Volume 25, Number 3 • Fall 2021

ISSN: 2692-241X

Electronic Journal for Research in Science & Mathematics Education

Flagship Journal of the International Consortium for Research in Science & Mathematics Education (ICRSME)

Sinai and Synapses Fellowship: **Elevating the Discourse Between Science and Religion**

ICRSME

EJRSME

Electronic Journal for Research in Science & Mathematics Education

PUBLISHER

ICRSME, International Consortium for Research in Science & Mathematics Education

Cover designed by Dusty Crocker

CONTENTS

Volume 25 No. 3 | Fall 2021

ICRSME Sponsor

COLLEGE OF
EDUCATION

ANDREWS INSTITUTE

Support Us

ICRSME is a nonprofit organization and your donations will help fund its various activities including the publication of EJRSME and hosting international consultations and virtual meetings.

https://icrsme.com/support-us

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 1-3

What is the Sinai and Synapses Fellowship?

Rabbi Geoffrey A. Mitelman
Founding Director of Sinai and Synapses

Today's society promotes a false belief in a fixed "either/or" sense of identity. On one side is "science," which tends to be perceived as being liberal and educated. The other side is "religion," which tends to be perceived as being conservative and uneducated. Not only that, but there's also an assumption that once you pick one side, you must choose all the other associations that come along with it. Each side then attacks the other as being wrong at best, and evil at worst. This false dichotomy, and these attacks and counterattacks, prevent real conversations from happening, keep people from working together to solve problems, and deepen the polarization and mistrust in our society today.

With issues like climate change and COVID-19, battles in schoolboards on how we teach both science and humanities, and a basic lack of trust in institutions, the public discourse has simply gotten worse over time. How do we resolve this? Many of us may think that more facts and more knowledge will change people's minds – and since science is what gives us a better understanding of the world, science is the way to do it.

But people – including scientists – are not disembodied brains, simply pursuing truth for its own sake. Instead, we need to ask people, "What are your deepest values? What frightens you? What gives you joy? What keeps you up at night, and what gets you out of bed in the morning?" Real people are more than soundbites or caricatures, and we need to understand educators, scientists, and laypeople in the fullness of their complex humanity.

That's what the Sinai and Synapses Fellowship aims to do. Since its launch in 2013, it showcases people who model constructive engagement across religious, academic, and geographic divides. By bringing together a select group of clergy, scientists, writers, and thinkers, we explore big questions – such the changing role of technology, advances in genetic engineering, and the role of truth and trust in our society – from both scientific and religious perspectives. It's designed to focus on fostering relationships, and through four cohorts, 55 Fellows have participated in the program, with 100% of them saying that the program impacted them personally, and 92% saying it impacted them professionally. This journal issue represents just a few of the incredible people who have been part of this network and seen its power.

Sinai and Synapses aims to celebrate multiple forms of diversity – not just of gender and ethnicity, but also of geography, professional background, age, and experience. By selecting both strong individual Fellows and a dynamic group, the Fellowship breaks down the many silos we see today and tries to combat the challenges we see in society today. After all, social media has become an echo chamber, simply reinforcing pre-existing beliefs. Academics are feeling lonely and isolated and have become so immersed in their own studies that there is almost no interaction with people from other fields, or even from specialized sub-fields besides their own. And clergy feel burnt out, with constant demands on their time and minimal time for reflection and study. The Sinai and Synapses Fellowship offers rejuvenation and opportunities for cross-pollination.

So, what exactly happens in the Fellowship? First, between twelve and eighteen Fellows are selected through a competitive application process. The Fellows then meet three times per year for two years, and ideally in person (although COVID has forced some of these meetings to be online). We intentionally select people who are not only experts in their field, but also people who are both curious and kind. More than knowledge, we want people who love to learn – both about scientific

subjects *and* about the people who are in the room. We want the Fellows to bring their whole selves to these conversations.

When the Fellows come to the meeting, we focus on a specific subject, such as, *The Cost of Being Right and the Benefit of Being Wrong in Both Science and Religion*. The sessions begin with an opening prompt to spark personal reflection on the theme of the day, such as *Share a story about when evidence changed your mind about a deeply held belief. What prompted you to change your mind and accept this new evidence*? By exploring a particular subject through both religious and scientific lenses, the Fellows can more easily bring their personal experience to bear on the question at hand, which then can spark new ideas or avenues of research, or simply recognize similar points of view that they might not have seen otherwise.

They then learn from an expert on the subject, with ample time for questions and answers, followed by small-group discussion on what they have learned and how it affects them either personally or professionally. These facilitated discussions allow creating a safe enough space to explore challenging – or even dangerous – questions. There becomes a level of trust and openness in these conversations, allowing people to discuss difficult and charged topics without fear of retribution or embarrassment. And as the Fellowship has grown over the years, we've also run multiple alumni meetings, where Fellows can 'workshop' their ideas before presenting them at a conference or trying to publish a new study. It has become a laboratory to see what we don't know, what we're missing, or how we need to communicate more clearly and effectively.

This leads to a second part of the Fellowship, and one that you see in this issue – namely, writing, publishing, and speaking on key issues where both science and religion can bring wisdom to bear on the conversation. Over 400 pieces of content have come out of the Fellowship, ranging from keynote presentations at academic conferences to articles for Forbes and Nautilus to articles in peer-reviewed journals. The essays you see here were inspired by the work our Fellows are doing and explore topics that range from reducing skepticism of science to how fear of death informs our lives to the ways environmental and racial justice intersect to the history of pandemics in Jewish thought. We can only imagine what new ideas will arise from these essays, and what they will spark in others.

