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Chapter 3

**THE EVERLASTING CONFLICT
EVOLUTION-AND-SCIENCE
VERSUS RELIGIOSITY**

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ABSTRACT

In this chapter, we examine theoretically and quantitatively the relationship science-and-evolution awareness versus religiosity. For this, we use a Cartesian landscape where the dependent variable acceptance of evolution is plotted as function of three factors: religiosity or an individual's personal belief-convictions, level of understanding the essence of science, and familiarity with the concept of evolution. We contrast acceptance of evolution among five United States (US) and international populations, including: university professors in various disciplines, an equally highly trained group of specialized protisto-biologists, atheists, educators of prospective teachers, and college students (Grand Total $N = 1,665$ participants in scientific online polling). We discuss evidence in support of the hypothesis that the controversy over evolution-and-science versus religiosity is inherent to the incompatibility between scientific

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rationalism/empiricism and the belief in supernatural causation. We report that the levels of understanding of science and evolution by the faculty, protisto-biologists, educators, and students decreased with increasing religiosity (= negative association of variables), and that the levels of understanding evolution increased with increasing understanding of science (= positive association of variables). Interestingly, the atheists, who had wide range of educational attainment and zero religiosity, had comparable levels of understanding the foundations of science and evolution to the highly educated faculty and protisto-biologists. The educators and students were the least knowledgeable about science/evolution and the most religious. After comparing our findings with the patterns of acceptance of evolution in the US and the world –and in the context of religiosity— we conclude that if science and religion *co-persist* in the future, the relationship between them will fluctuate between moderate and intense antagonism.

INTRODUCTION

The controversy over evolution-and-science versus religiosity –the latter exemplified in this chapter by creationists views about the origin and evolution of life on Earth, including Design Creationism or Intelligent Design, see **Box 1**— is inherent to the incompatibility between scientific rationalism/empiricism and the belief in supernatural causation (Paz-y-Miño-C and Espinosa 2012a). Here we examine this hypothesis theoretically and quantitatively by conceptualizing a Cartesian landscape where the dependent variable acceptance of evolution is plotted as function of three factors: first, religiosity or an individual’s personal belief-convictions; second, his/her level of understanding the essence of science (as method to explore reality); and third, his/her familiarity with the processes and forces of change in organisms (the concept of evolution). We contrast levels of acceptance of evolution among samples of five populations of variable educational attainment, including: (1) highly educated university professors of New England, United States (US); (2) an equally highly trained group of specialized international scholars in protistology –a subfield of biology dedicated to the study of unicellular organisms that have a nucleus; the protistologists, as expected, were particularly knowledgeable about science and evolution— native to 25 countries; (3) a group of atheists, non-believers and agnostics native to 35 states in the US; (4) a group of educators of future educators –that is college and university faculty specialized in training prospective teachers— from all 50 states in the US; and (5) a representative group of college students from public, secular private, and religious institutions in New England, US.

Box 1. Evolution, Creationism, Design Creationism or Intelligent Design.

Evolution.—The concept of evolution provides naturalistic explanations about the origin of life, its diversification and biogeography, and the synergistic phenomena resulting from the interaction between life and the environment (Paz-y-Miño-C and Espinosa 2011b); mutations, gene flow, genetic drift and natural selection shape life's biological processes in Earth's ecosystems (Mayr 2001). Since the publication of *The Origin of Species* by Charles Darwin, in 1859, Darwinian evolution has been scrutinized experimentally; today the *theory of evolution* is widely accepted by the scientific community (Coyne 2009; Dawkins 2009; Paz-y-Miño-C and Espinosa 2011a, b, 2012a).

Creationism.—In contrast to evolution, creationism, theistic evolution, creation science or young-earth creationism (Petto and Godfrey 2007; Matzke 2010; Phy-Olsen 2010) rely on supernatural causation to explain the origin of the universe and life. These views are not recognized by scientists as evidence-based explanations of empirical reality (Padian 2009; Scott 2009; Paz-y-Miño-C and Espinosa 2009a, b, 2011a, b), or of cosmic processes which, according to modern understanding of “cosmic evolution,” do encompass the formation of the universe, the emergence of the simplest elements that transformed into more complex elements and molecules, including prebiotic compounds in our planet and that, ultimately, led to the evolution of molecular diversity and complexity of today's living organisms and ecosystems (see Zaikowski et al. 2008; Krauss 2010; Paz-y-Miño-C and Espinosa 2011b, 2012a).

Design Creationism or Intelligent Design.—The doctrine of ID, born in the 1980s, proposes that a Designer is responsible, ultimately, for the assemblage of complexity in biological systems; according to ID, evolution cannot explain holistically the origin of the natural world, nor the emergence of intricate molecular pathways essential to life, nor the immense phylogenetic differentiation of life, and instead ID proposes an *intelligent agent* as the ultimate cause of nature (Pennock 2001; Young and Edis 2004; Forrest and Gross 2007a, b; Miller 2007, 2008; Petto and Godfrey 2007; Phy-Olsen 2010). In conceptually mistaken, type-I-error-based arguments to discredit evolution, ID has attributed randomness to molecular change, deleterious nature to single-gene mutations, insufficient geological time or population size for molecular improvements to occur, and invoked “design intervention” to account for complexity in molecular structures and biological processes (Paz-y-Miño-C et al. 2011). In 2005, ID was exposed in court (Dover, Pennsylvania, Kitzmiller et al. versus Dover School District et al. 2005; Padian and Matzke 2009; Wexler 2010) for violating the rules of science by “invoking and permitting supernatural causation” in matters of evolution, and for “failing to gain acceptance in the scientific community.” Today, “design creationism” (as we refer to ID due to its designer/creator-based foundations; Pennock 2001; Paz-y-Miño-C and Espinosa 2010, 2011b; Paz-y-Miño-C et al. 2011a, 2012a) although defeated by science and in the courts, grows influential in the US, Europe, Australia and South America (Cornish-Bowden and Cárdenas 2007; Padian 2009; Branch et al. 2010; Forrest 2010; Matzke 2010; Wexler 2010).

The over representation of New Englanders was deliberate, considering their progressive and liberal socio-political views (which allowed comparisons with their international protistologists counterpart, who were equally progressive, data below) and public level of acceptance of evolution, 59%, which is the highest in the US (The Pew Research Center for the People & the Press 2005). In addition, New England is the least religious region in the US, where 27% of its citizens are “very religious” (i.e. they state that religion is an important part of their daily life and attend religious services weekly) in contrast to an average 40% in the whole US (The Gallup Poll 2012).

