e.g., Miller, Scott, & Okamoto, 2006), we were as surprised by his reaction as he was by the situation. He wanted to know what else there was to accept, so we explained that it was roughly the Old Testament's Genesis story. When asked what the Shinto creation myth was, he eventually recalled, "Two gods were fighting and people resulted," but he could recall no particulars of how animals and plants arose. This episode, and less anecdotal evidence, led one of us (Ranney, 1998 & in press) to a conjecture about an answer to an oft-posed puzzle (e.g., Miller et al., 2006), which we will call the U.S. "divergence" question: Why does the United States lag so far behind comparable nations in its acceptance of evolution? The episode also highlights another element of cognition about evolution: human-centrism.

The U.S.'s modest embrace of evolution has been salient on the landscapes of both public opinion polls and biology education (e.g., Bishop & Anderson, 1990). Although this may amuse some citizens (even some scientists) from peer nations, the import of the U.S. evolutionary divergence goes well beyond science education (even plausibly engaging global climate change issues; Ranney, in press).

This chapter's central goal is to add richness to our collective knowledge of how people understand (and *could* understand) evolution. We take two approaches toward the goal, with the bulk of the chapter focusing on the concretely evidential and the rest providing a broad theoretical perspective in support. We first offer novel empirical evidence (two experiments and some survey data) that we hope both problematizes and enlightens discussions

about the cognition of evolution. A conjectural answer to the oft-posed question from above is then explicated in sweeping geopolitical terms. Our empirical results cohere with this conjecture about the relatively modest U.S. acceptance of evolution, but they stand on their own regardless of the conjecture's veracity.

Below, we describe two empirical ventures that address some of the landscape of how U.S. undergraduates think about the complex arena of evolution. Study 1's experiments address some interesting asymmetries in how undergraduates approach evolution in the realm of plants—compared to that of humans. Study 2 focuses on the relationships between undergraduate views regarding evolution and creationism—and which of these ought to be taught in U.S. schools.

Study 1: Perception of Evolution across the Tree of Life

A key aspect of evolutionary theory's appeal is its power to explain biological phenomena over many scales and situations using the same set of relatively simple mechanisms (see Ferrari & Chi, 1998, etc.). Darwin's two great ideas, natural selection and common ancestry, form an illuminating lens for analyzing and understanding virtually any aspect of biology. The basic process of natural selection is essentially the same, whether the evolving population is made up of cells in a Petri dish, asexual fungi, colonial coral, cognitively adept humans, fruit flies, or elephants. Similarly, the concept of common ancestry helps us understand widely divergent observations, from the vestigial "finger" bones in a whale's fin to the genetic code's chemical consistency.

Evolutionary theory's universality makes it the keystone of modern biology, yet the broader U.S. population seems to accept evolution piecemeal and in select situations. Human evolution, for example, may be (or often is) a sticking point. Surveys (e.g., Almquist & Cronin, 1988; Gallup Organization, 2001; People For the American Way Foundation, 2000) typically find that roughly half of the U.S. (e.g., Gallup Organization, 2001) rejects evolution as an explanation of human origins and development. However, these studies' implications are somewhat unclear because many implicitly frame human evolution as a controversy, defining evolution and creationism with respect to humans (e.g., People For the American Way Foundation, 2000) or failing to ask about anything except human origins and evolution (e.g., Gallup Organization, 2001). While others have examined this area, no study has explicitly compared the acceptance of human evolution to that of plant or animal evolution.

The evolution education literature includes a few studies with findings directly related to students' views of evolution in different organisms. Jenson, Settlage, and Odem (1996) found that U.S. students do not consistently and appropriately apply the concept of natural selection across different, non-

human organisms. Brem, Ranney, and Schindel (2003) found that many U.S. students favoring creationism believed that only non-human species had evolved. Evans, Stewart, and Poling (1997) found that U.S. parents are less likely to explain human origins to their children in terms of evolution than they are to explain dinosaur origins in terms of evolution. Others, though, found that human origins might be an evolutionary touchstone for students. Bizzo (1994) found that many Brazilian high school students use humans as a central reference for evolution and tend to view the evolutionary process as motivated by a conscious effort—one that can only be mustered by "higher" animals like humans, leaving organisms like plants in evolutionary limbo. A study performed at the University of California, Berkeley (Ranney, 1998) found that, when asked to write about evolution in general, the 30 undergraduates often spontaneously mentioned human evolution, and occasionally mentioned animal evolution, yet *never* mentioned plant evolution. These studies are consistent with the idea that people's views of evolution vary across organisms, but do not explain how or why.

To help illuminate this issue, Study 1 examines how accepting people are of evolution in different organisms (plants, animals, and humans)[1] and what factors into these acceptance levels (e.g., conceptions of evolution, affective constraints, and religious concerns) through two investigations. In both, participants responded to Likert-scale items asking about their agreement with evolutionary explanations for features of plants, animals, and humans. One investigation explored basic patterns with a set of surveys. The other used think-aloud protocols (TAPs) to explore participants' reasoning about plant and human evolution items. Full explanations of the materials, methods, results, coding schemes, and data transformations for these experiments are in Thanukos (2002). A brief summary of key points follows.

Surveys: Patterns across the Tree of Life

Seventy-six University of California at Berkeley undergraduates completed a Likert-rating survey and a demographics survey for psychology course credit. The Likert survey included 21 items probing acceptance of evolution in plants, animals, and humans—for example: "Scientists have found parts of fossilized animals that are very similar in form to a modern horse species. Evolutionary relationships are a major cause of this similarity." Students were asked to rate their agreement with the second sentence ascribing an evolutionary cause to the feature on a scale of –4 (totally disagree) to +4 (totally agree). The 21 items were divided into three sections containing isomorphic items on plant, animal, and human evolution.[2] Figure 7.1 summarizes the topics of the seven items in each section. Five of these (*adaptation framework items*) describe an adaptation or population characteristic and suggest that natural selection is the cause of this adaptation or characteristic; two (*similarity framework items*) describe a similarity between two organisms and suggest that common

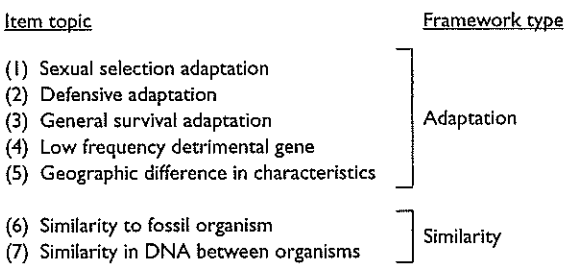

Figure 7.1 Summary of item topics and framework types. Adaptation items reference microevolutionary phenomena (evolution within a species) and similarity items reference macroevolutionary phenomena (evolution above the species level).

ancestry and subsequent evolution are causes of this similarity. Within each section, items were randomly ordered for each participant.

The demographics survey probed students' attitudes toward creationism and evolution. Based on a free-response item about the reality of evolution ("Do you believe that evolution, as you have described it, accurately depicts what happens in the real world? If not, what parts of it are incorrect?"), participants' attitudes toward evolution were coded as negative (at minimum, expressed doubts about whether human evolution happened), neutral (described some exceptions to the evolutionary process or some lack of confidence in their response), or positive (expressed no doubts at all about evolution or allowed for minor exceptions, such as a deity starting life but evolution taking over thereafter; see Thanukos, 2002 for item and coding details).