We're also pleased to announce that, with grant funding secured from the Issachar Fund, applications are now open for the fifth round of the Sinai and Synapses Fellowship. They will be open from October 4th through November 16th, 2021, and you can see more at sinaiandsynapses.org/sinai-and-synapses-fellowship. As we describe it, the ideal Fellow is someone who is:

- a professional in either religion or science (e.g. clergy person, working scientist, educator, professor, doctoral student, medical professional, journalist),
- passionate about elevating the discourse surrounding religion and science,
- a believer that both religion and science can have great value in our society,
- deeply curious about new ideas and new perspectives,
- excited about learning from both experts and peers,
- respectful when challenging others, and willing to be challenged themselves,
- searching for new questions, rather than trying to find answers,
- aware that there are often multiple truths on any subject,
- able to create content and run programs in his/her field, and
- active on social media.

If this sounds like you, and if these essays inspire you, raise questions for you, or lead you to think differently about these topics, we encourage you to apply. We are always looking for thoughtful people who believe science is crucial for learning of all ages, and who recognize that values, personal stories, and relationships are a central aspect of what it means to be human.

From a personal perspective, I'm deeply grateful to Mark Bloom and Ian Binns for editing this volume, to all the Fellows who contributed and to the Issachar Fund and the many other supporters of Sinai and Synapses for helping to significantly expand the reach and power of the Fellowship. This is far beyond what I could have imagined in 2013, when I called up a few friends to see if they'd be interested in talking about science and religion, and which ultimately became the Sinai and Synapses Fellowship. It has given me so much joy to see these ideas reaching such a wide audience, and that these relationships and connections – which simply continue to grow – have truly become so much more than the sum of its parts.

May we all go from strength to strength, bringing our values and our insights to inspire more people to love science, and all the ways it gives us life.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 4-9

Interactions Between Religion and Science Education: Perspectives of the Sinai and Synapses Fellows

Mark A. Bloom
Dallas Baptist University

Ian C. Binns
University of North Carolina at Charlotte

Context for this Special Issue

Several years ago, at a conference for science educators, we were discussing with colleagues the interactions between science and religion, particularly when it came to the students in our science classrooms. At that time, science educators who were interested in religion really didn't speak out much at academic meetings about their interest; it just didn't seem to be of much interest to the general science education community. In fact, in response to our discussion, a respected colleague said that he really didn't care about students' religious beliefs as they were not relevant to the science he was teaching in the classroom. That exchange led to much more reflection and dialogue over the coming years about how important it really might be for science teachers to consider the religious perspectives of their students; spoiler alert …we think it is important.

Why do we think understanding students' religious backgrounds matters to science educators? Well, consider that since the rise of science as the primary method of learning about the natural world, tension has existed between science and religion. A 2014 PEW study found that 59% of Americans believed science and religion to be in conflict with each other and only 38% believed them to be compatible (Funk & Alper, 2015). Across America, particularly in the South, many Christians view science as conflicting with their religious beliefs; as such, many Christians mistrust science (Alumkal, 2017), avoid pursuing STEM careers (Ecklund & Scheitle, 2018), and lack scientific literacy (Noll, 1994). Religious skepticism of science has more recently taken on political undertones as seen in the struggle to convince much of the U.S. population to wear masks, social distance, or get vaccinated to slow the spread of COVID-19 (Bloom & Quebec Fuentes, 2020). In the rapidly changing societies of the modern world, science plays an ever-increasing role in the lives of everyday citizens. In a democratic society, for example, citizens must have a working understanding of genetic medicine, emerging diseases, species loss, and climate change if they hope to make informed choices for themselves and in the voting booth (Hoezee, 2012). Perhaps, considering how students' religious backgrounds can impact their acceptance of, or willingness to consider, science might be a critical need to achieve science literacy. In the current climate of dangerous scientific skepticism, and worse, outright science denialism, this might be more crucial than ever.

In the years that followed that conference, when we first began engaging in serious discussions about science and religion, we found there was a growing body of science education scholars who shared our interest in how religious beliefs impacted our ability to successfully teach science - and our students' ability to listen and consider accepted science content. It's been great to see our professional community begin to explore science and religion more seriously. Some of the results of such collaborations include *Evolution Education in the American South: Culture, Politics, and Resources in and around Alabama* (Lynn et al., 2017), *Making Sense of Science and Religion: Strategies for the Classroom and Beyond* (Shane et al., 2020), and perhaps a bit less 'on the nose' but worthy of inclusion we think, *Virtues as*

Integral to Science Education: Understanding the Intellectual, Moral, and Civic Value of Science and Scientific Inquiry (Melville & Kerr, 2021).