We selected the groups above to assess not only acceptance of evolution as function of the variables religiosity, science and evolution literacy, or as function of differential education level (from professors in diverse disciplines to college students), but also in association with zero religiosity, represented by the views of atheists, non-believers and agnostics (all explicitly confirmed to their no religiosity). Each of the five groups, therefore, represented a data point for comparative analysis and also served as a control of group attributes. For example, the professors of New England, the protistologists, and the educators of prospective teachers represented highly educated audiences in multiple fields of expertise (= New England faculty in 40 research-based disciplines within a single nationality and/or country of residence; protistologists in a single field of research from multiple nationalities and/or countries of residence; educators of prospective teachers in a non-science field, in 32 education specializations, and within a single nationality and/or country of residence); the atheists, non-believers and agnostics (= in a range of educational attainments, mostly outside academia, and within a single nationality and/or country of residence); and the students (= within a range of college educational levels, from freshman to senior, within a single nationality and/or country of residence). The profiles of these five populations have been extensively discussed in our previous publications (Paz-y-Miño-C and Espinosa 2012a, b; 2011a; 2009a, b).

CONCEPTUAL AND QUANTITATIVE ASSESSMENT OF ACCEPTANCE OF EVOLUTION AS FUNCTION OF THREE VARIABLES: RELIGIOSITY, SCIENCE AWARENESS, AND EVOLUTION LITERACY

In a previous study (Paz-y-Miño-C and Espinosa 2012a), we plotted the dependent variable *acceptance of evolution* in a three-dimensional Cartesian

coordinate landscape where the independent variables, *personal religious convictions*, *understanding how evolution works*, and *understanding the essence of science*, occupied the axes x , y , and z , respectively (**Figure 1**). The point zero, from which the coordinates originate, corresponds to a low (labeled *none*) religiosity, evolution, or science awareness condition, or a *no awareness corner*, which is a low probability of occurrence corner (LPC). Away from zero, the tips of the coordinates' arrows correspond to a high or *deep* religiosity, evolution, or science awareness. The highest acceptance of evolution corner is located in the top right of the landscape, where religiosity is low or none and evolution and science awareness are high or deep. The lowest acceptance of evolution corner is located in the bottom left of the landscape, where religiosity is high or deep and evolution and science awareness are low or none. A potentially highest personal conflict corner resides at the intersection of high or deep religiosity and evolution and science awareness; this potential conflict condition, however, can be resolved by an individual adopting self-comforting positions, such as: evolution and creationism are in harmony, non-overlapping magisteria (NOMA = the view that science and religion occupy separate domains; as in Gould 1999), or declaring agnosticism (= doubting about the existence or nonexistence of a deity). Note that four other corners are labeled LPC in **Figure 1** due to their low probability of occurrence (e.g. high or deep understanding of science combined with no understanding of evolution and no religiosity, which is unlikely; after Paz-y-Miño-C and Espinosa 2012a).

To quantitate the levels of religiosity, understanding of science and the evolutionary process and plot them according to the parameters depicted in **Figure 1**, we (Paz-y-Miño-C and Espinosa 2011a, 2012a, b) have used three descriptive indexes as characterizers of acceptance of evolution (each ranging from 0 to 3; least to most religious or knowledgeable about science or evolution): Religiosity Index *RI* (after The Pew Global Attitudes Project 2007), Science Index *SI* and Evolution Index *EI* (both after Paz-y-Miño-C and Espinosa 2011a, 2012a, b). These indexes are powerful predictors of religious views worldwide (47 countries; The Pew Global Attitudes Project 2007) and of levels of understanding science and the evolutionary process (e.g. sample of 1,665 US and international adults with diverse academic backgrounds, from college students to university professors; Paz-y-Miño-C and Espinosa 2011a, 2012a, b, this chapter). Each index relies on examining responses to simple, informative questions: Religiosity *RI*: +1 if responders believe that *faith in God is necessary for morality*, +1 if *religion is very important in their lives*, and +1 if *they pray daily*. Science *SI*: +1 if responders reject the idea that *scientific theories are based on opinions by scientists*, +1 if they disagree with the notion that *scientific arguments are as valid*

and respectable as their non-scientific counterparts, and +1 if they reject the statement that *crime-scene and accident-scene investigators use a different type of scientific method to investigate a crime or an accident*; Evolution EI: +1 if responders reject the idea that *organisms acquire beneficial traits during their lifetimes and then pass on these traits to their descendants*, +1 if they disagree with the notion that *during evolution monkeys such as chimpanzees can turn into humans*, and +1 if they reject the statement that *the origin of the human mind and consciousness cannot be explained by evolution*.

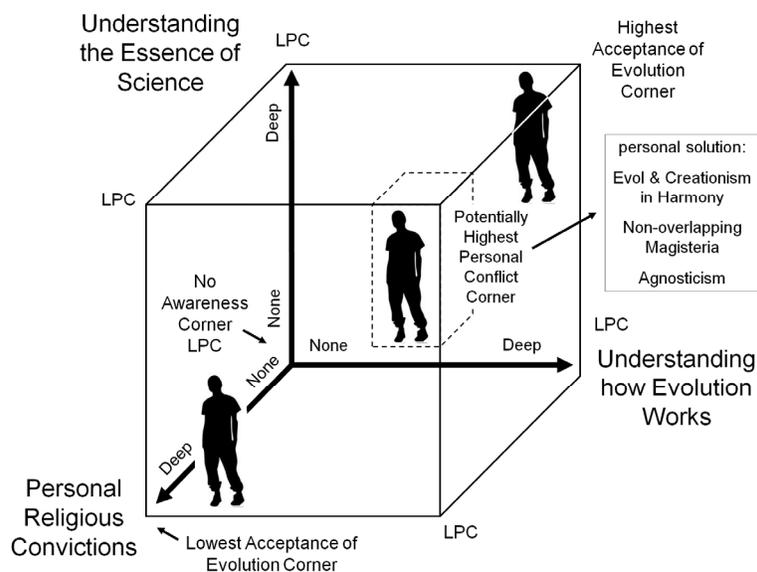


Figure 1. Theoretical three dimensional landscape where acceptance of evolution is depicted as function of religiosity, science awareness, and evolution literacy. The point zero corresponds to low/none personal religious convictions, understanding how evolution works, or understanding of the essence of science; zero is a *no awareness corner*, with low probability of occurrence (LPC). The tips of the coordinates' arrows correspond to a high/deep religiosity, evolution, or science awareness. The *highest acceptance of evolution corner* (top right) is characterized for its low religiosity and high/deep evolution and science awareness. The *lowest acceptance of evolution corner* (bottom left) is characterized by its high religiosity and low evolution and science awareness. A potentially highest *personal conflict corner* resides at the intersection of high or deep religiosity and evolution and science awareness; this conflict condition can be resolved by the individual adopting comforting positions, such as: evolution and creationism are in harmony, non-overlapping magisteria (= science and religion occupy separate domains), or agnosticism (doubt about the existence or nonexistence of a deity). Other corners are also labeled LPC due to their low probability of occurrence (modified from Paz-y-Miño-C and Espinosa 2012a, Journal of Eukaryotic Microbiology, with permission).