Here, we reflect on the results of three analytic threads (Analyses 1, 2, and 3): (1) a repeated measures analysis for organism type (plant, animal, or human), (2) a 3 (attitude toward evolution) × 3 (organism type) ANOVA, with organism type as a repeated measure, and (3) a repeated measures analysis for organism type and framework type (adaptation or similarity), including and excluding participants who were negative toward evolution.[3]

Think-Aloud Protocols (TAPs): Explanations for the Patterns

After training on non-evolutionary "warm-up" items to familiarize them with TAPs, 24 other students (from the same pool) received stimuli identical to *either* the plant *or* the human Likert items described above, but were asked to read each item aloud and to think aloud while rating it.[4] (Item orders were randomized for each participant, and responses were audiotaped.) They then completed the demographics survey on their attitudes toward creationism and evolution described above.

A TAP coding scheme was designed to include categories for all phrases or ideas appearing in two or more responses or that were particularly salient to differences between plants and humans (Table 7.1). Each Likert item was scored for the presence/absence of all categories in the scheme; thus, a response could be scored for multiple categories. A trained second individual coded 10% of the total data set, yielding an inter-rater reliability of greater than 97%.

Chi-square tests on the full data set compared the number of references made to specific categories across treatment (i.e., those receiving plant or animal items) groups. Several references to a category by a person were treated the same as a single reference to that category. So, for example, we compared the number of people in the plant treatment group who did and did not mention the relatedness of organisms to the number of people in the human treatment group who did and did not.

Results and Discussion

Our samples were more positive toward human evolution than the U.S. public. A national poll found that only 27% of the U.S. think that evolution is at least a "mostly accurate account of how humans were created and developed" (People For the American Way Foundation, 2000), yet on our surveys, averaging each participant's human evolution section rating yielded a set of acceptance scores with a high median: +2.50 on a −4 to +4 scale. Of course, Berkeley undergraduates are likely similar to Americans with college degrees, who are less likely to reject human evolution in favor of strict creationism than the general population. Of college graduates, 25% reject human evolution; 47% of all Americans do (ThinkQuest, 1999).

Plant Evolution Is More Acceptable Than Human Evolution

Despite participants' relatively high level of acceptance of human evolution, the surveys found plant evolution to be more acceptable than human evolution, which we will term the *human reticence effect.* Analysis 1 identified a borderline-significant main effect of organism type [$F(2,150) = 3.24$, $p = 0.05$], which was strengthened in other analyses when more variables were included in the model. Participants' mean response across plant items was marginally significantly higher than that for the human items ($p < 0.1$[5]; see Table 7.2, part I). Animal items were not rated differently than plant items or human items. This finding is not unexpected, given that many sources indicate human evolution to be dubitable for many Americans.

But why is that the case? It is plausible that human evolution conflicts with some people's worldviews—the sets of beliefs and ideas that shape our interpretations of the world. For example, some religious groups afford humans "exempt" status when it comes to evolution, but accept other organisms' evolution (Scott, 2000). On a less religious note, for some, acceptance of

Table 7.1 Frequency Distribution of References from Think-Aloud Protocols (TAPs), Displayed by Response Coding Scheme Categories. Numbers of references are collapsed across all items.

Coding scheme category	*References from human treatment group (and %)*	*References from plant treatment group (and %)*	*Total number of references*	*References by different participants (and % of 24)*
Availability, familiarity, and confidence				
Have Knowledge—has learned about the topic	15 (60%)	10 (40%)	25	16 (66.7%)
Lack of Knowledge—didn't know enough or about something	9 (36%)	16 (64%)	25	16 (66.7%)
Lack of Knowledge About Plants—didn't know about plants	0 (0%)	4 (100%)	4	4 (16.7%)
Unsure—felt unsure or not confident while responding	11 (42.3%)	15 (57.7%)	26	13 (54.2%)
Specific examples				
Human Example—referenced case of human evolution not in item	4 (50%)	4 (50%)	8	8 (33.3%)
Animal Example—referenced case of animal evolution not in item	4 (50%)	4 (50%)	8	5 (20.8%)
Plant Example—referenced case of plant evolution not in item	0 (0%)	1 (100%)	1	1 (4.2%)
Factors acknowledging evolutionary relationships over time				
Related Organisms—species are closely related or have common ancestor	22 (88%)	3 (12%)	25	14 (58.3%)
Similar DNA—since the species have similar DNA, they must be closely related	4 (57.1%)	3 (42.9%)	7	5 (20.8%)
Organism Hasn't Changed—organism has not changed much over evolutionary timescales	0 (0%)	4 (100%)	4	4 (16.7%)
References to natural selection or the products of natural selection				
Selection—causes death or leads to fewer offspring	9 (64.3%)	5 (35.7%)	14	14 (58.3%)
Adaptiveness—trait is adaptive for the organism	35 (44.9%)	43 (55.1%)	78	24 (100%)
Non-adaptiveness—trait is not adaptive for the organism	11 (91.7%)	1 (8.3%)	12	8 (33.3%)
Other factors likely to decrease the plausibility of an evolutionary explanation				
No Relationship Between—no relationship between evolution and the scenario in the item	3 (37.5%)	5 (62.5%)	8	7 (29.2%)
Innate Characteristic—trait is innate	3 (100%)	0 (0%)	3	3 (12.5%)
Human Interference—trait is a result of human interference on other species	0 (0%)	4 (100%)	4	2 (8.3%)
Environmental Influences—trait is a result of environmental influence	5 (50%)	5 (50%)	10	9 (37.5%)

Table 7.2 Summary of Effects and Interactions. Participants' acceptance of evolutionary explanations (i.e., their Likert ratings) for the survey, broken down by section and participant characteristics. The transformed mean column reports the mean of the transformed data, first averaged within section, framework type if appropriate, and participant; the next column reports the standard deviation of the same data. The final column reports the median of the untransformed data, first averaged within section and participant. Only responses to the items listed in Figure 7.1 are included in these analyses.

	Transformed data		*Untransformed median*
	Mean	*(Standard deviation)*	
I. Section			
Plant	103.9[a]	(44.7)	2.4
Similarity framework	104.5	(52.5)	2.5
Adaptation framework	105.9[b]	(46.2)	2.5
Animal	100.9	(48.1)	2.3
Similarity framework	109.1	(54.7)	2.5
Adaptation framework	99.6	(49.9)	2.2
Human	93.3[a]	(54.8)	2.5
Similarity framework	110.7[c]	(61.7)	3.0
Adaptation framework	88.5[bc]	(54.1)	2.2
II. Attitude toward evolution and section			
Negative attitude ($n = 8$)	38.8[de]	(41.1)	−0.4
Plant	56.9[f]	(39.6)	0.9
Animal	49.7	(49.5)	0.0
Human	9.9[f]	(9.0)	−1.4
Neutral attitude ($n = 12$)	92.4[d]	(48.2)	1.9
Plant	95.1	(51.1)	2.1
Animal	95.9	(42.1)	2.0
Human	86.2	(54.2)	1.5
Positive attitude ($n = 56$)	109.5[e]	(44.1)	2.6
Plant	112.5	(39.9)	2.6
Animal	109.3	(45.0)	2.4
Human	106.8	(47.8)	2.7

Note
Transformed means marked in the table above with paired superscripts are significantly or marginally significantly different from each other, as per the following tests of mean difference (e.g., the two superscripted b's above indicate that the adaptation framework items for plants yielded a higher mean acceptance of evolutionary explanations than did the adaptation framework items for humans): a, $t(75) = 2.17$, mean diff = 10.60±9.72, $p<0.1$; b, $t(75) = 3.48$, mean diff = 17.43±9.98, $p<0.05$; c, $t(75) = 5.32$, mean diff = 22.25±8.33, $p<0.01$; d, $t(58) = 4.47$, mean diff = 53.57±24.00, $p<0.01$; e, $t(190) = 7.40$, mean diff = 70.69±18.85, $p<0.01$; f, $t(7) = 3.82$, mean diff = 47.06±29.12, $p<0.05$.

human evolution may entail loss of a sense of "their spiritual nature and their capacity for moral reasoning" (Evans, 2000), less sense of purpose, lower feelings of self-determination, and increased justification for racism and selfishness (Brem et al., 2003).[6]

Think-aloud protocols did not identify clear references to such religious and non-religious "conflicting worldview" reasons for the human reticence effect (Table 7.1), and the demographics survey did not include measures of religiosity. Still, other data show that some students hesitate to express such misgivings in experimental settings: in a paired discussion task based on similar stimuli, one explicated that she was trying not to mention her own religious reservations about evolution (Thanukos, 2002). Further, TAPs can only detect conscious influences (Ericsson & Simon, 1993). It is possible that worldview conflicts play a role in ratings, but remain unreported.

