Acceptance of Evolution by America’s Educators of Prospective Teachers

...the disturbing reality of evolution illiteracy at colleges and universities

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What is Evolution?

The concept of evolution provides naturalistic explanations about the origin of life, its diversification and biogeography, and the phenomena resulting from the interaction between life and the environment; mutations, gene flow, genetic drift and natural selection shape life’s biological processes in Earth’s ecosystems.

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. Worldwide, the scientific community recognizes evolution as true.
The Concept of- vs. the Theory of- vs. the Phenomenon of Evolution

The ‘*concept of evolution*’ helps us understand the gradual process by which the universe changes, it includes the origin of life, its diversification and the phenomena resulting from the interaction between life and the environment.

The ‘*theory of evolution*’ (Greek *theoria*) provides naturalistic explanations of empirical observations; it organizes them in a comprehensive system with central and auxiliary hypotheses. From the epistemological perspective (Greek *episteme*, epistemology = theory of knowledge), the theory of evolution encompasses the nature and scope of knowledge about the *phenomenon of evolution* (= what really happens, the fact), including the chronological discoveries by naturalists and scientists during the development of our cumulative understanding of how evolution works. Scholars call the latter ‘*theory of evolution*,’ which epistemological beginning is [arguably] attributed to the mid and late 1800s, and to Charles Darwin and Alfred R. Wallace, as the main contributors to the conceptualization of evolution at the mechanistic level (= natural selection).

But the *phenomenon of evolution* is ongoing, precedes Darwin and Wallace in billions of years, and it shall continue, with comparable magnitude, in time and space. The *concept of evolution*, therefore, is about the occurrence of evolution (i.e. aggregation of matter, the emergence of organic compounds from simpler molecules, the formation of self-replicating macro-molecules, the encasing of chemical reactions within the boundaries of lipid-layered membranes, the formation of cells and their reproduction and differentiation, and the diversification of uni- and multi-cellular life) and it helps us understand and represent cognitively —via mental symbolism and abstraction— the reality of evolution. Our understanding of evolution improves with new discoveries, but the reality of evolution continues to exist regardless of our awareness and level of understanding of it.
What is Creationism?

Creationism, theistic evolution, creation science or young-earth creationism 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, or of cosmic processes, which —according to ‘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.

Creationism in principle (i.e. admittance that a proximate Creator/Designer of the universe is present in the foreground of causality) or creationism in practice (i.e. believe in a more distant Maker of the laws of nature, responsible for evolution via ‘evolutionary creation’) have no empirical support.
What is Intelligent Design or Design Creationism?

ID 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.

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. In 2005, ID was exposed in court 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.’
Acceptance of Evolution in the World vs. the United States
(for comparison only some countries are shown)

Based on Current Scientific Evidence, All People in the World Should Accept Evolution

However:
- 41% ‘accept evolution’ but conditionally: God created humans
- 31% do NOT know who to believe: scientists or spiritualists
- 28% ‘creationists’ who insist: humans are NOT apes

Adapted from IPSOS. 2011. Supreme Being, the Afterlife, and Evolution.

Acceptance of Evolution US By Education Level

- 94% New England Faculty*
- 74% Postgraduates
- 74% Biology High School Teachers**
- 63% New England College Students*
- 59% Educators of Prospective Teachers*
- 53% College Graduates
- 41% Some College
- 21% High School or Less

Adapted from Gallup 2009, *data this study, **data Berkman & Plutzer 2010.

Acceptance of Human Evolution US: Non-Religious vs. Religious

- 87% Atheists
- 81% Buddhist
- 80% Hindu
- 77% Jewish
- 58% Catholic
- 55% Orthodox
- 45% Muslim
- 35% Protestant
- 21% Mormon
- 8% Jehovah’s Witness

Acceptance of Evolution among the Highly Educated

New England College Students
- 63% Accept Evolution Openly
- 58% Think Evolution is Definitely True
- 37% Are Religious

Low Understanding of Science & Evolution, Low Acceptance of Evolution, Intermediate Religiosity

Educators of Prospective Teachers in the United States
- 59% Accept Evolution Openly
- 51% Think Evolution is Definitely True
- 59% Are Religious

Intermediate Understanding of Science & Evolution, Low Acceptance of Evolution, High Religiosity

New England Faculty
- 94% Accept Evolution Openly
- 82% Think Evolution is Definitely True
- 29% Are Religious

High Understanding of Science & Evolution, High Acceptance of Evolution, Low Religiosity

‘Acceptance of Evolution Openly’ and ‘Thinking that Evolution is Definitely True’ among Educators of Prospective Teachers in the United States (center). For comparison, New England College Students (left) and General Faculty (right) are depicted; both have the highest national levels of acceptance of evolution among students and university professors, respectively.

