

Why does Evolution Matter?
The Importance of Understanding Evolution

Why does Evolution Matter?
The Importance of Understanding Evolution

Edited by

Gabriel Trueba

**CAMBRIDGE
SCHOLARS**

P U B L I S H I N G

Why does Evolution Matter? The Importance of Understanding Evolution,
Edited by Gabriel Trueba

This book first published 2014

Cambridge Scholars Publishing

12 Back Chapman Street, Newcastle upon Tyne, NE6 2XX, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Copyright © 2014 by Gabriel Trueba and contributors

All rights for this book reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the copyright owner.

ISBN (10): 1-4438-6518-4, ISBN (13): 978-1-4438-6518-0

TABLE OF CONTENTS

Acknowledgements vii

Foreword ix
Andres Moya

Part I: Evolution and Society

Chapter One 3
The Incompatibility Hypothesis: Evolution vs. Supernatural Causation
Guillermo Paz-y-Miño-C and Avelina Espinosa

Chapter Two 17
The Evolution of Cooperation
Charles Snowdon

Chapter Three 35
Darwin and the Conservation of Galapagos Ecosystems
Diego Quiroga

Part II: Environmental Change

Chapter Four 61
Evolution Matters for Plant Reproduction in a Changing World
Sarah A. Bodbyl Roels

Chapter Five 77
Evolution in Relation to Environmental Impacts and Extreme Species Loss
Kelly Swing

Part III: Molecular Evolution

Chapter Six 87
Glimpse into the Origin of Life: What was First, the Genetic Code
or its Products, the Proteins?
Miri Krupkin, Anat Bashan and Ada Yonath

Chapter Seven.....	101
The RNA World: Stepping Out of the Shadows	
Antonio Lazcano	
Chapter Eight.....	119
From Ancient to Modern RNA World and Vice Versa: Looking through Viroids and Ribozyme Motifs	
Marie-Christine Maurel	
Part IV: Evolution and Public Health	
Chapter Nine.....	137
Evolution and Cancer	
Pierre Martinez and Trevor A. Graham	
Chapter Ten	155
The Forces behind the Spread of Virulence and Antibiotic Resistance	
Gabriel Trueba	
Chapter Eleven	165
Genetic Hyper-Codes and Multidimensional Darwinism: Replication Modes and Codes in Evolutionary Individuals of the Bacterial World	
Fernando Baquero	
Chapter Twelve	181
Examining Crypticity in <i>Entamoeba</i> : A Behavioural and Biochemical Tale	
Avelina Espinosa	
Contributors.....	191

ACKNOWLEDGEMENTS

I would like to thank to Carlos Montufar, Diego Quiroga, Santiago Gangotena and Carlos Mena for their commitment to sponsor the III World Summit on Evolution. Also I would like to express my appreciation to Stella de la Torre, Veronica Barragan, Sonia Zapata, Paulina Andrade, Andrea Encalada, Patricia Sierra, Maria de Lourdes Torres, Paula Cordova, and all the administrative personnel of the college of Biological Sciences for contributing to the development of this meeting; to Santiago Gangotena and Ricardo Vasquez for the design of the book cover. Also I would like to acknowledge Gabriela Vasco for helping with the organization of this book and Kelly Swing for his corrections and suggestions regarding writing style.

FOREWORD

The theory of evolution reaches out incessantly, its tentacles touching upon myriad areas of reality, together comprising a whole, waiting to be explored, waiting to be explained. This is, largely, the aim of this book—which you, the reader, are now browsing—, the second to be published as a result of the developments discussed at meetings held in the Galapagos Islands. The organizers of these activities, namely Antonio Lazcano, Gabriel Trueba and Carlos Montufar, should be acknowledged for their efforts to establish an International Centre for the Study of Evolution and, of course, for orchestrating the proposed formation of a Latin American Society for Evolutionary Biology in such a paradigmatic place as the Galapagos Islands. The time is ripe to promote evolutionary thought—and science in general—in the Latin American world.

It is essential to understand evolution, because everything evolves. Evolution (biological evolution) has become a branch of thought that continuously spreads out to understand the world. Probably the most significant contribution of biology to other disciplines is the very idea of evolution. Indeed, some of the early Greek philosophers had already sensed and pondered on the changing nature of worldly beings, but it was the alternative notion of the immutability and independent creation of life, which also sprung from Greek thinkers, that prevailed and continued with the Judeo-Christian theological tradition. The observation and objective scrutiny of nature through the eyes of science came with Newton and Galileo, at least with regard to non-living entities, while, centuries later, Darwin was to consolidate the notion of the changing nature of living things. The material explanation of organic change through natural selection has transcended beyond biology itself, to many other areas of knowledge about the world.