Think-aloud protocols, though, did identify several more scientific, less worldview-related factors that might help explain low ratings of the acceptance of evolutionary explanations. These include (see Table 7.1) learning and other *environmental influences* (i.e., a trait is better explained by an environmental factor—e.g., soil quality or learning—than by evolution) and *human interference* (i.e., humans, not evolution, manipulated another species' trait). Though more proximate than ultimate explanations for a particular trait, such reasons are certainly scientifically acceptable. Hence, scientifically valid arguments (and not just worldview conflicts) can *lower* the acceptance of evolutionary explanations for particular traits.

While many factors may help explain human reticence (e.g., recent research on life-status by Goldberg & Thompson-Schill, 2009, and on science standards by Mead & Mates, 2009), the finding had subtleties: patterns of acceptance varied depending upon item order and item topic, and these factors interacted with participants' attitudes toward, and experience with, evolution. We examine two "modulations" of the human reticence effect.

Modulation 1: Those generally less accepting of evolution were least accepting of human evolution. The human reticence effect seemed largely attributable to this group.

Analysis 2 on the survey data revealed a significant interaction between organism type and attitude toward evolution ($F[4,146] = 2.77$, $p < 0.05$; Figure 7.2).[7] Those negative toward evolution (eight participants) were less accepting of evolutionary explanations for human items than for plant items ($p < 0.05$; see Table 7.2, part II). In contrast, those positive (56 participants) and neutral (12 participants) toward evolution showed no differences in their acceptance of evolutionary explanations for plant, animal, and human items.

This coheres with Evans et al.'s (1997) finding that some are less likely to evolutionarily explain human origins, compared to other species' origins (dinosaurs, in this case—organisms of much intrinsic interest; e.g., Kaufman,

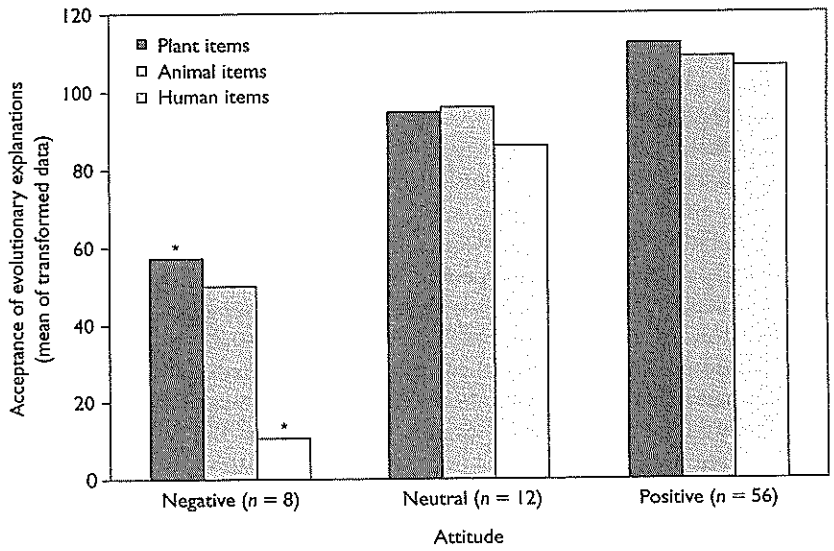

Figure 7.2 The interaction between organism type and attitude toward evolution. As expected, those positive and neutral toward evolution are more accepting of evolution in all organisms than are those negative toward evolution. However, only for those negative toward evolution is there a significant difference between acceptance of plant and human evolution, as indicated by the asterisks ($p<0.05$).

Ranney, Lewis, Thanukos, & Brem, 2000). Although Evans et al. identified this trend in fundamentalist Christians, there is likely an overlap between this group and our students who had negative evolution attitudes. Study 1 extends Evans et al.'s results by broadening the sorts of situations in which evolution is seen as a poor explanation of human history or characteristics. Additionally, Evans et al. examined evolution solely as an explanation for species origins (i.e., macroevolution); however, this study was concerned with other aspects of evolution, too (i.e., adaptation within a species—microevolution).

The human reticence effect was given many possible explanations above, but this modulation seems most consistent with the idea that human evolution conflicts with individuals' worldviews. The "negative attitude" group's stronger pattern would be expected if their (perhaps more religious or anthropocentric) worldviews diverged from those of people positive or neutral toward evolution.

Modulation 2: Participants positive and neutral toward evolution (68 participants) were unusually accepting of evolutionary explanations when items emphasized the relationships/similarities between

humans and other species—and for these items, exhibited a "reverse" human reticence effect.

Analysis 3 on the survey data revealed a section by framework type interaction ($F[2,150] = 8.88$, $p < 0.001$),[8] with items referencing human evolutionary relationships (human similarity items) rated higher than items explaining humans' adaptive traits via evolution (human adaptation items; $p < 0.01$; see Table 7.2, part I), but with plant similarity items not rated differently from plant adaptation items. In other words, human evolutionary relationships are surprisingly acceptable to many people. We will term this finding the "human origins acceptance effect." Interestingly, this effect is strengthened when those negative toward evolution are excluded ($F[2,134] = 10.83$, $p < 0.001$; Figure 7.3).[9] Those positive and neutral toward evolution rated plant items higher than human items for the adaptation items ($p < 0.05$), but rated human items marginally significantly higher than plant items for the similarity items ($p = 0.10$; see Table 7.3, part I).[10] On the other hand, those negative toward evolution did not differentiate between adaptation and similarity items in this way; they rated human items low in general and lower than plant items for adaptation items ($p < 0.05$) and marginally so for similarity items ($p = 0.058$;

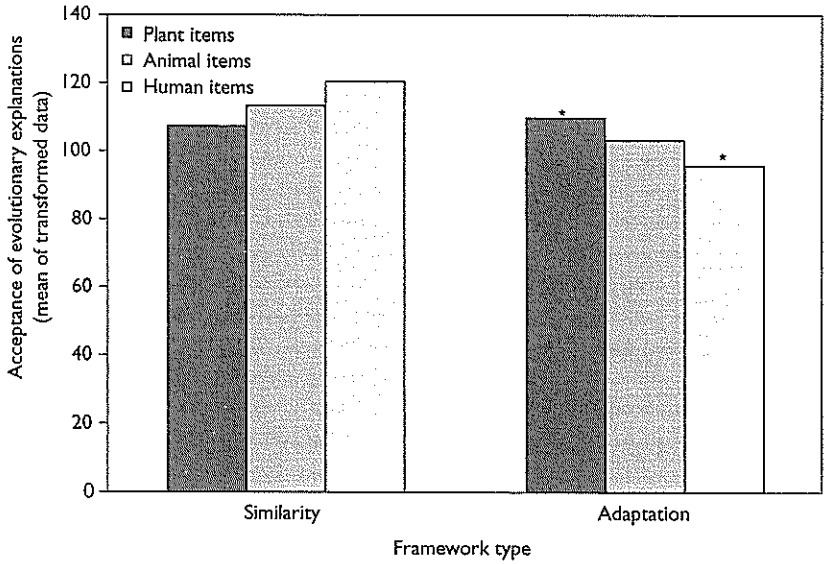

Figure 7.3 The interaction between organism type and framework type for those positive and neutral ($n = 68$) toward evolution. Plant evolution is more acceptable than human evolution for the adaptation items, as indicated by the asterisks ($p < 0.05$), but the same is not true for the similarity items. (Recall that each participant rated two similarity items and five adaptation items.)