Why People Do Not Accept Evolution: the 3D+S

- As a rational explanation of a natural phenomenon, the Incompatibility Hypothesis (IH) allows us to examine the controversy over evolution-and-science versus creationism. The observable ‘phenomenon’ in society is ‘the controversy,’ the conflicts that emerge when facts organized in a rational interpretation of empirical reality (= the science of evolution) challenge ‘belief’ and the ‘supernatural-causation-based’ answers to questions about the origin of the universe and life, the mutability and phylogenetic diversification of life, its extinctions, and the finite nature of Nature.

- IH is an ultimate-level hypothesis, rather than a proximate one; IH explains the ‘cause’ of the controversy, its fundamental reason. It also addresses directly the question: what elicits the controversy evolution-and-science versus creationism? Answer: their intrinsic incompatibility, their opposing approaches to assess reality, i.e. science via testing hypotheses, falsifying and/or testing predictions, and replication of experiments; creationism, in contrast, via the belief in supernatural causality. Belief disrupts, distorts, delays and stops (= 3D+S) the comprehension and acceptance of scientific evidence.

- We acknowledge and value proximate levels of analysis of the controversy, including the detailed and simultaneous characterization of multiple factors that can influence an individual’s acceptance of evolution and scientific evidence, for example, religious beliefs, pro-life beliefs and political ideology, or political activity, political and religious conservatism, knowledge about evolution and its relevance, creationist reasoning, evolutionary misconceptions, and exposure to evolution. From a research program perspective, however, IH is a central hypothesis, as a guiding ultimate level of analysis, while the indispensable proximate-level studies are auxiliary in essence.
• **Chronological-conflict-and-accommodation**, which explains the historical emergence of antagonism between evolution and religion when advances in science continue to challenge the belief in supernatural causation. In such situations, subsequent and gradual accommodation —by creationists— to the new scientific discoveries is expected. However, the clashes are destined to continue for as long as belief in the supernatural persists.

• **Change in evolution’s acceptance as function of educational attainment**, which explains the positive association between acceptance of evolution and overall level of education. Proper, comprehensive formal education leads to an organized exposure to subject content, rational assessment of facts, critical thinking, and adoption of an educated position in respect to evolution.

• **Change in evolution’s acceptance as function of religiosity**, which explains the negative association between acceptance of evolution and level of religious beliefs; high levels of belief in the supernatural correlate with low acceptance of evolution.
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 (NOMA = 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.
Religiosity Index $RI$ *

+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*.

New England Faculty $RI = 0.49$
Educators of Prospective Teachers $RI = 1.31$
College Students $RI = 0.89$
Kruskal-Wallis one-way ANOVA on ranks, $H = 84.987, df = 2, P \leq 0.001$

Science Index $SI$ *

+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*.

New England Faculty $SI = 2.49$
Educators of Prospective Teachers $SI = 1.98$
College Students $SI = 1.80$
Kruskal-Wallis one-way ANOVA on ranks, $H = 95.024, df = 2, P \leq 0.001$

Evolution Index $EI$ *

+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*.