Biological evolution provides clues to understanding the evolution of the universe and the worlds and beings that inhabit it, including man in his triple-faceted dimension: biological, social and cultural. Evolution goes far beyond evolutionary theory and, as remarked above, it is a vital page in the book of knowledge, helping us to discriminate between science and pseudo-science and, ultimately, to instruct society properly and provide citizens with criteria and the ability of critical judgment. This is because

science and evolutionary thought—one of its champions—is a fundamental instrument for the independence of judgment, something essential for every citizen.

Modern biology feeds evolutionary theory, while the latter is nourished by explanations supplied by modern biology, in a fruitful two-way interaction. For instance, we need evolutionary theory to understand the nature of disease, but modern biology also provides evidence of the complex interactions going on between beings that evolve, leading us to deeper formulations on the nature of the evolutionary process. Darwin formulated not only an explanatory material principle of biological change through natural selection but, more significantly, he speculated on the common origin of all organisms. Later, studies of molecular evolution became possible once we had revealed the primary sequence of proteins and nucleic acids and, more recently, of complete genomes. Indeed, the contemporary evolutionary study of genes, proteins and genomes has confirmed Darwin's seminal thesis on the origin of life, and the link between organisms that inhabit and inhabited the planet.

Categories of evolutionary thought such as population, selection, randomness and mutation, are scattered among disparate fields of current knowledge. Indeed, they can be found in disciplines that are not necessarily biological, such as those contemplating the origin of life on the planet, or those that have arisen with the evolution of our species: culture, sociology or economics.

And what about biomedicine? Biomedicine needs to be approached from evolution. This is not an ideological imposition, but following the train of thought that I have been developing in this foreword we should try to see humans from the perspective of beings that evolve, and must thus apply the evolutionary categories outlined above to explain, for example, the genesis and development of pathologies. Moreover, humans are just one of the many beings that evolve alongside others and, in the best tradition, follow the principle that, in order to continue (living), must transform to keep up with the others' manoeuvres. In other words, to stay (alive) one must change or, at any rate, adapt to the world one lives in, or perhaps adapt the world in which one lives.

The volume you are perusing holds an overview of the lectures presented at the third meeting held on evolution in the Galapagos Islands. This edition reflects what one could well call *applications* (environmental change, biomedicine and public health) and *expansions* (education,

sociology and science versus non-science) of evolutionary theory, while presenting results pertaining to the domain of biology itself (molecular evolution). We should applaud the organizers for this meeting and encourage them to continue these gatherings so they may become a beacon and a model of Latin American evolutionary thought.

Andrés Moya
Full Professor of Genetics, Universidad de Valencia (Spain)
Scientific Director, Fundación para el Fomento de la Investigación
Sanitaria y Biomédica de la Comunidad Valencia (Spain)
President of the Spanish Society of Evolutionary Biology

PART I:
EVOLUTION AND SOCIETY

CHAPTER ONE

THE INCOMPATIBILITY HYPOTHESIS: EVOLUTION VS. SUPERNATURAL CAUSATION

GUILLERMO PAZ-Y-MIÑO-C
AND AVELINA ESPINOSA

Introduction

Supernatural causation (i.e. the belief in a Supreme Being, creator and sustainer of the universe, omnipresent, omnipotent, omniscient) is a cultural pollutant, incompatible with empirical reality. “Belief” disrupts delays and/or stops the correct comprehension and acceptance of evidence. We have postulated that the controversy over evolution-and-science versus creationism is inherent in the incompatibility between scientific rationalism/empiricism and the belief in supernatural causation (Paz-y-Miño-C and Espinosa 2012a, 2013a). This hypothesis (=incompatibility) helps us understand and explain the everlasting and fluctuating antagonism—in cycles, from moderate to intense opposition during human history—in the relationship between science/evolution and religion (Paz-y-Miño-C and Espinosa 2013a). In this chapter, we examine conceptually the incompatibility hypothesis (IH), its predictions and alternatives, and approaches to test it quantitatively.

Conceptual Framework of IH

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* (Paz-y-Miño-C and Espinosa 2011a). The IH is an ultimate-level hypothesis, rather than a proximate one: IH explains the “cause” of the controversy, its fundamental reason (Paz-y-Miño-C and Espinosa 2012a, 2013a, b). It also directly addresses the question: what elicits the controversy evolution-and-science versus creationism? Answer: their intrinsic incompatibility, their opposing approaches to assessing reality, i.e. science via testing hypotheses, falsifying and/or testing predictions, and replication of experiments; creationism, in contrast, via the sole belief in supernatural causality (Paz-y-Miño-C and Espinosa 2013a, b). 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 (Miller et al. 2006), or political and religious conservatism, knowledge about evolution and its relevance, creationist reasoning, evolutionary misconceptions, and exposure to evolution (Hawley et al. 2011). From a research programme perspective, however, IH is a central hypothesis, as a guiding ultimate level of analysis, while the indispensable proximate-level studies are auxiliary in essence (=auxiliary hypotheses; Lakatos 1978).