Table 7.3 Interaction Associated With Framework Across Different Attitudes. Participants' acceptance of evolutionary explanations (i.e., their Likert ratings) for the survey, broken down by attitude toward evolution, framework type, and section. The first column reports the mean of the transformed data, first averaged within section, framework type, and participant; the second column reports the standard deviation of the same data. The final column reports the median of the untransformed data, first averaged within section, framework type, and participant. Transformed means marked with paired superscripts are significantly or nearly significantly different from each other.

	Transformed data		*Untransformed median*
	Mean	*(Standard deviation)*	
I. Positive and neutral attitudes			
Similarity framework			
Plant	109.8[a]	(50.9)	2.5
Animal	116.2	(51.3)	3.0
Human	123.0[ab]	(52.9)	3.0
Adaptation framework			
Plant	111.3[c]	(43.8)	2.6
Animal	105.1	(46.8)	2.3
Human	97.2[bc]	(50.1)	2.4
II. Negative attitudes			
Similarity framework			
Plant	59.2[d]	(47.2)	1.0
Animal	48.8	(47.3)	−0.3
Human	6.7[d]	(10.3)	−3.5
Adaptation framework			
Plant	60.2[e]	(42.3)	1.0
Animal	53.4	(54.6)	0.2
Human	14.2[e]	(15.3)	−1.3

Note
a, $t(67) = 2.17$, mean dif = 13.17 ± 12.14, $p = 0.102$; b, $t(67) = 5.83$, mean dif = 25.77 ± 8.83, $p < 0.01$; c, $t(67) = 2.67$, mean dif = 14.07 ± 10.53, $p < 0.05$; d, $t(7) = 3.02$, mean dif = 52.65 ± 41.20, $p < 0.1$; e, $t(7) = 3.62$, mean dif = 46.02 ± 30.02, $p < 0.05$.

see Table 7.3, part II). Since our sample included rather few negative attitude participants, here we focus largely on plausible explanations for the more robust patterns exhibited by the positive and neutral participants.

It is interesting that for those positive and neutral toward evolution, the idea of human macroevolution (that we share recent common ancestors with other apes—ideas tapped by the human similarity items) may be more acceptable than that of human microevolution (that many human features are adaptive and were built by natural selection within a population—ideas tapped by the human adaptation items). This human origins acceptance effect (coined above) is the reverse of anti-evolution groups' views that reject macroevolution (particularly human origins), even when they accept microevolution (Scott, 2000). Other studies provide no hints of such a diverging acceptance pattern regarding macro- and microevolution in groups more positive toward evolution.

There are many possible explanations for this human origins acceptance effect, but we particularly examine one: that for those *not* negative toward evolution, (1) prior knowledge impacts similarity items' ratings more than adaptation items' ratings, and (2) prior knowledge of human evolution is greater than that of plant evolution. Supposition 1 is plausible due to the nature of the similarity and adaptation items. Adaptation items describe population characteristics and ascribe them to natural selection. Similarity items suggest that two organisms share a similarity because of common ancestry and subsequent evolution. For those savvy about natural selection, the plausibility that natural selection caused a trait may be easily assessed without much prior knowledge of the scenario (i.e., "just so" stories are easy to make up, even in the absence of detailed content knowledge); but for items involving a proposed evolutionary relationship between two species, one might feel the need to know more details to assess the tightness of the relationship. That is, there is no substitute for specific content knowledge and familiarity with the organisms when it comes to assessing the plausibility or closeness of an evolutionary relationship between two lineages.

Several lines of evidence indicate that people know more about humans' (than plants') evolutionary relationships (supposition 2 above). In TAPs, interspecies relationships were mentioned much more often for human than plant items ($\chi^2[1, n=24] = 10.97$, $p < 0.005$, Fisher exact $p < 0.005$; see Table 7.1). Informal observations provide further support. Popular science articles often note that chimpanzees are *Homo sapiens*' closest living relatives, and the discovery (and media coverage) of new hominid relics is frequent—yet one rarely sees plant evolutionary relationships noted in a newspaper. Perhaps the human–chimp tie is so common that it has become uncontroversial for those without strong contrary commitments, and knowledge of human evolutionary relationships may be an area of relative confidence. Few people, though, hear about plant evolutionary relationships. Indeed, the relationships among many plant taxa are poorly resolved, while human evolutionary relationships

are better understood. Further, secondary education biology textbooks often centrally describe human evolutionary relationships, while plant evolutionary relationships (if present) are often relegated to introducing the plant physiology and chemistry chapter (e.g., DiSpezio, Linner-Luebe, Lisowski, Skoog, & Sparks, 1994; Wright, Coble, Hopkins, Johnson, & Lahart, 1993). In sum, many arguments suggest that plants' evolutionary relationships are less familiar than humans'.

A further explanation for the human origins acceptance effect is that many people who are not negative toward evolution may find human adaptation (as opposed to human origins) more troubling than plant adaptation. As this explanation may be counterintuitive, we elaborate: The idea that human behavioral and physical characteristics result from evolution may conflict with participants' worldviews and experiences—even for those who are not negative toward evolution. Viewing humans as subject to evolution suggests that we *are* animals (not just their relatives). Further, if accepting evolution correlates with a lower sense of self-determination (Brem et al., 2003), viewing human traits (especially behavioral traits, many of which we like to think we control) as adaptations should be even more tied to a void of self-determination. This lack of self-control may conflict with one's experiences as a decision-maker. Plant adaptation, though, may present fewer conflicts. This idea (we'll call it "human agential experience") coheres with TAP results that show that participants in the human condition are much more likely to reference an organism's trait not being adaptive than those in the plant condition ($\chi^2[1, N=24] = 6.75$, $p < 0.01$, Fisher exact $p < 0.05$; see Table 7.1). Thus, people may view human traits as less tuned for survival than plant traits.

Yet another explanation for a lessened willingness to tell adaptive "just so" stories for human traits may be that our familiarity with humans constrains our adaptive stories, compared to those we might create for (less familiar) plants. Plant ignorance may allow us *more* ways to tell adaptive tales about them. In contrast, both human adaptive story constraints (the difficulties of making up a "just so" story for humans when one knows humans well) and human agential experience (our reluctance to ascribe adaptive explanations for personal traits) could help explain the human origins acceptance effect and frequent references to non-adaptiveness in the human condition during TAPs.