New England Faculty $EI = 2.49$
Educators of Prospective Teachers $EI = 1.76$
College Students $EI = 1.60$
Kruskal-Wallis one-way ANOVA on ranks, $H = 174.958, df = 2, P \leq 0.001$

* $RI$, $SI$, $EI$: New England Faculty $N = 222$, Educators of Prospective Teachers $N = 411$, College Students $N = 576$
Understanding-of-Science Index (A), Understanding-of-Evolution Index (B), and Personal-Religious-Convictions Index (C) of New England General Faculty (N = 222), Educators of Prospective Teachers in 50 States of the United States (N = 411), and New England College Students (N = 576). Each index ranges from 0 to 3 (lower to higher levels of understanding of science and evolution, or least to most religious position): A, science index, Kruskal-Wallis one-way ANOVA on ranks, $H = 95.024$, $df = 2$, $P \leq 0.001$. B, evolution index, Kruskal-Wallis one-way ANOVA on ranks, $H = 174.958$, $df = 2$, $P \leq 0.001$. C, religiosity index, Kruskal-Wallis one-way ANOVA on ranks, $H = 84.987$, $df = 2$, $P \leq 0.001$. Lowercase letters indicate Dunn-test two-tail pair-wise comparisons within groups $P \leq 0.05$. Error bars are standard errors. Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.

Understanding-of-Science Index (A), Understanding-of-Evolution Index (B), and Personal-Religious-Convictions Index (C) of New England General Faculty (N = 222), Educators of Prospective Teachers per Region and in 50 States of the United States (N = 411: West N = 86, Midwest N = 84, South N = 174, North East N = 67), and New England College Students (N = 576). A, science index, Kruskal-Wallis one-way ANOVA on ranks, \( H = 101.557, df = 6, P \leq 0.001 \). B, evolution index, Kruskal-Wallis one-way ANOVA on ranks, \( H = 182.477, df = 6, P \leq 0.001 \). C, religiosity index, Kruskal-Wallis one-way ANOVA on ranks, \( H = 122.644, df = 6, P \leq 0.001 \). Error bars are standard errors. Vertical dashed line indicates placement of Educators’ national mean value (= 50 states in the US). Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.
Understanding of Science (A) and Evolution (B) was High Among the Non-religious and Low Among the Deeply Religious Educators of Prospective Teachers in 50 States of the United States; Understanding of Evolution was High Among Those With High Understanding of Science (C), $N = 411^*$

Linear regressions one tail: (A) Understanding of Science versus Personal Religious Convictions $R^2 = 0.814$, $P = 0.049$; (B) Understanding of Evolution versus Personal Religious Convictions $R^2 = 0.986$, $P = 0.003$; (C) Understanding of Evolution versus Understanding of Science $R^2 = 0.986$, $P = 0.003$.

*Total number of responders can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.
Understanding of Science and Evolution as Percentile of the Non-religious. The Majority of New England Faculty and College Students Scored Zero in Religiosity, but Only One Third of the Educators of Prospective Teachers Did. For understanding of science: Kruskal-Wallis one-way ANOVA on ranks, $H = 57.256$, $df = 2$, $P \leq 0.001$. For understanding of evolution: Kruskal-Wallis one-way ANOVA on ranks, $H = 114.006$, $df = 2$, $P \leq 0.001$. Lowercase letters indicate Dunn-test two-tail pair-wise comparisons within groups $P \leq 0.05$. New England Faculty $N = 155$, Educators of Prospective Teachers $N = 146$, College Students $N = 308$. Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.
Understanding of Science By Region in the US as Percentile of the Non-religious. Kruskal-Wallis one-way ANOVA on ranks, $H = 59.775$, $df = 6$, $P \leq 0.001$. New England Faculty $N = 155$, Educators Midwest $N = 27$, Educators West $N = 31$, Educators North East $N = 33$, Educators 50 states $N = 146$, Educators South $N = 55$, College Students $N = 308$. Vertical dashed line indicates placement of Educators’ national mean value. Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.
Understanding of Evolution By Region in the US as Percentile of the Non-religious. Kruskal-Wallis one-way ANOVA on ranks, $H = 127.896$, $df = 6$, $P \leq 0.001$. New England Faculty $N = 155$, Educators Midwest $N = 27$, Educators West $N = 31$, Educators North East $N = 33$, Educators 50 states $N = 146$, Educators South $N = 55$, College Students $N = 308$. Vertical dashed line indicates placement of Educators’ national mean value (= 50 states in the United States). Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.