Predictions of IH

The incompatibility hypothesis makes numerous testable predictions: here we examine three:

Chronological Conflict and Accommodation

IH predicts the emergence of conflict and accommodation, by creationism, when advances in science continue to challenge the belief in supernatural causation. Societal turmoil would not occur if scientific discoveries *proven-beyond-reasonable-doubt*, like evolution, were readily accepted by the public (note that no reputable scientist questions the reality of evolution, although scientific debates about evolution persist as part of the *modus operandi* of science). Examples include Nicolaus Copernicus’s heliocentric hypothesis (the sun at the centre of our solar system, 1543), confirmed by Galileo Galilei and Johannes Kepler (iconic contributors to astronomy in the 1600s), which challenged and replaced Claudius Ptolemy’s geocentric model (the Earth as the centre of the universe, ca160AD—a view worshipped as reality for 1500 years by early

astronomers and theologians); or Charles Darwin's Theory of Evolution by means of natural selection (Darwin 1859, 1871), which debunked the Victorian concept of "species' immutability" of the late 1800s (Montúfar 2013). IH also anticipates that creationist models that emerge and accommodate to modern scientific discoveries by inserting a Creator or Designer into the processes of nature (i.e. theistic evolution, creation science, Intelligent Design) will fail once scrutinized by science, of course not without agitated debate and lawsuits (e.g. Kitzmiller et al. versus Dover School District et al. 2005).

Testing the "chronological-conflict-and-accommodation" prediction requires historical documentation of the scientific discoveries and/or creationists' challenges to science as they have been systematically discredited by research, e.g. the flat-earth hypothesis versus oblate-sphere-at-the-poles versus oblate-sphere-at-the-equator planet, or geocentrism versus heliocentrism, or species immutability versus modern genetics and natural selection (above, see also Stenger 2012). A more recent chronology, which is limited to only two decades and involves the late Intelligent Design (ID) movement, is comparably vast: the fallacy of ID, a doctrine 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 biological diversity, and instead ID proposes an *intelligent agent* as the ultimate cause of nature (Pennock 2001; Young and Edis 2004; Forrest and Gross 2007a, b; Petto and Godfrey 2007; Phy-Olsen 2010; Paz-y-Miño-C and Espinosa 2013a, b). 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; Paz-y-Miño-C and Espinosa 2013a, b). 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". After 2005, ID continued to be debunked on additional grounds in which ID ventured to introduce an Intelligent Designer, e.g. string theory and cosmology in physics (Susskind 2006), geology and the fossil record in

paleontology (Schneiderman and Allmon 2009), or common descent versus common design in phylogenetics of unicellular organisms (Paz-y-Miño-C and Espinosa 2010).

IH also predicts differential levels of conflict between science/evolution and *proximate* (here meaning nearby and immediate Creator/Designer, rather than *proximate causality* as in above) versus *distant* creationist views (Creator/Designer in the background). Antagonism shall be intense with proximate creationism in principle and practice, like “Young Earth Creationism” (=the creation of the universe and life by God a few thousand years ago, as in *Genesis*). In contrast, antagonism shall be moderate with distant creationism in principle and practice, as with theistic evolution or creation science, where evolution is accepted conditionally, as a Creator-guided process, or with BioLogos which proposes merging Christianity with science (Paz-y-Miño-C and Espinosa 2013a, b).

IH explains that to minimize personal conflict, particularly among disciples of theistic evolution, creation science or BioLogos, an individual can adopt 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 declare agnosticism (=doubt about the existence or nonexistence of a deity) (Paz-y-Miño-C and Espinosa 2013a, b). Because disciples of all forms of creationism vary, as in a natural population, from moderate to extreme, IH predicts everlasting conflict, from moderate to intense, between scientific rationalism/empiricism and the belief in supernatural causation (Paz-y-Miño-C and Espinosa 2013a).

The chronological-conflict-and-accommodation prediction helps us rationalize that if during the history of science creationist arguments continue to emerge to either oppose science or force harmony between science and supernatural causation (e.g. omnipresent background Creator or Designer beyond the frontiers of the known), it follows that the weakness resides in “belief” not in empiricism. Only one can be true.