Also during those years, Ian was selected as a 2017-2019 Sinai and Synapses Fellow and Mark was selected for the subsequent fellowship from 2019-2021. In these fellowships, we have had the privilege of collaborating and learning with some of the brightest, kindest, and authentic thinkers about the intersection of science and religion - big "Thanks!" to Rabbi Geoffrey Mitelman and the Issachar Fund for these experiences! As an outgrowth of Ian's fellowship, he helped create the Down the Wormhole podcast, which explores the "strange and fascinating relationship between science and religion" - we hope you will give it a try. A result of Mark's fellowship is this issue. While COVID-19 did its best to disrupt the 2019-2021 fellowship, the fellowship served as a life raft to keep things intellectually stimulating during the pandemic. Throughout the six Sinai and Synapses meetings (five virtual) of the fellowship, Mark was able to meet 14 other fascinating individuals who explore the worlds of science and religion. As co-editor of EJRSME, he felt these fellows, along with those who came before could offer some helpful perspectives for the readers of this journal. Ian, an associate editor of EJRSME, was happy to join as co-editor of this special issue, which is composed of 10 manuscripts submitted by 13 fellows spanning all four cohorts. The authors represent science educators, clergy, chaplains, doctoral students, teachers, scientists, and other academics. In this special issue, we found several themes that were revealed across the contributions.

Understanding the Psychology Behind Religious Learners Encountering Science

Megan Cuzzolino, Ed.D. in Science Education, begins the issue with an overarching examination of the cognitive, developmental, and sociocultural influences that shape how students learn about science and religion. Jonathan Morgan, Ph.D. in Psychology of Religion, follows this with an explanation of how students bring to the classroom deeply held beliefs and concerns about scientific issues and how these beliefs can impact how they respond to science instruction. His examination into existentially motivated cognition offers some valuable advice to science instructors who teach content that can create controversy with religious students. Ashlynn Stillwell, Ph.D. in Civil Engineering, approaches the psychology behind religious learners in the context of sustainability. Her experiences teaching sustainability education to both secular and spiritual groups exposes three drivers for student learning. Isaac Alderman, Ph.D. in Biblical Studies, and Kendra Holt Moore, Ph.D. Candidate in Religious Studies, share how the idea of Terror Management Theory can inform science education when the content triggers 'death anxiety' as it conflicts with the learner's worldview.

Religious Practices Changing in Light of Scientific Findings

Another theme centering on how sometimes religious practices and/or beliefs can change in light of scientific observations. Rabbi Jonathan Crane, Ph.D. in Religion, shares an article about how 16th century (and earlier) Jewish law was adjusted in light of pandemics emerging from pigs and shows how science can inform and complement religious practices. Fast forward to 2020 and we see how Reverend Casey Bien-Aimé and Reverend Kristel Clayville, Ph.D. in Religious Ethics, adjust their chaplaincy duties in light of a modern COVID-19 pandemic but remain true to the spiritual needs of their patients. Reverend Ruth Shaver, Doctor of Ministry, describes a curriculum she helped create that is intended to expose religious communities to issues of environmental justice and environmental racism demonstrating an effort to adjust the actions and beliefs of religious people in light of scientific facts.

Adjusting Science Communication to Better Achieve Scientific Literacy

John ZuHone, Ph.D. in Astronomy and Astrophysics, shares his strategies of incorporating his religious identity with his scientific presence when communicating astronomy and astrophysics with religious communities as a way of reducing the perceived threat toward their religious beliefs. Matthew Groves, Harpeth Hall upper science and mathematics teacher, similarly describes how his choice of words and his approach to dialogue with learners rather than convert them helps him to better achieve his desired outcomes when teaching climate change science to evangelicals in settings ranging from public school classrooms to church Sunday schools. Closing the issue, Mark A. Bloom, Ian C. Binns, and Lee Meadows (each with a Ph.D. in Science Teacher Education) share strategies they have used to teach religiously and culturally sensitive science content to diverse populations - content spanning climate change, environmental racism, and human evolution.

We hope you will find each contribution as supportive of improving communication with students who hold deep religious beliefs and may be reticent to considering science content in the classroom. Below we share a brief description of each contribution to the special issue.

Rabbi Geoffrey Mitelman – What is the Sinai and Synapses Fellowship?

In a preface to the issue, Rabbi Mitelman explains the history and purpose of the Sinai and Synapses Fellowship. He also extends an invitation for applicants to the 2021-2023 Fellowship. Applications for the fellowship will be accepted through November 16, 2021.

Megan Powell Cuzzolino, Ed.D. – A Unique Way of Knowing: Children's Conceptions of the Nature of Science and its Relationship to Religion

Cuzzolino opens the issue with an overarching exploration into children's ideas about the relationship between science and religion, a largely unexplored topic in most public school classrooms despite the fact that it is a present (and often significant) feature of many students' lives outside of school. Through this review of the literature, she reveals what the extant research suggests are the cognitive, developmental, and sociocultural factors that shape how young learners develop conceptions of science and its relationship to religion and discusses the potential implications for exposing children to instruction that addresses the relationship between science and religion.

Jonathan Morgan, Ph.D. – Overlapping Magisteria: Motivated Cognition and the Places where Science and Religion Mingle

Morgan shares how scientific insights can help us better understand ourselves, others, and the world we share. Such insights can also radically challenge our sense of who we are, our place in the universe, and the very nature of the universe. He explains that when scientific theories venture into this existential terrain they quickly encounter dearly held religious beliefs. Where these two meaning-making systems overlap can often become places of friction as communicators and audiences alike are asked to balance our need for accuracy with our needs for existential security, all while humbling considering the limitations of scientific inference. His article brings together research on existentially motivated cognition and science communication in order to better understand these challenges and to offer a way to navigate this potentially fraught terrain.