Understanding of Science and Evolution as Percentile of the Deeply-religious. A Minority of New England Faculty Scored High in Religiosity. However, One in Every Five Educators of Prospective Teachers and One in Every Ten Students Were Deeply Religious. For understanding of science: Kruskal-Wallis one-way ANOVA on ranks, $H = 4.644$, $df = 2$, $P = 0.098$. For understanding of evolution: Kruskal-Wallis one-way ANOVA on ranks, $H = 10.223$, $df = 2$, $P = 0.006$. Lowercase letters indicate Dunn-test two-tail pair-wise comparisons within groups $P \leq 0.05$. New England Faculty $N = 7$, Educators of Prospective Teachers $N = 76$, College Students $N = 71$. Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.
Understanding of Science By Region in the US as Percentile of the Deeply-religious. Kruskal-Wallis one-way ANOVA on ranks, $H = 13.841$, $df = 6$, $P = 0.031$. New England Faculty $N = 7$, Educators Midwest $N = 15$, Educators West $N = 14$, Educators North East $N = 8$, Educators 50 states $N = 76$, Educators South $N = 39$, College Students $N = 71$. Vertical dashed line indicates placement of Educators’ national mean value ($= 50$ states in the US). Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.

Understanding of Evolution By Region in the US as Percentile of the Deeply-religious. Kruskal-Wallis one-way ANOVA on ranks, $H = 26.416$, $df = 6$, $P \leq 0.001$. New England Faculty $N = 7$, Educators Midwest $N = 15$, Educators West $N = 14$, Educators North East $N = 8$, Educators 50 states $N = 76$, Educators South $N = 39$, College Students $N = 71$. Vertical dashed line indicates placement of Educators' national mean value ($= 50$ states in the United States). Total number of responders per group can vary because participants were allowed to skip questions and/or end survey voluntarily at any time.

Educators of Prospective Teachers' Views About Intelligent Design or Design Creationism

A. Very Concerned About the Controversy “Evolution vs. Creationism vs. Intelligent Design and its Implications for Science Education”

- West of US: 28.9%
- Midwest of US: 31.3%
- South of US: 39.2%
- North East of US: 42.4%

North East N = 90
Midwest N = 107
South N = 212
West N = 99

B. Intelligent Design is “Religious Doctrine Consistent with Creationism”

- West of US: 39.8%
- Midwest of US: 39.2%
- South of US: 32.3%
- North East of US: 35.1%

North East N = 79
Midwest N = 99
South N = 196
West N = 97

C. Intelligent Design is “Not Scientific but Has Been Proposed to Counter Evolution Based on False Claims”

- West of US: 10.1%
- Midwest of US: 16.2%
- South of US: 16.5%
- North East of US: 19.9%

North East N = 79
Midwest N = 99
South N = 196
West N = 97

D. Intelligent Design is “Scientific Theory About the Origin and Evolution of Life on Earth”

- West of US: 42.2%
- Midwest of US: 47.7%
- South of US: 51.9%
- North East of US: 42.2%

North East N = 90
Midwest N = 107
South N = 212
West N = 99

Educators of Prospective Teachers’ Views About The Teaching of Evolution in Science Class

A. Evolution Should be Taught in Science Class

B. Equal Time Should be Dedicated to Evolution, Creationism, and Intelligent Design

C. Prefer Science Courses where Evolution is Discussed, Including Humans

Educators of Prospective Teachers’ Views About Evolution as Unifying Theme in Science

A. “Strongly Agree” and “Agree” (sum) with the Statement: “Evolution Is the Unifying Theme of All Sciences…”

B. “Strongly Disagree” and “Disagree” (sum) with the Statement: “Evolution Is the Unifying Theme of All Sciences…”

Educators of Prospective Teachers’ Agreement with Alternative Definitions of Evolution

A. “Evolution is a Gradual Process by Which the Universe Changes, It Includes the Origin of Life, Its Diversification and the Synergistic Phenomena Resulting from the Interaction Between Life and the Environment”

B. “Evolution is Gradual Process by Which Organisms Acquire Traits During Their Lifetimes, Such as Longer Necks, Larger Brains, Resistance to Parasites, and Then Pass on These Traits to Their Descendants” (Lamarckian View)
Educators of Prospective Teachers’ Views About the Evolutionary Process, Evolution of Consciousness and ‘Fine Tuning’