Change in Evolution’s Acceptance as Function of Educational Attainment

IH predicts a positive association between acceptance of evolution and level of educational attainment. This prediction can be tested by documenting and plotting acceptance of evolution as function of overall

education. For example, public acceptance of evolution in the United States increases from the high school (20/21%), to the some college (32/41%), college graduate (52/53%), post-graduate (65/74%) (Brumfield 2005; The Gallup Poll 2009), and university professor levels (94%; Paz-y-Miño-C and Espinosa 2012a, b). Likewise, it can be documented as function of world technological prosperity, which correlates with excellence in education, for example, public acceptance of evolution is above 50% in Sweden (68%), Germany (65%), China (64%), Japan (60%), Belgium (61%), Great Britain and France (55%), and Spain (53%); around or below 50% in Australia (51%), Canada (45%), South Korea (41%), Italy (40%), India (39%) and Argentina (37%); and alarmingly low in Mexico (34%), U.S. (28%), Russia (26%), Brazil (22%), Turkey (19%), Indonesia (11%) and Saudi Arabia (7%) (IPSOS 2011). Note that the U.S. and Russia (highly religious culturally) are exceptions. The underlying assumption of this prediction is that 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

IH predicts a negative association between acceptance of evolution and level of religiosity. This prediction can be assessed by documenting and plotting acceptance of evolution as function of diverse levels of religiosity, from no-religion (non-believer or atheist position), to moderate, and to deeply religious. The assumption is that atheists, non-believers and agnostics will accept evolution more than the moderate or deeply religious (Paz-y-Miño-C and Espinosa 2013a). We have documented such patterns by polling two distinct groups: first, self-identified atheists, non-believers and agnostics affiliated with the Atheist Alliance of America (AAA-US, N=133; Paz-y-Miño-C and Espinosa 2012c); and second, researchers, educators and students at 35 colleges and universities in New England, the U.S., plus European scientists from 25 countries (grand total N=1,392; Paz-y-Miño-C and Espinosa 2012a, b, 2013b). In a scale-religiosity index RI ranging from 0 to 3, least to most religious position, 93% of the atheists, non-believers and agnostics (whose RI=0 and educational attainment varied broadly) indicated to “accept evolution openly regardless of others’ opinions”, which was comparable to the 94% of the highly-educated New England researchers (RI=0.49) and 92% of the European scientists (RI=0.46), and significantly higher than the 72% of the New England educators (RI=1.31) and 63% of the students (RI=0.89) (Paz-y-Miño-C and Espinosa 2012a, b, c, 2013a, b). When RI was 0,

understanding of evolution—as function of an evolution literacy index EI, also ranging from 0 to 3, least to most knowledgeable about evolution—was high(er) in all groups (EI=2.59 among 70% of the New England researchers, EI=2.56 among 72% of the European scientists, EI=2.41 in 100% of the atheists, EI=2.16 among 36% of the New England educators, and EI=1.67 among 54% of the students; grand total N=778), however when RI was 3, understanding of evolution EI was low(est) (EI=2.0 among 3% of the New England researchers, EI=1.33 among 6% of the European scientists, EI=1.35 among 13% of the students, and EI=1.25 among 19% of the New England educators; grand total N=157) (Paz-y-Miño-C and Espinosa 2012a, b, c, 2013a, b).

The prediction can also be documented on a broader scale: acceptance of evolution is high among the least religious countries in the world and low among the most religious. For example, creationist views combined with the notion that “humans cannot possibly be apes” are low in Germany and Great Britain (12%), China, Spain and Japan (11%), Sweden (10%), France (9%) and Belgium (8%); higher in Russia (34%), India (33%), Mexico (32%), Argentina (26%), South Korea (24%), Canada (22%), Italy (21%) and Australia (15%); and even higher in Saudi Arabia (75%), Turkey (60%), Indonesia (57%), Brazil (47%), and the U.S. (40%) (IPSOS 2011). Note that scores for acceptance of evolution in these countries were given in the previous section.

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; 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 Gross et al. 2012). However, the point of this prediction is that “belief” disrupts, delays and/or stops the correct comprehension and acceptance of the evidence in support of evolution.

Alternatives to IH

The obvious alternative proposal to the incompatibility hypothesis is “compatibility” (CH) between scientific rationalism/empiricism and the belief in supernatural causation, which can be supported—at least temporarily—when the individual adopts the self-comforting positions of:

harmony (=compatibility in principle and practice), non-overlapping magisteria NOMA (=compatibility in practice), or agnosticism (=compatibility in principle and practice). However, harmony is short lasting considering that the essence of science is to examine with facts all harmony-seeking proposals and reject them when lacking support (e.g. theistic evolution, creation science, or BioLogos, which seek harmony). NOMA confines science and belief to separate domains and is compulsory, which challenges the freedoms of science or belief to scrutinize each other; historically, scientific rationalism/empiricism has consistently won the scrutiny battle (above). Agnosticism offers an uncompromising escape route inconsistent with the straightforwardness of science; therefore, it is destined to fade away. Although not strict a alternative hypothesis to IH, harmony, NOMA and agnosticism have been discussed under such premise (Paz-y-Miño-C and Espinosa 2013a).