Summary and Implications

Table 7.4 summarizes a subset of the factors hypothesized to affect one's acceptance of an evolutionary explanation. These factors need not be directly competitive and may simply reflect the various thought modes, unconscious influences, and interactions that play roles in the complex domain of evolution—with its personal, social, and scientific ramifications (Brem et al., 2003). For example, one's rating might simultaneously reflect plant unfamiliarity,

Table 7.4 Summary of Factors Hypothesized to Influence Ratings. The major factors identified as potentially increasing or decreasing a participant's acceptance of an evolutionary explanation for a feature.

Factors increasing acceptance	*Factors decreasing acceptance*
More *positive* attitude toward evolution	More *negative* attitude toward evolution
Topic's *consistency* with worldview	Topic's *conflict* with worldview
Higher familiarity/availability of topic	*Lower* familiarity/availability of topic
Perceived *adaptiveness* of feature	Perceived *non-adaptiveness* of feature
Perceived *lack of influence* of the environment on the feature	Perceived *influence* of the environment on the feature

religious commitments, and a recently read news piece on human evolution. Our data show that many considerations and modes of thought are invoked for judgments on evolution.

This study posed two main questions, for which answers are now clearer. Question 1: Do students differentially accept evolution across organisms? Answer: They do, and some groups accept human evolution less than plant evolution. Question 2: Are students' views of evolution in different organisms consistent over different evolutionary scenarios? Answer: No, the acceptance of evolution across organisms varies depending on whether evolutionary relationships (e.g., via similarity) or evolutionary adaptations are emphasized.

We found other interesting, novel results. Students distinguished between organisms' origins and adaptation (respectively reflected in their similarities and apt traits)—two aspects of evolution not previously examined in social science research. We also found that evolutionary attitudes across organisms are less obvious than one might imagine (e.g., many accept human evolution *less* than plant evolution) and may be strongly mediated by personal characteristics (e.g., general attitude toward evolution) and the aspect of evolution referenced (adaptation vs. common species origins).

For the population studied herein, at least some aspects of human evolution may not represent a very thorny social issue: many students were familiar, and not uneasy, with humans' evolutionary ties to other animals. In this way, the media's influence may have yielded a positive effect by reinforcing this idea. However, people may accept human adaptation less, perhaps because it conflicts with their experiences as decision-makers or implies that they *are* animals (and not just related to animals).

Our results are consistent with the idea that the acceptance of evolutionary explanations is influenced by many factors—notably, familiarity (Table 7.4). Implications of familiarity's role ought to encourage defenders of evolution,

suggesting that further efforts to explain evolution via media outlets may make its aspects more familiar and acceptable. Increasing evolution's familiarity may entail a markedly different approach than increasing its understanding (which does not seem much related to equivalent increases in accepting evolution; e.g., Bishop & Anderson, 1990; Demastes, Settlage, & Good, 1995; cf. Shtulman & Calabi, 2008). Increasing evolutionary familiarity might involve, for example, citing evolution whenever relevant, inhibiting publications from avoiding references to evolution, and highlighting evolution's wide acceptance among scientists. In contrast, increasing the understanding of evolution may involve more challenging educational interventions.

Beyond the basic conclusions of this study, we highlight a finding that we will return to toward the end: As others have noted about the approach of some religious groups toward evolution (e.g., Miller et al., 2006; Scott, 2000; Scott & Matzke, 2007), many of our participants acted as if humans have a special exemption from evolutionary processes—or are "above the game"—as suggested by the human reticence effect. We note that many people find adaptation in humans to be more troubling than in plants. We will return to speculations regarding why U.S. residents, compared to those of peer nations, are more likely to confer evolutionary exemptions upon themselves.

First, though, let us consider another line of research from our laboratory (with Jennifer Schindel) that provides evidence regarding a proximal issue: How do U.S. undergraduates' various levels of evolutionary acceptance play out in terms of a core element of national consciousness—namely how should our schools address the origins and diversity of life?

Study 2: U.S. Undergraduate Views Related to Teaching Evolution and Creationism

To better understand relationships among students' views about pedagogy and biological change, a series of written surveys were given to 113 paid University of California at Berkeley undergraduates (Schindel & Ranney, 2001). Four clusters of questions were presented, two of which we discuss here. Each student selected, from a given set of five statements in each cluster, the statement that best expressed his/her opinion; the student followed the choice with three written elaborations: (a) paraphrasing the chosen statement, (b) explaining how the statement matched his/her own opinions, and (c) explaining how the statement differed from his/her opinion. Quantitative and qualitative analyses were performed on objective and open-ended responses, respectively.

Question 1's five alternative statements regarded the origins and development of life on Earth, running a continuum from one typical of non-theistic evolutionists to one typical of no-evolution creationists; intermediate statements included those representative of theistically initiated evolution, deity-intervening evolution, and all-but-human evolution (i.e., human exceptionalism). Question 2's

five alternatives focused on schools teaching about creation and/or evolution, running a continuum from one typical of evolution-only adherents to one typical of creation-only adherents (and one for those who believe *neither* should be taught); intermediate statements included the notion that both should be taught in schools (but need not be in the same class), and that both should be taught *side-by-side* in schools.

The objective choices and written responses received both intensive quantitative analyses and qualitative analyses; for instance, logistic regression statistical analyses were employed, and undergraduates' writings were subjected to a 14-code protocol scoring rubric—with code-titles such as "Let students decide" and "Equal time: 50/50." These analyses suggested the presence of three main groups of respondents (the third of which seemed least coherent as a cluster) and a fourth, residual, group. The groups generally become increasingly less likely to prefer the teaching of evolution in schools (and generally less likely to accept evolution), as ordered in what follows.

The first group, the "evolution advocates," believe that only evolution should be taught in schools; the group includes an atheistic subgroup that Schindel and Ranney (2001) termed "evolution warriors." Strongly evolutionist in their beliefs, they prototypically refer to church–state separations, and some focus on teaching evolution as teaching "proven facts." If creation *were* to be taught, they often suggest a particular, separate, non-science course (like philosophy).

The second group, the "fence-sitters," are more likely to believe that evolution and creation should both be taught, although not necessarily in the same class. They are less likely to name a course in which creation should be taught than do evolution advocates. Fence-sitters are also more likely than evolution advocates to find a role for a supreme being who intervenes in the evolutionary process, and they tend to focus on the pedagogical importance of multiple views.

The third, "side-by-side," undergraduate group subsumes two subgroups, due to a shared interest in teaching evolution and creation together—albeit for different reasons. The "pluralist" subgroup resembles the fence-sitters in focusing on the importance of diversity and freedom of thought. In contrast, the "no-evolution creationist" subgroup is motivated by the belief that species did not evolve, and thus that students need to receive alternatives to evolution.

The final, fourth, group of college students preferred excluding the teaching of evolution altogether. These (usually creationist) "evolution exclusionists" either believed that only creation ought to be taught *or* that neither evolution nor creation ought to be taught.

In general, our findings indicate that undergraduates' views are not mere reflections of either their beliefs or the strengths of a particular theory. Ranking the objective responses from the two questions on separate evolution-to-creation continua indicated that the more one accepted evolution, the more one wished evolution to be preferentially taught (Spearman's $r = 0.263$, $p < 0.01$; e.g., "No supreme being plays a role in evolution" was associated with "Only evolution should be taught in schools"; $x^2(1) = 6.67$, $p < 0.01$); however, the 0.263 correlation is hardly close to 1. Notions of fairness and freedom of thought/expression led the majority of the participants (71% of them, all coming from the fence-sitters and side-by-siders groups) to believe that schools should teach both evolution and creation (cf. Brem et al., 2003). The most frequently tallied of the 14 written response categories (30% of responses) was the one that included responses indicating that multiple or all views/sides should be taught.