A. “All Current Living Organisms Are Descendants of Common Ancestors, Which Have Evolved for Thousands, Millions or Billions of Years”

B. “Humans Are Apes, Relatives of Chimpanzees, Bonobos, Gorillas and Orangutans”

C. “The Origin of the Human Mind and Consciousness Cannot Be Explained by Evolution”

D. “The Universe, Our Solar System and Planet Earth are Finely Tuned to Embrace Human Life”

Educators of Prospective Teachers’ Views About the Evolution of Earth, its Moon, the Solar System, and the Universe

A. “The Earth and Its Moon Are Several Billions of Years Old”

B. “Evolution Also Applies to the Origin and Processes of Change in the Universe, the Galaxies, Solar Systems and Planets”

C. “Our Sun is the Center of the Universe”

D. “A Future Catastrophic Collision Between Earth and a Large Asteroid or Comet Will Happen”

1) Apply equal rigor to the training in pedagogy and science/evolution; the educators of prospective teachers should reach comparable levels of understanding science/evolution and accepting evolution to those of the non-educator professors.

2) Dialog with the science faculty at their own institutions and concur to fortify the on-the-job-science/evolution training of the educators of prospective teachers, as well as of the students enrolled in education programs. The ubiquitous disconnect between the education departments and the rest of the academic fields at the US colleges and universities is concerning, and it requires immediate approach between the educators and the general faculty.

3) Educate themselves about the ‘antievolution wars’ and participate decisively in the pro-teaching-of evolution movement. It is crucial that the educators of prospective teachers lead the institutional (their own colleges and universities), regional and national strategies to secure proper science/evolution education among the prospective teachers who earn degrees under their guidance. As university professors, the educators of prospective teachers are less vulnerable to institutional or societal reprisal for leading the teaching of evolution than their academic progeny of young teachers. The educators of future educators are as responsible for sponsoring proper science/evolution training to the prospective teachers as the latter are of acquiring and communicating that knowledge to their students.

4) Study the legal protection that guarantees proper science/evolution education at all academic levels and make that information available to the prospective teachers as part of their regular training.

5) Implement curricular reform at their education departments and institutions to fortify science training of prospective teachers. Higher-education programs in science, particularly biology, are fundamental to integrate evolution into the academic backgrounds of prospective teachers. (...next page)
Recommendations... continued

6) Poll in-campus variations in attitudes toward science and evolution among the educators of future educators, the prospective teachers they mentor, and the general faculty, and coordinate immediate responses to the emerging antievolutionism in the US campuses.

7) Co-sponsor with the general faculty in- and off-campus lecture series, workshops and debates to examine the antievolution phenomena, learn about the obstacles raised by schools boards on the science school curriculum and orient other educators of future educators and prospective teachers on how to communicate modern science to all. Workshop-discussion modules on why evolution matters can be particularly effective when organized for educators of future educators and prospective teachers.

8) Pursue participation in- and organization of ‘town halls for scientists and public’ to discuss issues related to scientific research and the controversy evolution versus creationism and all its forms, including Intelligent Design, Theistic Evolution [e.g. BioLogos = Evolutionary Creation], and Creation Science.

9) Participate in and sponsor multidisciplinary conferences (anthropology, biology, education, ethics, history, law, philosophy, political science, social psychology, religious studies) committed to advice community groups on theoretical and practical aspects of civil action to counter antievolution campaigns, anti-intellectualism tendencies, and pro creationism agendas.

10) Monitor the antievolution movements that grow strong among misinformed citizens, vary in impact geographically, and benefit from the disconnect between highly-educated audiences, like educators of prospective teachers/general faculty, and society. The educators of prospective teachers must take the lead in conceptualizing and strategizing the civil discourse and societal action to ensure internationally competitive science/evolution literacy in the US.
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Images cover: Hominid reconstructions based on fossils (Paranthropus boisei, Homo erectus, Homo neanderthalensis, Australopithecus anamensis, by Atelier WILD LIFE ART © W. Schnaubelt & N. Kieser, Germany, info@wildlifeart.de), exhibition ‘Becoming Human – Hominid Evolution’ (Hessen State Museum in Darmstadt), Museum für Naturkunde Berlin © photo G Paz-y-Miño-C

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