IH foresees everlasting struggle within the harmony, NOMA or agnosticism positions. Ultimately, IH offers a logical explanation—the “incompatibility” itself—for the causality of the conflict between science/evolution and religion, one that can be tested historically by recounting the chronological victories of science over all creationist challenges, or contemporarily by applying the scientific method to examining the controversy as function of its characterizing variables (see multiple-variable analyses below). IH is founded on the premise that because supernatural causation is improbable, the conflict emerges as an intrinsic outcome of the debate about its likelihood of occurrence. In contrast, CH is founded on the belief that a Creator or Intelligent Designer is possible and, therefore, “harmony” is necessary. We challenge the “compatibility” principle for lacking scientific support.

How to Test IH and Its Auxiliary Hypotheses

To examine IH theoretically and test it quantitatively, we have conceptualized a Cartesian landscape where the dependent variable acceptance of evolution is plotted as a function of three factors (Fig. 1): personal religious convictions (=belief), understanding how evolution works (=familiarity with the processes and forces of change in organisms), and understanding the essence of science (=method to explore reality) (Paz-y-Miño-C and Espinosa 2012a).

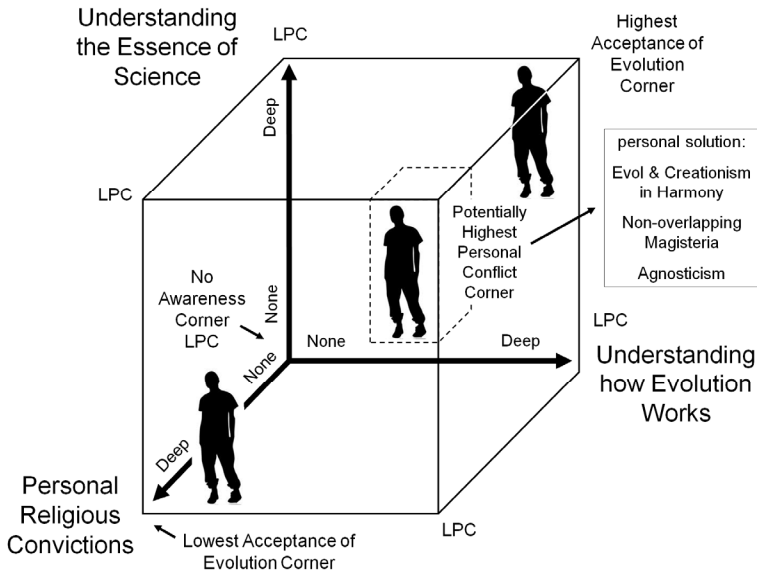


Fig. 1 Conceptual three-dimensional landscape where the acceptance of evolution is depicted as a function of religiosity, science awareness and evolution literacy (adapted from Paz-y-Miño-C and Espinosa 2012a, with permission).

The point zero in the Cartesian landscape depicted in Fig. 1, from which coordinates x , y and z originate, corresponds to a low (labelled *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 arrows of the coordinates 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 the individual's adopting comforting positions: evolution and creationism are in harmony, non-overlapping magisteria NOMA, or agnosticism (above). Note that four other corners are labelled LPC in Fig. 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).

To quantitate the levels of religiosity, understanding of science and the evolutionary process, and plot them according to the parameters depicted in Fig. 1, we 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* (The Pew Global Attitudes Project 2007), Science Index *SI* and Evolution Index *EI* (Paz-y-Miño-C & Espinosa 2011b). 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 1,133 U.S. adults with diverse academic backgrounds, from college students to university professors; Paz-y-Miño-C & Espinosa 2011b, 2012b, 2013a, b).

Each index relies on examining responses to simple, informative questions: (i) 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*; (ii) 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*; and (iii) 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*.

Our studies on patterns of acceptance of evolution and attitudes towards science in New England (i.e. university professors, educators and college students), or among European scientists and members of the AAA (above) have given us robust results, consistent with the conceptualization depicted in Fig. 1: understanding of science and acceptance of evolution has always decreased with increasing religiosity. Acceptance of evolution has increased with higher levels of understanding science. The non-religious responders have reached the highest levels of understanding of science and evolution (=no conflict with science/evolution), in contrast to the deeply

religious who have scored lowest in science- and evolution-literacy indexes (=highest conflict with science/evolution) (Paz-y-Miño-C and Espinosa 2012a, b; 2013a, b). Those exposed to science courses, particularly biology, were more inclined to accept evolution than those deficient in science (Paz-y-Miño-C and Espinosa 2009a). In all groups, acceptance of evolution increased conspicuously with academic level (Paz-y-Miño-C and Espinosa 2009a, b, 2011b, 2012b, and 2013b).