APPLYING THE *RI*, *SI* AND *EI* CARTESIAN LANDSCAPE TO FIVE POPULATIONS

In **Figure 2**, we summarize the results of using this index approach to assess the patterns of acceptance of evolution as function of *RI*, *SI* and *EI* among the five populations mentioned above, which summarized profiles were (demographic details of each population are provided in Paz-y-Miño-C and Espinosa 2012a, b; 2011a; 2009a, b): 244 New England faculty (93% PhD/doctorate holders in 40 disciplines across 35 colleges and universities), 50 international protistologists (70% Ph.D./doctorate holders), 133 atheists, non-believers and agnostics (28% bachelors degree, 26% masters, 20% Ph.D./doctorate holders, 13% associate or technical degrees, 7% high school degree, and 6% professional degrees), 411 US educators of prospective teachers (85% Ph.D./doctorate holders in 32 education specializations), and 827 New England college students (freshman 26.3%, sophomore 24.3%, junior 23.6%, senior 25.8%; who were enrolled at three types of institutions: public 21.0%, secular private 50.5%, and religious 28.5%).

Note that although participants in our online surveys were asked to not skip questions, they could do it freely (= human subjects/Institutional Review Policies across institutions that granted permission to our studies); therefore, the total number of responders (*N* values) per group and per survey topic, which is reported in **Figures 2 to 6**, can vary; this should be evident when comparing among figure captions.

The New England faculty held the highest acceptance of evolution position as function of *RI*, *SI* and *EI* (**Figure 2**): 94% indicated to *accept evolution openly regardless of others opinions* and 82% thought that *evolution is definitely true* (*RI* = 0.49; *SI* = 2.49; *EI* = 2.49), followed by the atheists (93% and 90%; *RI* = 0.00; *SI* = 2.34; *EI* = 2.41), the protistologists (92% and 82%; *RI* = 0.46; *SI* = 2.30; *EI* = 2.48), the educators of prospective teachers (72% and 63%; *RI* = 1.31; *SI* = 1.98; *EI* = 1.77), and the students (63% and 58%; *RI* = 0.89; *SI* = 1.80; *EI* = 1.60).

When analyzing these patterns in more detail, we found –and this was noteworthy in respect to the atheists— that the levels of understanding the foundations of science and evolution among the professors, the atheists and the protistologists were statistically similar and higher than the educators’ or the students’ (**Figure 3a** and **b**); note that the latter two groups were statistically indistinguishable from one another. Although not surprisingly the atheists’, non-believers’ and agnostics’ religiosity was zero, the protistologists and New England faculty were the next least religious groups, followed by the educators of

prospective teachers, and the students (**Figure 3c**). Remarkably, the educators were significantly more religious than the students.

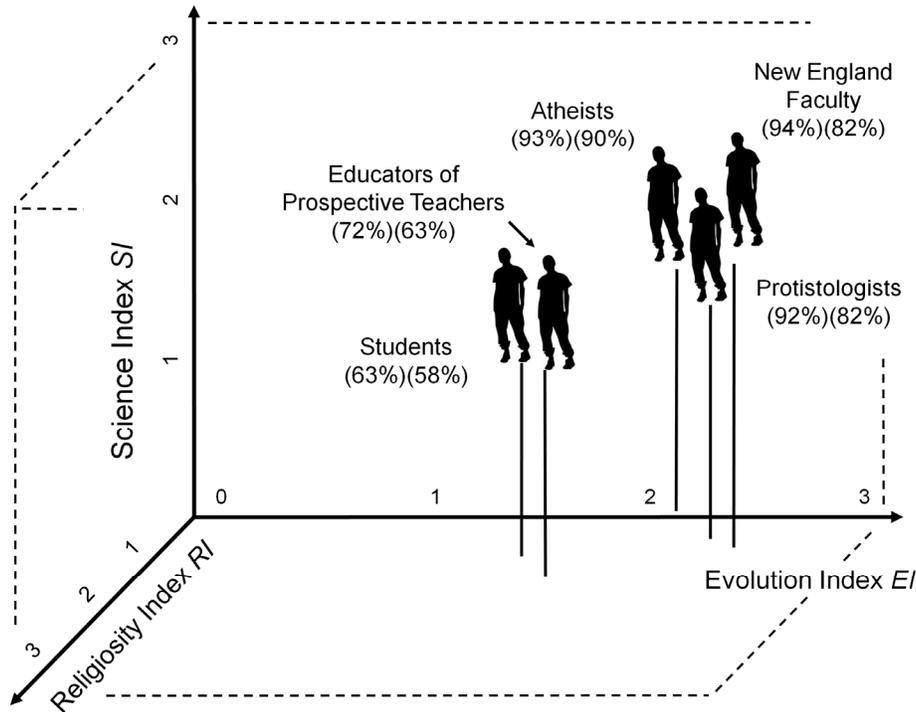


Figure 2. Acceptance of evolution plotted as function of religiosity (RI), science (SI), and evolution (EI) indexes. Each index ranges from 0 to 3 (least to most religious or knowledgeable about science or evolution; see text for details). The three-dimensional landscape is consistent with the theoretical parameters depicted in Fig. 1; note, however, that in this Figure the scale of each dimension differs to enhance the display of data. The New England faculty held the highest acceptance of evolution position ($N = 244$; $RI = 0.49$; $SI = 2.49$; $EI = 2.49$), followed by atheists ($N = 133$; $RI = 0.00$; $SI = 2.34$; $EI = 2.41$), protistologists ($N = 50$; $RI = 0.46$; $SI = 2.30$; $EI = 2.48$), educators of prospective teachers ($N = 411$; $RI = 1.31$; $SI = 1.98$; $EI = 1.77$), and students ($N = 827$; $RI = 0.89$; $SI = 1.80$; $EI = 1.60$). Percentage values written within brackets correspond to responders admitting to *accept evolution openly regardless of others opinions* (first value), or thinking that *evolution is definitely true* (second value).