An interesting element among the undergraduates' responses was that they seemed to view evolution and creation as inherently in conflict (consistent with prior work by Kaufman, Thanukos, Ranney, Brem, & Kwong, 1999; also see below). For instance, in contrast to the rhetoric one often hears associated with evolution and biology education, only three of the 113 participants volunteered that evolution and creation should *not* be viewed as incompatible. Regardless of where individuals fell on the continuum of evolutionary–creationist acceptance, most of our participants seemed to view evolution and religion as competitive or even incompatible. This is one of the reasons that the undergraduates would so often advocate letting students decide for themselves between the "two sides." Some even suggested that students choose the *one* view that is right for them, which is perhaps a multiplist epistemological perspective on evolution.

This study reveals that many U.S. residents—perhaps most of them—view evolution and religion as incompatible (see more evidence of this below), regardless of where they fall on a spectrum of "atheistic evolutionists" to "anti-evolution creationists." This conflict may not be logically necessary (as many flavors of God-believing, evolution-accepting Americans, including some prominent biologists, naturally point out), but it follows from the scientific principle of parsimony: given that species (including humans) arose, it is more likely that one process (i.e., evolution or creation) was involved than multiple processes (i.e., evolution and creation). (This point will be elaborated upon later.) However, people seem more nuanced with their educational preferences. They are more willing to balance children's educational needs by allowing a multiplicity of views about the origins and diversity of life.

We now return to some conjectural theorizing to help connect and contextualize results from the two studies. In doing so, we discuss why Americans seem more likely to consider themselves special, why that reflects a modest national evolutionary orientation (which is one in a reasonably coherent configuration of salient ways in which the U.S. is an outlier nation; e.g., Paul, 2005), and why so many in the U.S. would even entertain teaching creation alongside evolution in schools.

The Received View of the U.S. Divergence Phenomenon

As befits evolution—a realm of inquiry that involves historical analysis—answers to the divergence question tend to revolve around history. In brief, what Ranney (in press) calls the "received view" of U.S. divergence, although not often made this explicit (cf. Scott, 2004, 2006), is as follows: A society founded upon both (a) isolated frontier needs and (b) immigrants seeking religious (and speech, etc.) freedoms yielded (c) rather fiercely decentralized governmental (e.g., school district) and religious control, leading to (d_1) fundamentalist Christian groups, (d_2) anti-evolutionism in school curricula, and—because of (d_1), etc.—(e) rather low evolutionary acceptance among U.S. adults (relative to peer nations).

This received view has some problems, though (Ranney, in press). First, its adherents often focus largely on religion because (b) and (d_1) are among the precursors for (e), the U.S. divergence phenomenon. However, reasons for the U.S.'s religious mixture—and its anomalous religious fervor (given its security and wealth; Norris & Inglehart, 2004)—are far from clear and open to many other interpretations. Indeed, Norris and Inglehart effectively negate part of the received view—that religious pluralism and a lack of regulation yield greater national religiosity, as the U.S. is again a distinct outlier on that score (also see Paul, 2005). Furthermore, creationist fundamentalism is not the only source of resistance to scientific thinking; for instance, Griffin (2007) suggests that people often try to satisfy goals about affect, rather than accuracy (so one's goals interact with one's scientific beliefs, in contrast to them being readily compartmentalized separate spheres). In addition, religion (even conjoined with a frontier history, to the degree that the U.S. is more "frontier" than other nations) is only one way that the U.S. diverges from peer nations; its society has also had a dramatically different geopolitical, social, and economic development (cf. Paul, 2005). Further still, the received view uses a century-old fundamentalist religious framing (i.e., The Twelve Fundamentals, booklets from 1910 to 1915; Scott, 2006, p. 450; also see Scott & Matzke, 2007). Finally, by focusing more on the laggard (i.e., the U.S.) than the advanced, the received view largely ignores other possible answers to the U.S. divergence question—a question that should *also* be phrased, "Why have peer nations accepted evolution more readily than the U.S.?"

The RTMD (Reinforced Theistic Manifest Destiny) View of the U.S. "Divergence"

Ranney (initially mentioned in Ranney, 1998, and elaborated in Ranney, in press) offers a conjectural answer to the divergence question; as it helps frame our results, it is described here to the degree space allows. The conjecture expands the received view, offering more predictive power. In a nutshell, the

received view seems to lack an updated geopolitical perspective that includes national reinforcements regarding theistic manifest destiny—particularly feedback about war and (perhaps less so) economics. The expansive conjecture, now called reinforced theistic manifest destiny theory (RTMD; Ranney, in press), focuses on how nations are militarily, economically, or otherwise reinforced regarding their collective desires (e.g., for stature, security, and prosperity)—and on how the reinforcements impact nations' theistic (and related) beliefs. World War II (WWII) represents a central RTMD event, as it (and/or World War I) markedly affected virtually all of the 34 nations in Miller et al.'s (2006) recent and striking evolution survey. The U.S. ranked only 33rd of these nations in evolutionary acceptance—results that are core data for RTMD as it employs 20th century military, economic, and geopolitical history to generally account for several of the ways in which the U.S. is, societally (e.g., Paul, 2005), an outlier among its otherwise more natural peer nations.

Only the gist of RTMD can be provided here (but it is expanded upon in Ranney, in press). The theory includes intentionally colloquial, national-identity, stochastic, and metaphorical constructs, such as a nation being an "organism" "reinforced" for a war or (as below) that a nation's "god" "won" a war for them (e.g., the "national god" of the U.S. in both WWI and WWII vs. that of Germany). Of course, a victorious nation may formally have many religions and/or multiple "gods." A more obvious caveat is that RTMD is a (fairly historical) theory, and all theories—even ones about gravity—are likely to be inaccurate in detail, and perhaps even in gist.

Given these caveats, RTMD theory's gist is: (1) From 1859 (Darwin's publishing *On the Origin of Species*) to 1917, the U.S. was not alone in being slow to accept evolution, but likely slower than Europe, due to factors noted in the received view. (2) Since WWI, WWII, and beyond, the U.S. has been uniquely reinforced as a military and (less so) an economic victor, helping maintain or enhance in its populace mutually supportive notions of religiosity, belief in an afterlife, and manifest destiny. (3) These effects further retarded the U.S.'s acceptance of evolution (and perhaps retarded the U.S.'s acceptance that humans are at least partially causing global climate change; see Ranney, in press, and data from Leiserowitz, 2007; also see remarks by Dr Gavriel Avital, chief scientist of Israel's Education Ministry, in which he both connects and explicitly doubts the plausibilities of evolution and global climate change; Kashti & Rinat, 2010).

The RTMD theory accounts for a good deal of evidence—from anecdotes to formal data sets. For instance, a Japanese colleague (different from the one mentioned above) noted that Japan's textbooks excluded Shinto creation myths after WWII, when its emperor effectively renounced Imperial divinity. Reinforced theistic manifest destiny theory suggests that the Japanese "god" lost, and that Japan understood this as a reinforcement about how its theistically linked manifest destiny had ebbed. The theory further suggests that this

is why Japan ranks high in accepting evolution—fourth of 34 (Miller et al., 2006). In contrast, the big victor of WWII, the U.S., ranks 33rd—sandwiched between the only two countries surveyed that have major non-Christian influences: Cyprus (32nd) and Turkey (34th).