In significant studies, Miller et al. (2006) and Hawley et al. (2011) have used structural equation models to explore the interconnectivity of multiple characterizers of acceptance of evolution. These approaches are critical for the comprehensive understanding, at the proximate level (=proximate hypotheses), of the dynamic and multi-factor nature of the controversy. For example, Miller et al. (2006) have determined that public opposition to evolution in the U.S. resides in specific variables: 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 U.S. ($R^2=0.46$ total effects) and Europe ($R^2=0.18$ total effects). Although in the U.S. and Europe religiosity is the main factor associated negatively with acceptance of evolution, the North American and European populations differ distinctively in the magnitude and/or set of variables influencing the phenomenon. Hawley et al. (2011) have gone further into the multiple variable analysis of attitudes towards evolution and identified six “higher-order” factors (political activity, political and religious conservatism, knowledge about evolution and its relevance, creationist reasoning, evolutionary misconceptions, and exposure to evolution) which interact with sixteen other “lower order” constructs (e.g. political, religious, moral and social commitments and/or objections; knowledge about science, evolution and technology; and exposure to evolution and/or its misconceptions; among others), thus illustrating the multidimensional complexity of the controversy.

The auxiliary hypotheses, as examined by Miller et al. (2006) and Hawley et al. (2011), are susceptible to rapid change, for example, the relationship among religious beliefs, pro-life beliefs or political ideology will vary in the short-term depending on societal circumstances; the same applies to Hawley et al.’s higher- and lower-order factors. The IH, however, as central hypothesis, is less prone to abrupt transformations (it predicts everlasting conflict between science/evolution and religion), unless “belief” vanishes and, therefore, the conflict ceases. Importantly, the auxiliary proposals are essential to study and characterize IH.

Acknowledgments

We thank University San Francisco of Quito and its Galapagos Institute for the Arts and Sciences for inviting us to participate, as keynote speakers, at the Galapagos III World Evolution Summit (June 1-5, 2013) and to write this chapter. Carlos Montúfar, Diego Quiroga, Gabriel Trueba, Verónica Barragán, Patricia Sierra, Carlos Valle, Lourdes Torres, Stella de la Torre and Paula Córdova hosted the Summit splendidly. G Paz-y-Miño-C is supported by the UMassD Office of Faculty Development (Innovation in Teaching Awards AY0910, Undergraduate Research Grants F09) and A Espinosa by NIH grant 8P20GM103430-13. Paz-y-Miño-C and Espinosa are sponsored by New England Science Public and the Roger Williams University's Center for the Public Understanding of Science.

References

- Apple, Michael W. "Evolution Versus Creationism in Education." *Educational Policy* 22 (2008): 327–335.
- Berkman, Michael B., and Eric Plutzer. "Scientific Expertise and the Culture War: Public Opinion and the Teaching of Evolution in the American States." *Perspective on Politics* 7 (2009): 485–499.
- Berkman, Michael B., and Eric Plutzer. "Defeating Creationism in the Courtroom, But Not in the Classroom." *Science* 331 (2011): 404–405.
- Brumfiel, Geoff. "Who Has Designs on Your Students' Minds?" *Nature* 434 (2005): 1062–1065.
- Darwin, Charles. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. London: John Murray, 1859.
- . *The Descent of Man, and Selection in Relation to Sex*. London: John Murray, 1871.
- Ecklund, Elaine H, and Jerry Z. Park. "Conflict Between Religion and Science Among Academic Scientists?" *Journal for the Scientific Study of Religion* 48 (2009): 276–292.
- Forrest, Barbara C., and Paul R. Gross. "Biochemistry by Design." *Trends in Biochemical Sciences* 32 (2007): 301–310.
- Forrest, Barbara C., and Paul R. Gross. *Creationism's Trojan Horse: The Wedge of Intelligent Design*. New York: Oxford University Press, 2007.
- Gould, Stephen J. *Rocks of Ages*. New York: Ballantine Books, 1999.