Rabbi Jonathan Crane, Ph.D. – Zoonotic Pandemics and Judaism's Early-Modern Turn to Science

In this insightful piece, Crane describes how science and religion can support each other using an example from as far back as the 2nd century. He describes a vignette from the Babylonian Talmud when Rabbi Judah HaNasi connects the pestilence among pigs to similar sickness in humans. He then shares a passage from 16th century Jewish law in which another Rabbi admonishes his people to fast when there is 'pestilence among pigs' as he has evidence that when the pigs get sick so do humans. Crane points out that this shift towards empiricism, experience, and experimentation, so characteristic of the Enlightenment Period, suggests a new legitimate epistemology for shaping Jewish norms and behaviors and represents the Jewish community's acceptance of science, scientific method, and evidence as helpful, especially in regard to personal health and food.

John ZuHone, Ph.D. – Reducing Scientific Skepticism

ZuHone describes how education, public outreach, and popularization efforts in astronomy and space science can provide opportunities for scientists and religious believers to engage with each other, and ideally result in greater public confidence in science. How religious communities, when faced with difficult scientific questions with an open mind, have used the overlap of science and religions to constructively engage and resolve tensions between scientific discoveries and interpretations of the world offered by their faith perspectives. The result is that leaders of these communities, seen as important authorities within them, have been able to project a message of confidence in science, incorporation into their worldview, and a lessening of the perceived threat of science to their belief system.

Ashlynn Stillwell, Ph.D. – Sustainability for Secular and Spiritual Groups: A Framework from University and Community Education

Education around the concept of sustainability, encompassing the environment, economy, and society, presents challenges of context among diverse groups. In this contribution, Stillwell presents a framework for sustainability education based on experience with educating secular groups in a university context and educating spiritual groups in a community context. This sustainability education framework highlights three drivers for student learning: passion, experience, and uncertainty. Examples from education of secular and spiritual groups illustrate the importance of projects, challenges, and dialogue. Sustainability education can reveal common ground between science and religion.

Rev. Ruth Shaver, DMin – Wonder as an Invitation to Engage in Environmental Justice

Shaver shares a curriculum specifically developed for educating religious communities about environmental justice issues and emphasizing that environmental care is an essential part of following one's religious faith. She describes the process in developing this program for communities who typically don't have a strong science background. Her hope is that this program will help participants become involved in environmental justice.

Isaac Alderman, Ph.D. and Kendra Holt Moore – Terror Management and Religious Literacy in the Classroom

Over the past decade, Terror Management Theory (TMT) has been widely studied for its role in conflict management and in shaping the behavior of target populations, including in the classroom. Emerging from research on the importance of self-esteem, TMT submits that much of our behavior is driven by death anxiety and its effects are particularly evident when one's "worldview" is threatened by another, incompatible "worldview." When a student is threatened by learning about a topic that is incompatible with their worldview, their response is more contingent upon their sources of self-esteem and meaning than upon the reception of straightforward information on the topic itself. Their religious identities provide yet another layer of framing for self-esteem and belonging that may or may not interfere with their learning. In this article, Alderman and Holt Moore urge educators to recognize the importance of religious literacy when incorporating the insights of TMT into their pedagogical strategies when teaching topics that may be incompatible with the worldview of many of their students.

Matthew Groves – Communicating with Skeptical Audiences

Groves draws upon his many years of communicating the science of climate change with skeptical audiences in schools, churches, media, and professional conferences and shares the lessons he has learned. His insights into effective communication with climate change deniers are critically important to science teaching in the age of the Anthropocene, especially in light of the current war on science and the politicization of scientific issues so prevalent in the U.S.

Rev. Casey Bien-Aimé and Rev. Kristel Clayville, Ph.D. – Called to Care, Trusted to Teach: The Role of Hospital Chaplain in Educating Patients, Families, and Medical Staff during a Pandemic

Bien-Aimé and Clayville discuss how they advocate for patients, give voice to the voiceless, and facilitate communication between medical providers, patients, and families while navigating challenging situations. They explain how, with care and sensitivity, they translate the technical, esoteric, and oftentimes frightening language of medical providers so that it is understandable by those receiving care. They address how the rapidly changing COVID-19 pandemic, and shifting recommendations, made already difficult tasks even more challenging.

Mark A. Bloom, Ph.D., Ian C. Binns, Ph.D., & Lee Meadows, Ph.D. – Communicating Religiously and Culturally Sensitive Science Content

Bloom, Binns, and Meadows describe distinct experiences teaching content that historically causes discomfort among conservative Christian students in formal and informal settings. Bloom shares his experiences teaching climate change science among conservative evangelicals at a private Christian university in Texas. Binns describes his experiences communicating a wide variety of sensitive topics on a public platform. Finally, Meadows shares his experiences using a hands-on approach to teaching human evolution in Alabama.

References

Bloom, M. A., & Quebec Fuentes, S. (2020). Addressing public mistrust of science and mathematics. *Electronic Journal for Research in Science & Mathematics Education,* 24(4).

Alumkal, A. (2017). *Paranoid science: The Christian right's war on reality*. New York University Press.

Ecklund, E. H., & Scheitle, C. P. (2018). *Religion vs. science: What religious people really think*. Oxford University Press.

Funk, C., & Alper, B. A. (2015). *Perceptions of conflict between science and religion*. Pew Research Center. Retrieved online at http://www.pewinternet.org/2015/10/22/perception-of-conflict-between-science-and-religion/.

Hoezee, S. (2012). Introduction. In Haarsma, D. & Hoezee, S. (Eds.). Delight in creation: Scientists share their work with the church. Center for Excellence in Preaching.