Reinforced theistic manifest destiny theory's cognitive competition model is supported by national and international data—as well as elements of logic. For empirical support, if one examines data from the 13 nations in common among Norris and Inglehart's (2004) corpus and Miller et al.'s (2006) corpus (including the U.S., Japan, and much of Europe), one notes that countries that rank high in accepting evolution rank low in (a) believing in an afterlife and (b) believing in God (i.e., strong *negative* correlations result; both r's$=-0.8$; $p<0.001$; Paul, 2005, noted a related theism–evolution anti-link across 11 nations). In terms of logic, recall that RTMD holds that the U.S. is more likely, among peers, to view God as "on its side," and this inhibits the atheistically correlated evolutionary view. Virtually no atheists are creationists; this conjunction is basically an empty cell in the 2×2 matrix when one crosses "evolution vs. creation" with "theism vs. atheism." The cell's void helps drive the theism–evolution anti-correlation (i.e., the competition). Consistent with this logic, Preston and Epley (2009) recently reported data consistent with an automatic opposition between "God" and "science"—including an experiment that highlighted scientific origins (namely, the big bang and primordial soup notions).

Reinforced theistic manifest destiny theory is also supported by some verbal report data. Ranney (in press) notes that many people, if not most—even those with postgraduate biology degrees—prefer biological evolution to *not* be "true." Typically, when asked for their reasoning, people essentially replied: "Duh; God!" That is, while not formally contradictory, a creation-spawning deity at least indirectly competes with evolution in explaining species because parsimony suggests that one *or* the other is in force (and less likely both—just as parsimony can suggest that the K-T extinctions were due to an asteroid *or* volcanoes, rather than both; also see Preston & Epley, 2009). In connectionist modeling terms (e.g., Ranney & Schank, 1998), parsimony means that reducing the relative probability of evolution increases the relative probability of a deity, which increases the relative probability of life after death—which seems to be a major motivational reason to prefer the absence of evolution. In short, most people prefer evolution not to be true due to its undesirable coherence with "just moldering in the grave." Similarly, the five evolutionary impact areas Brem et al. (2003) studied and found to be relative "downers" if evolution were true—namely, plausibly reducing spirituality, self-determination, and a sense of purpose, while enhancing (otherwise heaven-inhibiting) selfishness and racism—implicitly engage the idea of an afterlife as a kind of "just desserts."

Many of the post-WWII dynamics of Japanese, German, and U.S. (and others') beliefs in an afterlife also seem consistent with RTMD's competition model (Ranney, in press). Data about the East/West German divide (Kutschera, 2008), data across English-speaking nations (Norris & Inglehart, 2004; Paul, 2005), combat death data (e.g., Fischer, Klarman, & Oboroceanu, 2007), and many historical considerations (e.g., some in Ruse, 2005, but many more—about invasions, the absence of invasions, military occupations, and economics) also cohere with the notion that a U.S.-benevolent deity preferentially shepherds its citizens to a good afterlife (Ranney, in press).

Because the received view of U.S. divergence focuses more on description than generativity, it is unclear what it predicts. Reinforced theistic manifest destiny theory, though, offers predictions about the potential for changes in the U.S.'s (and other nations') public acceptance of evolution (Ranney, in press), and predicts many relationships that are empirically testable in controlled settings. Across multiple surveys, Ranney (in press) has already observed a good number of RTMD-compatible correlations (or negative correlations, as appropriate) among beliefs about evolution, creation, theism, nationalism, the afterlife, and global climate change. (Also consistent with RTMD, our laboratory has found our atheistic participants to be the least nationalistic and the most accepting of evolution—while being part of the vanguard of accepting global climate change.) Laboratory manipulations—such as manipulating nationalistic emotions—may affect ratings on five or more related dimensions (e.g., evolutionary acceptance and even the idea that our planet's temperature increases are largely being caused by human activities). The theory thus has implications for individual cognition, U.S. diplomacy, and purported U.S. anti-intellectualisms (e.g., Ranney, in press).

If one believes that one's nation is the best—morally, militarily, or due to God's selective grace—one is likely to de-activate acceptance among discordant elements, such as evolution, to yield greater explanatory coherence (cf. Ranney & Schank, 1998; see Lombrozo, Shtulman, & Weisberg, 2006 for some links among morality, science, and evolution). This inhibition should be especially heightened for *human* evolution, leading to human exceptionalism (see the studies above, and Miller et al., 2006; Scott, 2000; etc.)—after all, a nation's non-humans (e.g., shrubs and owls) rarely go off to war. Therefore, we would expect people in the U.S. to be more comfortable with explanations about evolutionary changes in plants than in humans. Although Study 1's results were much richer than just this human reticence effect, this element of RTMD's predictive character was borne out.

Why Evolution Matters: Possible Implications of Human-Centrism and the RTMD View

Knowledge or understanding without acceptance is inert—it is rather like how we may understand a lot about Zeus (or the galaxy from the Star Wars films) but do not act on that knowledge because we reject its veracity. Is it all right that many in the U.S. "understand but reject" biological evolution—as if

it would rarely, if ever, entail action? We were recently at an evolution-cognition conference at which a group of about 50 were asked why students' acceptance of evolution is important. (This question is revisited at this piece's end.) Even though many in the room knew the question was coming, it was greeted initially with silence and then responses that implicitly deflected the question. When the question was reiterated, the few responses were unimpressive and well-worn ones, such as why one should take all the pills one's physician prescribes. Virtually all of the voiced responses involved within-species changes and did not directly address questions of possible extinction(s), "die-offs," or dramatic lifestyle changes for humans. In short, none of the reasons for accepting evolution seemed to rival its potential import regarding environmental stewardship—for instance, regarding anthropogenic global climate change.

In contrast, RTMD explicitly addresses how thoughts about evolution connect to those about climate change. There may be common cause(s) between the U.S.'s over-representative contribution to Earth's warming and the country's peer-divergence in evolutionary acceptance (and theistically related beliefs). A nation that fails to fully understand or accept evolution may be less likely to readily act in ways to reduce the expected mass extinction of species (Wake & Vredenburg, 2008)—possibly including we humans. (A 4°C rise may yield over a 90% human "cull" (Vince, 2009)—yet Poling & Evans' 2004 data suggest that many U.S. adults do not even believe human extinction is *possible*.) Evolutionary non-acceptance would hardly be the sole cause of the U.S.'s carbonic overindulgence, but a society that more fully understands that environmental changes (whether atmospheric or biospheric) drive extinctions would likely act more quickly to reduce its international pollution asymmetry. We note that Brazil, site of mass Amazonian deforestations, also has a rather modest evolutionary acceptance rate (which RTMD may also account for). If most models of global climate change are apt, then the divergence problem (cf. Europe) may hardly be a "merely academic" concern.

Ultimately, the received view model (see (a)–(e) above), which helps explain pre-WWI U.S. religiosity, must be elaborated on and extended by RTMD differently for each particular nation's history. For nations like the U.S. that appeared to win WWI and WWII (and perhaps other wars)—especially when accomplished with rather mild trauma—RTMD conjectures: (1) that pre-WWI notions of humans as special (e.g., to a deity and/or as a species) were reinforced (as were the usual human optimism biases; Lovallo & Kahneman, 2003), and (2) that this specialness notion is suggested to have slowed both the acceptance of evolution, as well as—more speculatively—the U.S. acceptance of human-generated climate changes. For nations that were most scathed by wars, though, it is conjectured that notions of human specialness were inhibited, leaving national cultures that were more likely to accept evolution and perhaps even (at least partially) human-driven global climate change.