- Hawley, Patricia H., Stephen D. Short, Luke A. McCune, Mark R. Osman, and Todd D. Little. "What's the Matter with Kansas?: The Development and Confirmation of the Evolutionary Attitudes and Literacy Survey (EALS)." *Evolution, Education and Outreach* 4 (2011): 117–132.
- IPSOS. "Supreme Being, the Afterlife, and Evolution." 2011. Accessed October 3, 2013.
<http://www.ipsos-na.com/news-polls/pressrelease.aspx?id=5217>.
- Kitzmiller, Tammy et al. versus Dover Area School District et al. 2005. Accessed October 3, 2013.
http://ncse.com/files/pub/legal/kitzmiller/highlights/2005-12-20_Kitzmiller_decision.pdf.
- Lakatos, Imre. *The Methodology of Scientific Research Programmes, Philosophical Papers Volume 1*. Cambridge: Cambridge University Press, 1978.
- Lerner, Lawrence S. *Good Science, Bad Science: Teaching Evolution in the States*. Washington DC: The Thomas B. Fordham Foundation, 2000.
- Lerner, Lawrence S., Ursula Goodenough, John Lynch, Martha Schwartz, Richard Schwartz, and Paul R. Gross. *The State of State Science Standards*. Washington DC: Thomas B. Fordham Institute, 2012.
- Matzke, Nicholas J. "The Evolution of Creationist Movements." *Evolution, Education, and Outreach* 3 (2010): 145–162.
- Miller, John D., and Robert T Pennock. "Science Education and Religion in America in the 21st Century: Holding the Center." In *Secularism and Science in the 21st Century*, 9-32. Harford, MA: Institute for the Study of Secularism in Society and Culture, 2008.
- Miller, John D., Eugenie C. Scott, and Shinji Okamoto. "Public Acceptance of Evolution." *Science* 313 (2006): 765–766.
- Montúfar, Carlos. "From Copernicus to Darwin (1473-1882)." In *Evolution From the Galapagos, Social and Ecological Interactions in the Galapagos 2*, 11–14. New York, NY: Springer Science Business Media, 2013.
- Moore, Randy. "Teaching Evolution: Do State Standards Matter?" *BioScience* 52 (2002): 378–381.
- . "How Well Do Biology Teachers Understand the Legal Issues Associated with the Teaching of Evolution?" *BioScience* 54 (2004): 860–865.
- Padian, Kevin, and Nicholas Matzke. "Darwin, Dover, 'Intelligent Design' and Textbooks." *Biochemistry Journal* 417 (2009): 29–42.

- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "The Everlasting Conflict Evolution-and-science versus Religiosity." In *Religion and Ethics*, edited by Gloria Simpson and Spencer Payne, 73–97. New York: NOVA Publishers, 2013.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "Attitudes toward Evolution at New England Colleges and Universities, United States." *New England Science Public: Series Evolution* 1 (2013): 1–32.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "Introduction: Why People Do Not Accept Evolution?" *Journal of Eukaryotic Microbiology* 59 (2012): 101–104.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "Educators of Prospective Teachers Hesitate to Embrace Evolution Due to Deficient Understanding of Science/evolution and High Religiosity." *Evolution: Education & Outreach* 5 (2012): 139–162.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "Atheists' Knowledge About Science and Evolution." *Secular World* 18 (2012): 33–36.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "On the Theory of Evolution versus the Concept of Evolution: Three Observations." *Evolution, Education, and Outreach* 2 (2011): 308–312.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "New England Faculty and College Students Differ in Their Views About Evolution, Creationism, Intelligent Design, and Religiosity." *Evolution, Education, and Outreach* 2 (2011): 323–342.
- Paz-y-Miño-C, Guillermo, Avelina Espinosa, and Chunyan Y. Bai. "The Jackprot Simulation Couples Mutation Rate with Natural Selection to Illustrate How Protein Evolution is Not Random." *Evolution: Education and Outreach* 4 (2011): 502–514.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "Using Horizontal Gene Transfer and Common Descent to Depict Evolution and Contrast it with Common Design." *Journal of Eukaryotic Microbiology* 57 (2010): 11–18.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa. "Assessment of Biology Majors versus Non-majors Views on Evolution, Creationism and Intelligent Design." *Evolution, Education and Outreach* 2 (2009): 75–83.
- Paz-y-Miño-C, Guillermo, and Avelina Espinosa A. "Acceptance of Evolution Increases with Student Academic Level: A Comparison between a Secular and a Religious College." *Evolution, Education, and Outreach* 2 (2009): 655–675.
- Pennock, Robert T. *Intelligent Design Creationism and its Critics*. Cambridge: Massachusetts Institute of Technology, 2001.