Lynn, C. D., Glaze, A. L., Evans, W. A., & Reed, L. K. (Eds.). (2017). *Evolution education in the American South: Culture, politics, and resources in and around Alabama*. Palgrave Macmillan.

Melville, W., & Kerr, D. (Eds.). (2021). *Virtues as integral to science education: Understanding the intellectual, moral, and civic value of science and science inquiry*. Routledge.

Noll, M. A. (1994). *The scandal of the evangelical mind*. William B. Eerdmans Publishing Company.

Shane, J. W., Meadows, L., Hermann, R., & Binns, I. C. (Eds.). (2020). *Making sense of science and religion: Strategies for the classroom and beyond*. NSTA Press.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 10-33

A Unique Way of Knowing: Children's Conceptions of the Nature of Science and its Relationship to Religion

Megan Powell Cuzzolino
Harvard Graduate School of Education

ABSTRACT

There is an increasingly rich body of developmental research on children's understanding of science and religion as ways of knowing. In this manuscript, I put this scholarship in conversation with applied research on science education and consider the potential implications for exposing children to instruction that addresses the relationship between science and religion. I begin by outlining three bodies of literature that can inform our understanding of how learners – especially young learners – make sense of potentially conflicting explanatory frameworks from the domains of science and religion: 1) the literature on testimony, which provides insight into how children learn about science and religion; 2) the literature on epistemological reasoning, which examines how learners think knowledge is conceptualized in different ways of knowing (in this case, science and religion); and 3) the bodies of literature on situated cognition and collateral learning, which posit that the experience of actively grappling with conflicting testimony is emotionally charged and connected to issues of culture and identity. After synthesizing the literature in these three areas, I turn to the science education literature to consider the implications for classroom culture and pedagogy, where I argue that the reviewed research supports the practice of making room for ideas that sit outside the traditional bounds of science as a powerful pedagogical tool. Specifically, I posit that students' questions and ideas about concepts that fall outside these typical domain boundaries can be leveraged by science teachers for deeper understanding – not just about the intended scientific content goals, but also about concepts such as disciplinarity and perspective taking – and for a more inclusive classroom environment that invites all students to engage in scientific thinking, regardless of their cultural or religious backgrounds.

Keywords: children, science and religion, testimony, epistemological reasoning, situated cognition, collateral learning

Editors' Comment

Dr. Megan Powell Cuzzolino, Ed.D., (2015-2017 Fellow), *is the Senior Project Manager at the Next Level Lab, a research group at the Harvard Graduate School of Education that draws on research from the learning sciences to address emerging and urgent issues in education and workforce development. Her doctoral research investigated the role of the emotion of awe in scientific learning and discovery. In this contribution to the special issue, Dr. Cuzzolino presents a thorough examination of the literature on learners' understanding of science and religion and how they make sense of conflicting ideas presented by each. She then makes clear the pedagogical importance of understanding students' ideas about science and religion in order to more successfully teach religiously sensitive science content and, therefore, the need to incorporate this need into science teacher preparation. She also makes clear that, to accomplish such goals, there must be a shift in the mindset of academics regarding the importance of research into*

students' beliefs about supernatural phenomena. We feel this manuscript establishes the importance of understanding learners' beliefs about science and religion and sets the stage for the subsequent shorter contributions about specific interactions between religion and science teaching.

Introduction

"*Science investigations begin with a question.*" This sentence appears in the Next Generation Science Standards (NGSS) as an "Understanding of the Nature of Science" at the Kindergarten-Grade 2 level (NGSS Lead States, 2013), and sure enough, this was how most investigations began in my classroom during my years as an elementary school science teacher. Some questions were more notable than others, but few were as memorable as the line of inquiry that began one morning as I sat on the carpet with a class of first graders, when a conversation about states of matter suddenly turned existential. One student interrupted my review of solids, liquids, and gases to inquire about why matter existed in the first place. Her classmates perked up, and soon others were joining in with questions about when the first matter came into being and whether someone or something was responsible for creating it. Before my eyes, the carpet full of six-year-olds had erupted into a full-scale debate about the nature of the universe.

The NGSS also state that "*Science is a unique way of knowing, and there are other ways of knowing.*" Although this standard is intended for high school students, I felt it was critical, in this moment of organic curiosity, to share the sentiment with my first graders. From the origins of matter and the evolution of life to the risks of global climate change and the exploration of deep space, it is no exaggeration to state that some of humanity's most pressing issues sit at the intersection of science, philosophy, ethics, and faith. I wanted my students to know that the questions they were asking were complex, enormous, and important, and that it would likely take more than science alone to answer them.

I was fortunate to teach in a unique independent school where students were empowered to ask questions and teachers were granted the flexibility to deviate from the planned curriculum. Childhood curiosity, however, is far from unique; in classrooms everywhere, students are likely pondering questions that sit outside the traditional bounds of science, whether they express them or not. These questions, if asked, may reveal valuable information about a student's current understanding of a particular concept or of their broader understanding of the nature of science – information that might lead a teacher to revisit a lesson or reframe a concept to build on the learner's prior knowledge. Yet, in many classrooms, these conversations do not happen. A teacher may be unsure of how to answer, or may fear the consequences of acknowledging concepts that delve into spiritual or religious territory; in other situations, the classroom climate may be such that questions simply linger in students' minds, unasked.