Beyond what is cited above, the U.S. is also an outlier nation in not ratifying the international Kyoto protocol on climate change and in delaying action on the protocol's successor—suggesting a harmful collective denial. Ranney (in press) notes several ways in which the high U.S. religiosity (Norris & Inglehart, 2004), fanned by RTMD influences, may have caused some subsets of U.S. society to, by act or thought, ignore global climate change. Given that Earth's warming may cause many catastrophes, if RTMD is correct, it seems critical for science educators to redouble their efforts to inform students and U.S. citizens about biological evolution. Otherwise, biospheric changes may lead to an evolutionary path quite different from the one pre-industrial Earth was on (e.g., CO_2 levels were just 73% of recent levels in the year 1750; Intergovernmental Panel on Climate Change, 2007). Further, RTMD theory has implications for classroom practice, as it suggests that teaching about global climate change (or even the ills of nationalism, perhaps) may yield students who are more likely to understand and accept biological evolution—without even confronting students' religious beliefs.

Summary and Conclusions

We have tried to articulate a number of aspects that highlight the richness and centrality of the cognition of evolution in people's lives. Although the empirical studies carried out were with U.S. undergraduates, our findings' implications go far beyond both our samples and U.S. borders. Study 1's experiments highlighted human exceptionalism in its finding of a human reticence effect (in contrast to plants) regarding accepting evolutionary explanations. This effect coheres well with the reinforced theistic manifest destiny theory (RTMD) described above (Ranney, in press), which incorporates and extends prior thinking about why the U.S. diverges from peer nations in its relatively diminutive acceptance of evolution as accounting for biological change. Study 1's other findings also relate well. In particular, RTMD resonates with several of Table 7.4's "factors that may influence the acceptance of evolutionary explanations"—especially "consistency with worldview." The other factors are more indirectly related to RTMD, but related nonetheless; for instance, even the perceived adaptiveness of a feature can be a function of whether your theo-political worldview allows you to have a positive view of evolution, such that you have more familiarity with the topic, and such that you will consider the environment to be less of a determinant of the feature.

One of Study 2's findings was that even relatively strong acceptors of evolution, while largely viewing that acceptance as conflicting with creationism, still believed that both evolution and creationism should be taught in schools; indeed 62% of non-theistic evolutionists advocated teaching both perspectives. The data suggest a culture that continues to be dominated by the traditional U.S. principles of fairness and freedom of choice (which infuse both the received view's and RTMD's explanations of the U.S.'s modest acceptance of evolution). These principles are laudable in many aspects of society (although

the U.S. has not cornered the market on them), but they cause problems when the drive for equity allows dramatically less scientific (or evidence-infused) explanations such as creationism to encroach on science instruction; we have good reasons to no longer present astrological, phrenological, geocentric, and flat-Earth theories alongside more normative scientific ones, and those reasons apply to creationism. (See Griffith & Brem, 2004, Sinatra, Brem, & Evans, 2008, and Thagard & Findlay, 2010, etc., for some perspectives on the many issues relating to teaching evolutionary biology.)

As noted above, RTMD is a historical account, even as it involves a good deal of cognitive and social theorizing. Some of the conjecture's implications need more development—for instance, that the U.S. reluctance to more aggressively combat anthropogenic climate changes (Leiserowitz, 2007) may have causal roots similar to those that yield the U.S.'s reluctance to fully embrace evolution. In essence, RTMD theory seeks to further extend theorizing about the development of evolutionary understanding beyond individuals—to cultures, to all nations, and to international groups. Of course, as is the way of virtually all theories, it may be subsumed by other ideas, rejected due to some failing(s), or substantially modified due to more data and considerations; hopefully, the theory will prove productive for now.

Since science educators are among this volume's intended readers, let us revisit this piece's focus on the acceptance (e.g., across organisms) and teaching of evolution. In many arenas, acceptance is tantamount to performing reasonably: If one truly doesn't accept chemistry, one is more likely to ingest poison; denying the physics of friction means one's car may quit for want of oil; rejecting supply-and-demand economics may lead to opening yet another café in downtown Seattle; denying physiology might lead to putting off life-saving treatments. However, farmers and ranchers who explicitly reject evolution can still raise produce and livestock effectively. So, if evolution were "just history," why should educators care if students accept it, or if it were only accepted for a subset of species? We believe there are two main reasons for such caring, which need not be seen as of equal weight. First, evolution is the future as well as the past. *Our* future seems to bring nontrivial global climate change, which holds many evolutionary entailments about extinctions and lifestyle, as well as both intra- and interspecies change. So, we must not shrink from frank explications of evolution, regardless of where they lead us. The second reason is that people should accept evolution, for now, if it is the theory that accounts for the greatest breadth of data with the most coherent, parsimonious, etc., explanations. By our lights, it is *clearly* that theory.

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Notes

1. Although the category "animal" technically encompasses humans, they will be herein treated as non-overlapping categories, because they are often viewed as such—and to avoid the cumbersome phrase "non-human animal." This approach is consistent with that taken by many attitudinal studies of evolution, which inquire about human evolution explicitly and don't assume that accepting evolution in some situations implies acceptance of human evolution.
2. In addition, each Likert survey included an item probing evolution's ability to explain traits of *all* living things. The study design was balanced such that six different survey versions were examined, with three different positions for the general item (before the first section, after the first section, and after the last section) and two section orderings (plant→animal→human or human→animal→plant). The section ordering mattered, as participants who saw the low-rated human evolution items first gave relatively high average ratings compared to those who saw the plant evolution items first (Thanukos, 2002); without checking for order effects, one might have mistakenly concluded human evolution to be as (or more) acceptable than plant evolution to the students.
3. Mean responses within survey version and section were not consistently normally distributed, exhibiting left skewness (*skewness/SES* < −2) and significant kurtosis (*kurtosis/SEK* > 2), likely due to a ceiling effect. To allow the use of analyses of variance (ANOVAs), the data were transformed (by $[x+4]^{2.5}$) to more closely approximate normal distributions, eliminating significant skewness and kurtosis, reducing the spread, and yielding distributions with similar standard deviations. The ratio of the largest standard deviation to the smallest standard deviation of the transformed scores was less than two, supporting the use of ANOVAs (Moore & McCabe, 1993). Nonparametric tests were also performed and yielded similar patterns of significance to those obtained using parametric statistics on transformed data; back-transforming the transformed data also yielded appropriate results (Thanukos, 2002).
4. Participants also responded to the item probing evolution's ability to explain characteristics of all living things.
5. When appropriate—as here—all p-values are Bonferroni adjusted.
6. Brem et al. (2003) did not compare human evolution with evolution in other organisms, but these associations would seem stronger if accepting evolution entails accepting human evolution and less strong if it does not.
7. Analysis 2 also revealed, as expected, a main effect regarding attitude [$F(2,73) = 11.64$, $p < 0.001$]: those negative toward evolution gave lower ratings than those neutral and positive [$p < 0.01$ for each contrast] (see Table 7.2, part II).
8. Analysis 3 also revealed a main effect of framework type ($F[1,75] = 8.53$, $p < 0.01$),

with similarity items rated higher than adaptation items [$t(227) = 3.60$, mean diff = 10.09 ± 5.52, $p < 0.001$].

9. Note that the relevant three-way interaction involving attitude toward evolution is non-significant, possibly due to power limitations relating to a relatively low number of negative attitude participants.
10. Within-section contrasts suggest that those positive or neutral toward evolution rate human similarity items above human adaptation items ($p < 0.01$; see Table 7.3, part I), but rate plant and animal items similarly.

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