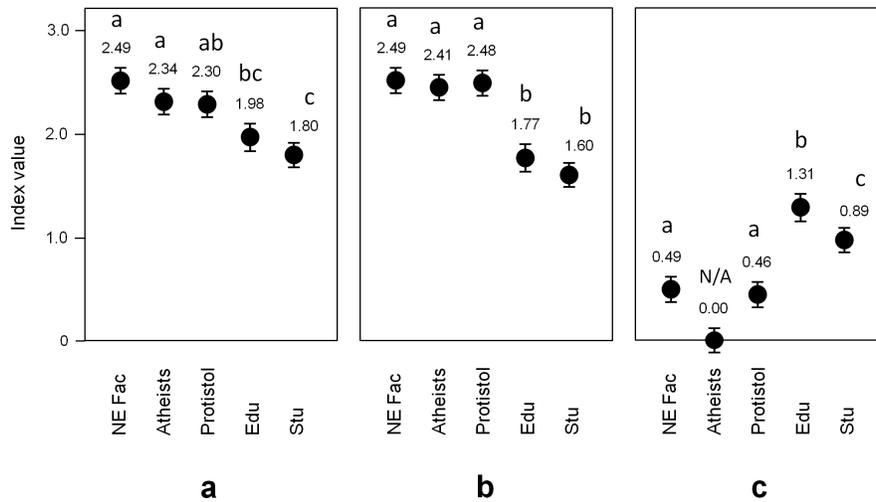


Figure 3. Understanding-of-science, evolution and religiosity indexes of New England faculty (*NE Fac*), atheists, protistologists (*Protistol*), educators of prospective teachers (*Edu*) and college students (*Stu*). Each index ranges from 0 to 3 (lower to higher levels of understanding of science and evolution, or least to most religious position) as follows: *a*, for the *understanding-of-science index*, responders received +1 if they rejected the idea that *scientific theories are based on opinions by scientists*, +1 if they disagreed with the notion that *scientific arguments are as valid and respectable as their nonscientific counterparts*, and +1 if they rejected the statement that *crime-scene and accident-scene investigators use a different type of scientific method to investigate a crime or an accident*; Kruskal-Wallis one-way ANOVA on ranks, $H = 119.336$, $df = 4$, $P \leq 0.001$. *b*, for the *evolution index*, responders received +1 if they rejected the idea that *organisms acquire beneficial traits during their lifetimes and then pass on these traits to their descendants*, +1 if they disagreed with the notion that *during evolution monkeys such as chimpanzees can turn into humans*, and +1 if they rejected the statement that *the origin of the human mind and consciousness cannot be explained by evolution*; Kruskal-Wallis one-way ANOVA on ranks, $H = 262.282$, $df = 4$, $P \leq 0.001$. *c*, for the *religiosity index*, responders received +1 if they agreed with the idea that *faith in God is necessary for morality*, +1 if they accepted the statement that *religion is very important in their lives*, and +1 if they admitted to *pray daily*; Kruskal-Wallis one-way ANOVA on ranks, $H = 95.678$, $df = 3$, $P \leq 0.001$ (N/A = non-applicable for Atheists whose RI = 0). Lowercase letters indicate Dunn-test two-tail pair-wise comparisons within groups $P \leq 0.05$. *NE Fac*, $N = 222$; *Atheists*, $N = 133$; *Protistol*, $N = 50$; *Edu*, $N = 411$; and *Stu*, $N = 576$. Error bars are standard errors.

INDEX ASSOCIATIONS BETWEEN RELIGIOSITY, SCIENCE AWARENESS, AND EVOLUTION LITERACY

The five groups showed directionality in the association between indexes (**Figure 4**). Except for atheists, non-believers and agnostics, whose religiosity was always zero ($RI = 0$; 100% of responders, **Figure 3c**), and science awareness and evolution literacy high ($SI = 2.34$ and $EI = 2.41$, respectively, 100% of responders, **Figure 4b, g**), the levels of understanding of science and evolution by the New England faculty, protistologists, educators of prospective teachers, and students decreased with increasing religiosity (= negative association of variables); in contrast, the levels of understanding of evolution increased with increasing understanding of science (= positive association of variables).

The scale at which the SI and EI indexes decreased as function of increasing RI was in accordance with the high levels of understanding of science/evolution, and low religiosity, by the faculty and protistologists in respect to an intermediate and low levels of understanding of science/evolution, and high religiosity, by the educators of prospective teachers and the students, respectively (first and second rows, **Figure 4**). Analogously, the scale at which the EI index increased as function of SI was in accordance with the high understanding of science/evolution by the faculty, atheists and protistologists, and the intermediate and low levels of understanding of science by the educators of prospective teachers and the students, respectively (third row, **Figure 4**).

Note as well the following pattern in **Figure 4**: in the context of SI versus RI comparisons, the highest to lowest levels of understanding of science by the faculty (NE Fac $SI = 2.59$ to 2.0 ; 69.8% to 3.2% of responders; index $R^2 = 0.964$, $P = 0.009$; **Figure 4a**), protistologists (Protistol $SI = 2.31$ to 1.33 ; 72.0% to 6.0% of responders; index $R^2 = 0.355$, $P = 0.202$; **Figure 4c**), educators of prospective teachers (Edu $SI = 2.15$ to 1.57 ; 35.5% to 18.5% of responders; index $R^2 = 0.814$, $P = 0.049$; **Figure 4d**), and students (Stu $SI = 1.97$ to 1.32 ; 53.5% to 12.3% of responders; index $R^2 = 0.969$, $P = 0.007$; **Figure 4e**) corresponded to the lowest to highest levels of religiosity ($RI = 0.0$ to 3.0) in each group, respectively.

In the context of EI versus RI , the highest to lowest levels of understanding of evolution by the New England faculty (NE Fac $EI = 2.53$ to 2.0 ; 69.8% to 3.2% of responders; index $R^2 = 0.811$, $P = 0.049$; **Figure 4f**), protistologists (Protistol $EI = 2.56$ to 1.33 ; 72.0% to 6.0% of responders; index $R^2 = 0.732$, $P = 0.072$; **Figure 4h**), educators of prospective teachers (Edu $EI = 2.16$ to 1.25 ; 35.5% to 18.5% of responders; index $R^2 = 0.986$, $P = 0.003$; **Figure 4i**), and students (Stu $EI = 1.67$ to 1.35 ; 53.5% to 12.3% of responders; index $R^2 = 0.894$, $P = 0.027$; **Figure 4j**)

corresponded to the lowest to highest levels of religiosity ($RI = 0.0$ to 3.0) in each group, respectively.