My own experiences as a teacher led me to wonder what could be gleaned from existing research to inform thoughtful pedagogy that takes into consideration children's early conceptions about science and its relationship to other ways of knowing. I was particularly interested in children's ideas about the relationship between science and religion, as this is likely a largely unexplored topic in most public school classrooms despite the fact that it is a present (and often significant) feature of many students' lives outside of school. To explore these ideas, I have conducted a review of the research, asking the following guiding questions of the literature:

1. *What does the extant research suggest are the cognitive, developmental, and sociocultural factors that shape how young learners develop conceptions of science and its relationship to religion?*
2. *What are the potential implications for exposing children to instruction that addresses the relationship between science and religion?*

Methods and Organization of Paper

In conducting this review, I have used academic databases including Academic Search Premier, ERIC, Google Scholar, and PsycINFO to seek out relevant research. I also used a snowballing technique to gather additional references. Given my interest in younger learners, I primarily limited my search to studies that focused on children ages twelve and under, though I occasionally incorporated research on older learners to inform my understanding in areas where the literature on young learners was scarce, particularly with regards to research on students' engagement with school science. It is also important to note that the literature on science and religion in schools is primarily an exploration of American Christian contexts (Hanley et al., 2014). As such, this paper is largely a review of studies conducted in the United States, many of which used language that explicitly or implicitly invoked Christian or Judeo-Christian conceptions of religion. The paper does include occasional references to European research, especially because some of the studies reviewed took a comparative approach with samples from the United States and other countries.

I rely on working definitions offered by Sinatra and Nadelson (2011) to characterize the domains of science and religion for the purposes of this paper. *Religion* is considered to be "a set of commonly held beliefs and practices often codified through specific religious doctrine or religious law" (Sinatra & Nadelson, 2011, p. 176). This generic sort of definition is how the term "religion" is typically discussed in the education policy sphere (given the global nature of the language in the establishment clause of First Amendment), making it appropriate for the context of this paper. For the term *science*, Sinatra and Nadelson cite the definition used by the National Academy of Sciences: "the use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process" (National Academy of Sciences, 2008, p. 10). Additionally, when I use the term *instruction*, I am referring primarily to formal school learning settings, which are distinguished from informal learning contexts in important ways as I discuss sources of information and the familiarity and cultural relevance of particular explanatory frameworks.

I begin this piece with a brief overview of how the relationship between science and religion has been framed theoretically in the literature and introduce the connection I seek to make between this conceptual framing and the implications for education. I then unpack three bodies of literature that can inform our understanding of how learners – especially young learners – make sense of potentially conflicting explanatory frameworks from the domains of science and religion:

1. The literature on *testimony* provides insight into how children learn about scientific and religious phenomena that they cannot perceive firsthand and explores the cognitive process of grappling with counterintuitive and often conflicting explanatory framework offered by various sources.
2. The literature on *epistemological reasoning* examines how learners think knowledge is conceptualized in different ways of knowing (in this case, science and religion), and suggests that being able to reason about epistemology is necessary for making sense of scientific and religious explanations.
3. The bodies of literature on *situated cognition* and *collateral learning* posit that the experience of actively grappling with conflicting testimony is emotionally charged and connected to issues of culture and identity, thus implying that a *cold* model of conceptual change (Pintrich et al., 1993) that does not account for affect and social context is insufficient for understanding the learning process.

After reviewing the literature in these three areas, I turn to the science education literature to consider the implications for classroom culture and pedagogy, where I argue that the reviewed research supports the practice of making room for ideas that sit outside the traditional bounds of science as a powerful pedagogical tool. Specifically, I posit that students' questions and ideas about

concepts that fall outside these typical domain boundaries can be leveraged by science teachers for deeper understanding – not just about the intended scientific content goals, but also about concepts such as disciplinarity and perspective taking – and for a more inclusive classroom environment that invites *all* students to engage in scientific thinking, regardless of their cultural or religious backgrounds.

Overview of Conceptual Background

There is a rich body of theoretical literature focused on the relationship between science and religion as epistemologies (e.g., Barbour, 1966; Coleman, 2014; Gould, 1999; Wilson, 1998). One of the most commonly cited frameworks comes from Ian Barbour, who posited four models of the relationship between science and religion: *conflict, independence, dialogue,* and *integration* (Barbour, 1988). In contemporary American rhetoric, conflict seems to be the most regularly evoked model. There is a common assumption embedded in much of our popular discourse that religious beliefs inhibit understandings of, and positive attitudes towards, science (Evans & Evans, 2008; Gauchat, 2015). These ideas are regularly reflected in the results of public opinion polls that inquire about Americans' views on science and religion, though some of these polls also begin to hint at the complexity of individuals' real beliefs. For instance, a Pew Forum survey (Pew Forum, 2009) found that while 55% of participants responded affirmatively to the question "Are science and religion often in conflict?", only 36% said yes to the follow-up question, "Does science sometimes conflict with your own religious beliefs?"

Though opinion polls tend to focus on adults' beliefs, the conflict narrative is perhaps most salient in the American public school classroom.[1] The most well-known example is likely the Scopes *Monkey Trial* (Scopes Case, 1927), in which the classroom teaching of evolution was debated in a dramatic and widely publicized court case, but it is just one of many legal and cultural battles that have contributed to the image of science and religion as being at odds in the educational context. Psychological research indicates that adult perceptions of science and religion have origins in early childhood (Bloom & Weisberg, 2007), and, as with adults, it seems unwise to assume that young learners intuitively gravitate toward the conflict model. As the anecdote in the introduction suggests, children's questions do not always fall neatly within domain boundaries. Research indicates that children use parallel strategies to make sense of scientific and supernatural explanations for phenomena (Harris & Koenig, 2006), and that the conflict model fails to fully account for the complex processes that students use as they develop beliefs and attitudes toward science and religion (Koul, 2006; Abo-Zena & Mardell, 2015). Thus, in this paper I seek a more nuanced understanding of how children reason about the nature of science and its relationship to religion, especially in the context of concepts that are widely seen as relevant to both domains.