- Petto, Andrew J., and Laurie R. Godfrey. *Scientists Confront Intelligent Design and Creationism*. New York, NY: W. W. Norton and Company, 2007.
- Phy-Olsen, Allene S. *Evolution, Creationism, and Intelligent Design: Historical Guides to Controversial Issues in America*. Santa Barbara: Greenwood, 2010.
- Schneiderman, Jill S., and Warren D. Allmon. *For the Rock Record: Geologists on Intelligent Design*. Berkeley & Los Angeles, CA: University of California Press, 2009.
- Stenger, Victor J. *God and the Folly of Faith: The incompatibility of Science and Religion*. Amherst, NY: Prometheus Books, 2012.
- Susskind, Leonard. *The Cosmic Landscape: String Theory and The Illusion of Intelligent Design*. New York: Little Brown and Company, 2006.
- The Gallup Poll. "On Darwin's Birthday, Only 4 in 10 Believe in Evolution." 2009. Accessed October 3, 2013. <http://www.gallup.com/poll/114544/xDarwin-Birthday-Believe-Evolution.aspx>.
- The Pew Global Attitudes Project. "World Publics Welcome Global Trade But not Immigration." Washington D. C. 2007. Accessed October 3, 2013. <http://pewglobal.org/files/pdf/258.pdf>.
- Wexler, Jay D. "From the Classroom to the Courtroom: Intelligent Design and the Constitution." *Evolution: Education, and Outreach* 3 (2010): 215–24.
- Young, Matt, and Taner Edis. *Why Intelligent Design Fails: A Scientific Critique of the New Creationism*. New Brunswick, NJ: Rutgers University Press, 2004.

CHAPTER TWO

THE EVOLUTION OF COOPERATION

CHARLES T. SNOWDON

Humans (and some other species) are cooperative. However, the phenomenon of cooperation creates several problems for evolutionary theory. Popular views of evolution include phrases such as “survival of the fittest”, “nature red in tooth and claw”, “most animals live lives that are nasty, brutish and short”. Is not evolution really about competition and aggression? Isn't life a struggle for reproductive success? In the context of these popular views about evolution, how can we explain cooperation and altruism? How can it be adaptive for one organism to help another?

Darwin recognized the problem, but suggested that humans and other animals were cooperative:

Finally the social instincts, which no doubt were acquired by man as by the lower animals for the good of the community, will from the first have given him some wish to aid his fellows and compelled him to regard their approbation and disapprobation (Darwin, 1875, p.124).

And Darwin saw the solution to the issue of cooperation in terms of group selection:

It must not be forgotten that although a standard of morality gives but a slight or no advantage to each individual man and his children over other men of the same tribe, yet that an increase in the number of well-endowed men will certainly give an immense advantage to one tribe over another (Darwin, 1875, p. 137).

Recently, several books have been published where the authors attempt to address the issue of the evolution of cooperation (Boehm, 2012; Bowles & Gintis, 2011; Henrich & Henrich, 2007; Nowak & Highfield, 2011, Sober & Wilson, 1998; Tomasello, 2009; Wilson, 2012). Although the books

differ in many specifics, they converge on several common themes. The most common explanations of cooperation and altruism, which are based on shared genetic descent (kin selection) or strict reciprocal altruism, are rejected as not being adequate to account for all of the varieties of cooperation seen among humans. Second, most authors appeal to Darwin's explanation that group selection or multi-level selection is necessary based on the dogma that groups of altruists can out-compete groups of selfish individuals. Third, all theories try to explain altruism and cooperation on the basis of genes (and for modelling, most use single genes or only a limited number of genes). Fourth, most of the authors argue that cooperation within groups is based on punishment of freeloaders (cheaters) and the negative social emotions of shame and guilt. That is, our basic human nature is to be selfish and we need group social norms to enforce our cooperation. Finally, all authors note that humans are special, and differ in dramatic ways from our closest relatives the great apes and, in particular, chimpanzees. The authors collectively have generated a long list of behaviours that they think are unique to humans (see Table 1 below).

Challenging These Views of Cooperation

There are several problems with the accounts summarized here. I want to challenge several of these key points and develop an alternative scenario for the evolution of cooperation. First of all, we do not need to invoke concepts of group or multilevel selection in order to explain altruism, if we think more broadly about relatedness and reciprocity (West, el-Mouden & Gardner, 2011). Hamilton's rule of kin selection, whereby we should calculate the relatedness of close kin based on relatedness, really only considers genes shared by common descent. In the small hunter-gatherer groups from which modern humans are thought to have descended, it is quite likely that there is a high relatedness among all group members as well as between adjacent groups, expanding greatly the concept of kin selection. Within a small geographical area, the degree of relatedness among all group members is likely to be quite high. Furthermore, generalized reciprocity, whereby a recipient of an altruistic act will in turn do something to benefit another group member and not necessarily reciprocate to the initial donor, can explain the much broader range of helping behaviour seen among humans (West et al., 2011). Thus, with broader definitions of relatedness and generalized reciprocity we do not need to invoke multi-level selection.