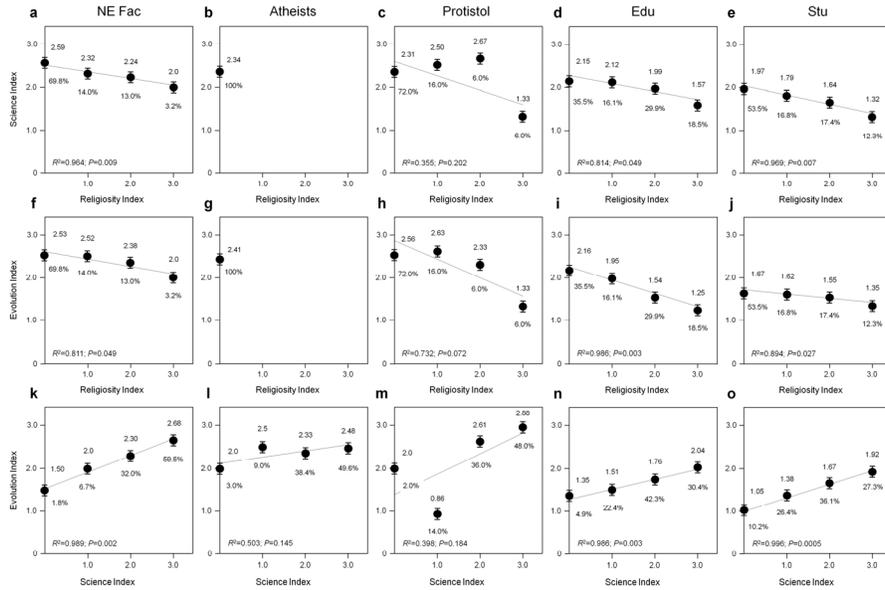


Figure 4. Association between understanding-of-science, evolution and religiosity indexes of New England faculty (*NE Fac*), atheists, protistologists (*Protistol*), educators of prospective teachers (*Edu*), and college students (*Stu*). The linear regressions depict the association between the 0-to-3 levels of: first row, *science index* versus *religiosity index*; second row, *evolution index* versus *religiosity index*; and third row, *evolution index* versus *science index* for each of the subpopulations of responders (i.e., *NE Fac*: a, f, k; *Atheists*: b, g, l; *Protistol*: c, h, m; *Edu*: d, i, n; and *Stu* e, j, o); the inverse association between level of understanding of science/evolution and level of religiosity (first and second rows), as well as the direct association between level of understanding of evolution and level of understanding of science (third row) are evident. Numbers above and below regression lines correspond to index values and percent of responders per data point, respectively. Linear regressions one tail: a, $R^2 = 0.964$, $P = 0.009$; b, N/A; c, $R^2 = 0.355$, $P = 0.202$; d, $R^2 = 0.814$, $P = 0.049$; e, $R^2 = 0.969$, $P = 0.007$; f, $R^2 = 0.811$, $P = 0.049$; g, N/A; h, $R^2 = 0.732$, $P = 0.072$; i, $R^2 = 0.986$, $P = 0.003$; j, $R^2 = 0.894$, $P = 0.027$; k, $R^2 = 0.989$, $P = 0.002$; l, $R^2 = 0.503$, $P = 0.145$; m, $R^2 = 0.398$, $P = 0.184$; n, $R^2 = 0.986$, $P = 0.003$; and o, $R^2 = 0.996$, $P = 0.0005$. *NE Fac*, $N = 222$; *Atheists*, $N = 133$; *Protistol*, $N = 50$; *Edu*, $N = 411$; and *Stu*, $N = 576$. Error bars are standard errors.

Finally, in the context of *EI* versus *SI*, the lowest to highest levels of understanding of evolution by the New England faculty (*NE Fac* $EI = 1.50$ to 2.68 ; 1.8% to 59.5% of responders; index $R^2 = 0.989$, $P = 0.002$; **Figure 4k**),

atheists, non-believers and agnostics (Atheists $EI = 2.0$ to 2.48 ; 3.0% to 49.6% of responders; index $R^2 = 0.503$, $P = 0.145$; **Figure 4l**), protistologists (Protistol $EI = 2.0$ to 2.88 ; 2.0% to 48.0% of responders; index $R^2 = 0.398$, $P = 0.184$; **Figure 4m**), educators of prospective teachers (Edu $EI = 1.35$ to 2.04 ; 4.9% to 30.4% of responders; index $R^2 = 0.986$, $P = 0.003$; **Figure 4n**), and students (Stu $EI = 1.05$ to 1.92 ; 10.2% to 27.3% of responders; index $R^2 = 0.996$, $P = 0.0005$; **Figure 4o**) corresponded to the lowest to highest levels of understanding of science ($SI = 0.0$ to 3.0) in each group, respectively.

In summary, the data presented in **Figure 4** confirms that the higher the level of understanding of science and evolution the lower the level of religiosity among all responders, but remember the 0% religiosity among atheists and their comparable science- and evolution-literacy levels to the professors and the protistologists (**Figure 3** and **4b, g**). Likewise, the higher the level of understanding of science the higher the level of understanding of evolution in all groups (lower row **Figure 4**). Note that **Figures 3a, b** and **4b, g, l** do not imply that atheists, non-believers and agnostics have equal training in the sciences or evolution as the highly educated scholars or educators, but simply that in the questions reported here these groups were comparable, except for religiosity which, among atheists, non-believers and agnostics, was always 0.0% .

It is interesting, however, that the atheists, non-believers and agnostics showed the least steepness in the regression line between EI and SI ($R^2 = 0.503$, $P = 0.145$; **Figure 4l**), suggesting an intrinsically high understanding of both evolution and science, consistent with and probably linked to their zero religiosity (data this chapter) and their pre-college household background characterized by a strong liberal-arts upbringing (see Paz-y-Miño-C and Espinosa 2009a, b). Note that educational attainment was highly variable among atheists (28% bachelors degree, 26% masters, 20% Ph.D./doctorate holders, 13% associate or technical degrees, 7% high school degree, and 6% professional degrees) and below the New England faculty, protistologists, and educators of prospective teachers (93% , 70% and 85% Ph.D./doctorate degree holders, respectively), which implies that the atheists', non-believers' and agnostics' high acceptance of evolution had little association with obtaining an advanced academic degree (opposite to all other groups, below). Previous studies have documented high knowledge among atheists not only about evolution (Paz-y-Miño-C and Espinosa 2012c, this chapter) but also about American history, literature, politics, the role of religion in public life, and awareness about world religions (The Pew Forum on Religion and Public Life 2010).