Children's Reliance on Testimony from Others

The Role of Testimony in Conceptual Development

Historically, the research on how natural and supernatural reasoning coexist in the mind has been somewhat limited. Legare et al. (2012) posit that this lack of existing research may be because researchers did not traditionally see it as appropriate to empirically investigate supernatural thinking. However, cognitive developmental literature has emerged over the past ten to fifteen years that has begun to shine a light on the development of religious or spiritual conceptions and their relationship to other modes of reasoning.

[1]As noted previously, though the potential for the conflict narrative to arise exists across many religious denominations, coverage of this topic in the United States tends to be focused on Christianity (Hanley et al., 2014).

This research suggests that from an early age, there are parallels between the processes for how children learn about scientific and religious concepts. In both domains, there are numerous phenomena and entities that cannot be understood through first-hand experience; to learn about such concepts, children frequently rely on testimony presented by other, typically more knowledgeable individuals (Harris, 2002). In the domain of science, there are many concepts that are difficult or impossible for learners – especially young learners – to observe directly, often because they operate on very large or small spatial or temporal scales, and may involve causal relationships that are outside of the learner's attentional frame (Grotzer & Solis, 2015). For instance, few children have the opportunity to view the shape of the earth (Nussbaum, 1985; Vosniadou & Brewer, 1992), perceive the causal mechanisms underlying magnetic attraction (Lesser, 1977), or witness the biological processes involved in death (Harris & Giménez, 2005). Likewise, although some research suggests that children are "intuitive theists" (Kelemen, 2004, p. 295), testimony likely still has a large impact on their conceptions of spiritual matters, including the existence of a higher power and an afterlife, as well as the efficacy of prayer (Harris & Koenig, 2006).

Counterintuitive phenomena, in particular, are often hard to conceptualize and impossible or challenging to verify through first-hand experience, and the research suggests that similar factors influence the acceptance of counterintuitive phenomena in both natural and supernatural domains (Lane & Harris, 2014). These factors include the developmental capacity of the recipient to conceptualize the idea, the context in which the information is presented, the demonstrated expertise of the informant, and the qualities of the information itself (such as whether or not the information as affective appeal, or the range of phenomena that an explanation covers). Thus, for both scientific and religious concepts, young learners are heavily dependent on the information provided by external sources, and the features of that informational transaction significantly influence understanding.

On some occasions, children may hear testimony – either from different sources, or from the same source in different contexts – that presents both scientific and religious explanations for the same concept. In these instances, the learner may compartmentalize these explanations as isolated concepts, or he or she must decide how to reconcile the potentially conflicting explanatory frameworks, whether by selecting one as the preferred explanation, choosing to apply one or the other depending on the context, or generating a new framework that combines or synthesizes the disparate claims. Children do seem to distinguish between scientific and religious domains in certain ways; notably, they typically express greater confidence about the existence of scientific entities. This may stem from the fact that discourse around scientific entities tends to take their existence for granted, while language used to discuss special beings often includes assertions of belief or faith, which may lead children to recognize that some people doubt the existence of these beings. Alternatively, children may be aware of the lack of consensus amongst adults discussing special beings, leading to less confidence in their own assertions (Harris & Koenig, 2006). It is important to note that the majority of this research is focused on scientific phenomena that are typically deemed uncontroversial (e.g., atoms, germs); the parallels between scientific and religious reasoning patterns may perhaps be even more pronounced for topics that tend to evoke a greater sense of controversy or uncertainty for many people, such as climate change or human origins.

Children also appear to employ strategies (whether consciously or subconsciously) for connecting the explanations they are familiar with to new scenarios; namely, when discussing concepts that have both scientific and religious explanations, children tend to offer context-appropriate accounts. For instance, when asked to provide an explanation for a character's death in a narrative, a child who hears about the character's corpse will likely apply a biological model, while a child who hears about ancestral rituals in the character's community is more apt to apply a spiritual model (Harris & Koenig, 2006). Harris and Koenig (2006) also found that children who grow up in a community where conflicting testimony is frequently presented are likely to acknowledge the possible existence of multiple correct beliefs. However, they do not typically engage in a process for evaluating the

relative merit of each belief, nor are they often capable of proposing methods for doing so. Thus, when faced with the challenge of making sense of potentially contradictory statements, children may require explicit guidance about how to adjudicate between different types and sources of information. I will return to this notion below in the section on epistemology.

The Nature of Testimony to Young Learners on Science and Religion

Before children are of school-age, much of the early testimony they hear about both science and religion comes from parents, caregivers, and other members of their local community, often by way of spontaneous or informal discussions as well as more formal rituals. The literature on how adults talk to young children about science is somewhat limited, as compared to other domains like language and mathematics (Vlach & Noll, 2016). To date, the bulk of the research in this area has examined the types of explanations that children hear while engaged with adults in science talk at museums (e.g., Crowley et al., 2001; Haden, 2010) and in laboratory settings (e.g., Luce et al., 2013), though several studies have looked at scientific and causal language used in more naturalistic settings (e.g., Callanan & Oakes, 1992).