For the non-atheist populations, studies suggest that pro-evolution views strongly correlate with level of formal education. For example, acceptance of

evolution in the US increases from the high-school- (20/21%), to the some-college- (32/41%), college-graduate- (52/53%), post-graduate- (65/74%)($N = NA/1,018$; Brumfiel 2005; The Gallup Poll 2009), and university-professor levels (94%, data this chapter). Keep in mind that the average acceptance of evolution by the US general public is 35-40% (Brumfiel 2005; Miller et al. 2006), which coincides with the population attaining only some college education (above). Only the US post-graduates in our studies of college students, educators of prospective teachers, and research faculty have levels of acceptance of evolution comparable to or higher than the general public in other industrialized and prosperous nations like Iceland, Denmark, Sweden, France, Japan and the United Kingdom ($\approx 75-85\%$; Miller et al. 2006; see detailed discussion in Paz-y-Miño-C and Espinosa 2011a).

THE VIEWS OF THE NON-RELIGIOUS

To explore further the relationship between no-religiosity and science-and-evolution literacy, we plotted *SI* and *EI* values exclusively for our subsamples of non-religious New England faculty, protistologists, educators, and students, and compared these indexes among groups and with those of the atheists' (**Figure 5**). The non-religious faculty, atheists and protistologists had statistically similar *SI* and *EI*; the non-religious educators and students had lower *SI* and *EI* scores than all groups; the statistical significance among all groups was variable and overlapping in a decreasing-index-value pattern (see details in **Figure 5**). The take-home message inferable from **Figure 5** is twofold; first, non-religious individuals in all groups scored the highest *SI* and *EI* of all responders (except for the protistologists, see below); to visualize the latter, it is important to compare **Figure 5** with **Figure 4** (emphasis on *SI* and *EI* values as function of zero *RI*); and, second, there was a steady decline in *SI* and *EI* values across groups, although not significant for faculty, atheists and protistologists, but accentuated statistically toward the educators and students (**Figure 5**). We interpret this decline as a possible effect of differential awareness about science and evolution among groups (New England faculty and protistologists as scholars versus the atheists, educators and students as non-scholars; see Paz-y-Miño-C and Espinosa 2012a for a discussion on potential differential academic training between New England faculty and educators of prospective teachers in the US). Although protistologists showed a negative relationship between *SI/EI* and *RI*, (similar to that of other groups, **Figure 4**), this association was less pronounced than that of the other groups (**Figure 4c, h**). We attribute this partially to the higher variability

in country of origin within protistologists (25 nationalities and/or place of residence) in respect to the other groups (data above), and to potential cultural differences –possibly derived from distinctive schooling systems— in perceiving the questions in the surveys (although the *SI*, *EI* and *RI* are robust parameters to assess opinions on science and evolution awareness and level of religiosity; above), but these speculations need further investigation.

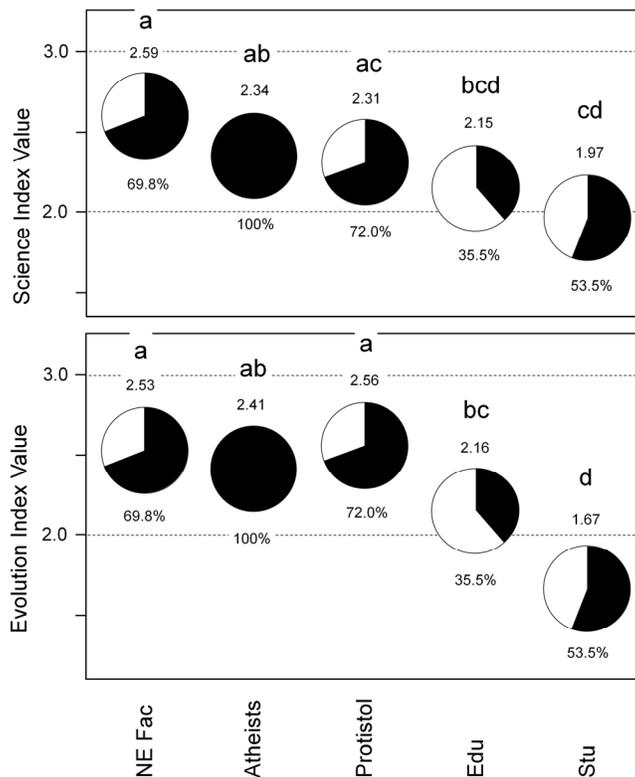


Figure 5. Understanding-of-science and evolution indexes among the non-religious New England faculty (*NE Fac*), atheists, protistologists (*Protistol*), educators of prospective teachers (*Edu*) and college students (*Stu*). Black areas in circles correspond to the percentage of the non-religious in respect to the total number of individuals surveyed within groups. The center of each circle is aligned with its Science Index or Evolution Index values on the vertical axis. For Science Index Value: Kruskal-Wallis one-way ANOVA on ranks, $H = 63.403$, $df = 4$, $P \leq 0.001$. For Evolution Index Value: Kruskal-Wallis one-way ANOVA on ranks, $H = 151.854$, $df = 4$, $P \leq 0.001$. Lowercase letters indicate Dunn-test two-tail pair-wise comparisons $P \leq 0.05$. Number of non-religious individuals per group: *NE Fac*, $N = 155$; *Atheists*, $N = 133$; *Protistol*, $N = 36$; *Edu*, $N = 146$; and *Stu*, $N = 308$.

THE VIEWS OF THE RELIGIOUS

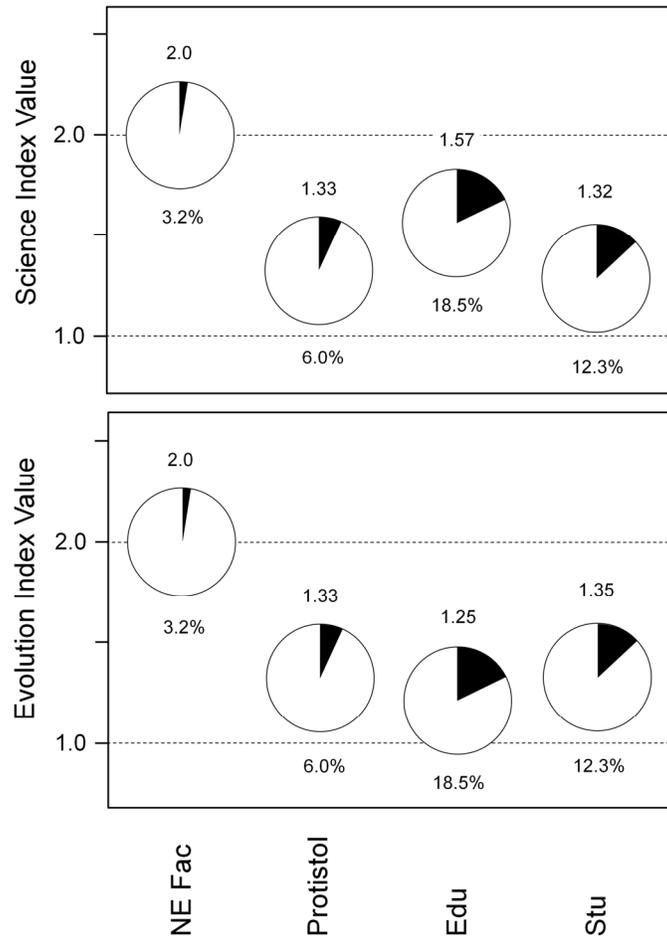


Figure 6. Understanding-of-science and evolution indexes among the most religious (Religiosity Index $RI = 3.0$, see text for details) New England faculty (*NE Fac*), protistologists (*Protistol*), educators of prospective teachers (*Edu*) and college students (*Stu*). Black areas in circles correspond to the percentage of the most religious in respect to the total number of individuals surveyed within groups. The center of each circle is aligned with its Science Index or Evolution Index values on the vertical axis. For Science Index Value: Kruskal-Wallis one-way ANOVA on ranks, $H = 4.806$, $df = 3$, $P = 0.187$. For Evolution Index Value: Kruskal-Wallis one-way ANOVA on ranks, $H = 12.169$, $df = 3$, $P = 0.007$. Number of most religious individuals per group: *NE Fac*, $N = 7$; *Protistol*, $N = 3$; *Edu*, $N = 76$; and *Stu*, $N = 71$.

To contrast the responses of the non-religious subjects (above) with those of the most religious, we plotted *SI* and *EI* values exclusively for the New England faculty, protistologists, educators, and students scoring 3.0 in their *RI* and compared these values among groups (**Figure 6**). The most religious faculty, protistologists, educators, and students had statistically indistinguishable *SI*. Although the *EI* values were significantly different between groups (Kruskal-Wallis one-way ANOVA on ranks, $H = 12.169$, $df = 3$, $P = 0.007$; **Figure 6**), the small representation of highly religious individuals within the New England faculty (3.2%) and protistologists (6.0%) did not allow further pair wise comparisons. Note that high religiosity among educators (18.5%) and students (12.3%) was more pronounced in respect to the faculty and protistologists, and consistent with the former overall lower science and evolution literacy combined with lower acceptance of evolution than the latter (data in **Figures 2, 3 and 4**).

SIGNIFICANCE OF THE SCIENCE-, EVOLUTION-, AND RELIGIOSITY- INDEXES

The *SI*, *EI* and *RI* index patterns examined above concur with the proposal of various scholars (Bishop and Anderson 1990; Downie and Barron 2000; Trani 2004; Paz-y-Miño-C and Espinosa 2009a, b, 2011a, b, 2012a, b; but see Miller et al. 2006; Nadelson and Sinatra 2009) that the interaction between science/evolution literacy and level of religiosity influence an individual's acceptance of evolution, which is corroborated by the data compiled by us in all our studies (Paz-y-Miño-C and Espinosa 2009a, b, 2011a, b, 2012a, b, c): (1) the overall high and *open acceptance of evolution regardless of others opinions* (**Figure 2**) by the New England faculty (94%), atheists, non-believers and agnostics (93%), protistologists (92%), intermediate by the educators of prospective teachers (72%), and low by the students (63%); and (2) the observation that 90% of the atheists, 82% of the New England faculty and protistologists (high), 63% of the educators of prospective teachers (low), and 58% of the students (low) thought that evolution is definitely true (**Figure 2**).

Various studies have detected inverse correlation between religiosity/belief and acceptance of evolution (Miller et al. 2006; The Gallup Poll 2008, 2009, 2010; Nadelson and Sinatra 2009), and a positive association between evolution acceptance and scientific literacy, particularly genetics (Miller et al. 2006); however, there is some discrepancy about the association between general educational attainment and attitudes toward evolution (Miller et al. 2006;

Pigliucci 2007; Nehm and Schonfeld 2007) which, in our studies, is only corroborated by the atheists' data (Paz-y-Miño-C and Espinosa 2012c; this chapter). It is important to emphasize that the religiosity indexes of our samples of protistologists ($RI = 0.46$), New England faculty ($RI = 0.49$), students ($RI = 0.89$), and educators of prospective teachers ($RI = 1.31$) were below the US national score $RI = 1.40$, $N = 2,026$ (The Pew Global Attitudes Project 2007), respectively, but that only protistologists and the New England faculty had levels of religiosity comparable to that of the general public in Western Europe, the lowest worldwide (The Pew Global Attitudes Project 2007; Paz-y-Miño-C and Espinosa 2011a, 2012a). Our educators of prospective teachers sampled here were statistically more religious than the students (**Figure 2**) and more religious than the Canadian general public ($RI = 0.72$; The Pew Global Attitudes Project 2007) whose overall acceptance of evolution is 58%, although 63% of East Coast Canadians accept evolution ($N = 1,007$; Angus Reid Strategies 2008), which is comparable to 59% of their East Coast American counterparts (The Pew Research Center for The People & The Press 2005).

TRENDS OF RELIGIOSITY AMONG RESEARCHERS, EDUCATORS, AND STUDENTS

Let us examine in more detail the contrasting levels of religiosity among the highly educated scholars, the educators, and the students; the following data has been extracted from our surveys (Paz-y-Miño-C and Espinosa 2012a, this chapter): 29% of the New England faculty, 26% of the protistologists, 51% of the educators of prospective teachers, and 37% of the students considered *religion to be very important in their lives*. Interestingly, 5% of the New England faculty, 10% of the protistologists, 15% of the educators of prospective teachers, and 25% of the students believed that *faith in God is necessary for morality*. And 17% of the New England faculty, 10% of the protistologists, 45% of the educators of prospective teachers, and 28% of the students confessed to *pray daily*.

In our previous studies (Paz-y-Miño-C and Espinosa 2012b), we have referred to the educators of prospective teachers as “hesitant to embrace evolution due to deficient understanding of science/evolution and high religiosity,” and the statistics above support this assertion. Moreover, the levels of religiosity among the educators are among the highest reported for Ph.D.-educated audiences. For example, 33% of American scientists ($N = 2,533$) admit to believe in God (The Pew Research Center For The People & The Press 2009), in contrast to 12% of

“professional evolutionary scientists” ($N = 149$ members of North American, European, United Kingdom and other countries’ National Academies of Sciences; Graffin and Provine 2007) and 7% of members of the US National Academy of Science ($N = 260$) who believe in a personal God (Larson and Witham 1998). Two studies ($N = 1,646$ Ecklund and Scheitle 2007; $N = 1,417$ Gross and Simmons 2009) have documented that $\approx 30\%$ of the American professoriate (ca. 630,000 faculty teaching full-time at colleges and universities) is religious across institutions and fields, highlighting that researchers in the natural sciences (physics, biology) are less religious than their social sciences counterparts (sociology, economics, history, except psychology); our sample of educators of prospective teachers was indeed highly religious.

WORLD VIEWS ABOUT EVOLUTION IN THE CONTEXT OF RELIGIOSITY

We have previously stated that based on current scientific evidence, 100% of all people should accept the *concept of evolution* (Paz-y-Miño-C and Espinosa 2012c). However, only 41% of adults worldwide (24 countries, $N = 18,829$) accept evolution, and they do it under the premise that a deity created humans; 31% do not know who to trust in matters of evolution, neither scientists or spiritualists; and 28% are strict creationists who believe in religious scriptures concerning the origin of our universe and of humans (e.g. *Genesis*: the creation of the universe by God a few thousand years ago = *Young Earth Creationists*), and explicitly reject the fact that humans are apes (IPSOS 2011).

Among the 41% (above) of citizens who accept evolution conditionally (i.e. they think that the evolutionary process is true but humans were specially created), the range of opinions by nation is evident ($r = 7-68\%$). Among the top countries are Sweden (68%), Germany (65%), China (64%), Japan (60%), and Great Britain and France (55%). In the middle are Spain (53%), Australia (51%), Canada (45%), South Korea (41%), Italy (40%) and Argentina (37%). And in the bottom are Mexico (34%), US (28%), Russia (26%), Brazil (22%), Turkey (19%), Indonesia (11%) and Saudi Arabia (7%)(not all countries listed here; for details see IPSOS 2011).

Among the 28% of creationists (above) who believe in religious scripture and emphasize --wrongly-- that humans cannot possibly be apes, the range of views by nation is conspicuous ($r = 8-75\%$). Among the top countries are Saudi Arabia (75%), Turkey (60%), Indonesia (57%), Brazil (47%), US (40%), Russia (34%)

and India (33%). In the middle are Mexico (32%), South Korea (24%), Canada (22%), Italy (21%) and Australia (15%). And in the bottom are Germany (12%), Great Britain (12%), China and Japan (11%), France (9%) and Belgium (8%)(not all countries listed here; for details see IPSOS 2011).

Public acceptance of evolution is particularly high among prosperous nations (e.g. Sweden, Germany, Belgium, Japan, France, Great Britain, data above; see also Miller et al. 2006), except for the US where only one in three adults thinks evolution is true (IPSOS 2011; Miller et al. 2006). In fact, the US is the only outlier, among other wealthy nations (i.e. per capita Gross Domestic Product GDP \approx \$50,000), whose level of religiosity is much higher (1.4 versus 0.6 in the scale of *RI* from 0 to 3, see above) than its Eastern and Western European counterparts (The Pew Global Attitudes Project 2007); and, as we have demonstrated in this chapter, level of religiosity is negatively associated with acceptance of evolution in our five samples (see also Paz-y-Miño-C and Espinosa 2012a, b). Furthermore, national polls conducted in the US, report that frequency of religious practices correlates negatively with acceptance of evolution: 24% among weekly churchgoers versus 71% for seldom or never ($N = 1,007$; The Gallup Poll 2007).

Geographically, world Christians in six continents (North America 30%; South America 30%; Europe and Great Britain 50%; Asia 30%; Africa 25%; and Australia 30%; data extracted from Wilson 2010) accept evolution more than Muslims in Turkey (19-22%), Indonesia (11-16%), Pakistan (14%), Malaysia (12%) and Egypt (8%), except for Kazakhstan (38%)(data extracted from IPSOS 2011 and Hameed 2008). But what is crucial to deduce from these international trends is that religiosity, all over the world, interferes with acceptance of evolution, and that the negative correlation between religiosity and science/evolution literacy is inherent to their incompatible nature: supernatural causation versus empirical reality. We acknowledge, of course, that societal interactions between science/evolution and religiosity, as much as between science broadly defined and ideology, are complex, multi factorial, variable in a spatio-temporal context, and subject to public policy, demographics, law and socio-economic change (Lerner 2000; Moore 2002, 2004; Gross et al. 2005; Apple 2008; Miller and Pennock 2008; Berkman and Plutzer 2009, 2011; Ecklund and Park 2009; Padian and Matzke 2009; Matzke 2010; Wexler 2010; Paz-y-Miño-C and Espinosa 2011a, b). For example, opposition to evolution in the US resides in specific measurable cultural factors: religious beliefs, pro-life beliefs, and political ideology account for most of the variance against evolutionary views (total nine independent variables), which differ distinctly between the US ($R^2 = 0.46$ total effects) and Europe ($R^2 = 0.18$ total effects; Miller et al. 2006; Miller and Pennock 2008; see The Pew Forum on Religion & Public Life 2008 for

detailed statistics on the relationship between religious affiliations and pro-life beliefs, political ideology, and evolution). Conservative, religious and pro-life republicans in the US accept evolution less than progressive liberals and independents (30% versus 60%, respectively, $N = 1,007$; The Gallup Poll 2007).

CONCLUSION

Harmonious coexistence between science/evolution and religion is illusory. They are destined to interact in conflict due to the inherent incompatibility between scientific rationalism/empiricism and the belief in supernatural causation. Societies, therefore, will struggle, indefinitely, to achieve long-lasting camaraderie between science and religion. If *co-persisting* in the future, the relationship between science and religion will fluctuate between moderate and intense antagonism.

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