Based on this existing research, it seems that many parents and caregivers regularly engage in what could be considered informal science talk as they explore and explain causal relationships, make connections to other experiences, and introduce new vocabulary with their young children (Callanan et al., 2013).[2] Though science learning may not be the primary purpose in such interactions, these everyday conversations are often more likely to be tailored to the interests and experiences of the particular child (Callanan et al., 2013). On the other hand, talking to children about science may pose a particular set of challenges. While in many domains, adults intuitively talk to children in ways that are developmentally appropriate and beneficial to their learning, science may be an exception, given that adults tend to have less practice talking about scientific concepts with conversation partners of any age (Vlach & Noll, 2016).

Adults seem to believe that they should adjust their language when talking to children about science, but they may not always know how to do this effectively. Vlach and Noll (2016) found that when asked to explain science concepts to a range of listeners, college-age adults provided more varied types of explanations to five-year-old children than to adults. These explanations included higher frequencies of beneficial features, such as analogies and connections to prior knowledge, but they also included higher frequencies of potentially disadvantageous or confusing features, such as personification and references to magic. However, when asked to reflect on their explanations, the study participants assessed their explanations to children as being more accurate than their explanations to adults. Vlach and Noll (2016) hypothesize that adults employ a greater number of explanatory features in their science talk with children because they are more concerned with correct instruction than they might be with adult interlocutors. They also posit that the inclusion of more disadvantageous features, such as magical or supernatural explanations, may reflect the belief that a secondary goal of explaining science to children is to make it more fun and engaging; this hypothesis is speculative at this point and warrants further empirical testing, especially given that if this is indeed a common belief among adults, there may be implications for how science is typically framed for young children in other educational settings.

In considering how children think about concepts that sit at the boundary of science and other domains, it is noteworthy that issues of morality often seem to spontaneously emerge in parent-child discussions about science. In three studies (one laboratory study with children in grades 3-5, and two

[2] It is important to note that the parents and caregivers included in the samples of these studies are the ones who have chosen to take their children to a research lab or a museum, and thus are not necessarily representative of the population as a whole. This limitation in the sample points to the need for further research in naturalistic, more inclusive settings.

museum studies with children aged 3-10 years), Callanan et al. (2014) recorded conversations between parents and their children about a variety of science topics, including climate change and gender differences. The conversations were coded for instances in which moral issues were mentioned. The authors identified four categories of moral issues: avoiding harm or promoting care, promoting justice or fairness, being a good or responsible person, and tolerating differences or accepting essential truths. Callanan et al. (2014) found that topics of socialization and morality emerged throughout the discussions of science-related topics, with parents and children "often slipping back and forth between notions of ideas that are factually 'right' versus morally 'right'" (p. 121). However, the nature of the discussions about morality varied greatly based on the content domain at hand; i.e., parents and children introduced concepts of morality in different ways when talking about a physical domain than a social domain. Sometimes, references to moral issues were driven by the parent, in an apparent effort to seize the opportunity to attend to their child's character development. In other cases, the discussion of morality stemmed from the child, who raised questions or expressed the adoption of a particular moral stance related to the topic at hand.

More research is needed to determine the impact of these discussions of morality in the context of scientific explanations. Callanan et al. (2014) note that in regular conversation, we employ two distinct meanings for the word *right* – an epistemological definition, in which something is evaluated for factual correctness, and a moral definition, in which something is evaluated for whether or not it is just or virtuous – and it may be that discussions such as the ones described above cause these definitions to get conflated in children's minds. However, the authors also suggest that opportunistic discussions about morality could potentially be more impactful than strategic ones, as children may take particular note of topics that they interpret as being significant enough to warrant an interruption to the flow of conversation. Callanan et al. (2014) also posit that cultural or philosophical differences in worldview might impact the nature of discussions of morality that arise within conversations about science topics and the ideas that children take away from these conversations. The epistemological perspectives that parents implicitly or explicitly endorse are likely to impact their children's ideas about how to answer questions and evaluate evidence (Luce et al., 2013).

These findings merit further research to explore the potential impact of exposing children to the idea that morality is relevant to scientific issues. Notably, the topic of morality is often at the heart of religious conversations with young children, especially given that they are frequently learning about religion in the context of parables that lead to moral conclusions. It is possible that hearing about morality in both religious and scientific contexts may lead children to see connections between the two domains (e.g., by linking a stewardship narrative of the earth to concepts of ecology and environmentalism). Alternatively, if the concept of morality is discussed differently in the scientific context than the religious context, a child may perceive further distinctions between the two domains.

The Developmental Trajectory of Processing Scientific and Religious Testimony

Many of the ideas that young children form about science and religion persist into adulthood. To some extent, supernatural explanatory frameworks seem rooted in human cognitive architecture. Though the developmental literature has traditionally argued that supernatural explanations are supplanted by natural explanations over time, it is clear that supernatural explanations do remain prevalent in adult cognition across cultures (Legare et al., 2012). Moreover, the generalized preference for teleological explanations exhibited by children seems to carry over into an adult tendency to perceive an inherent purpose in significant life events (Banerjee & Bloom, 2014). Teleological intuitions, including those about natural phenomena, persist even for adults who do not identify as religious – and in fact, even among those who claim aversion to religion (Järnefelt et al., 2015). Regardless of age, religion, or cultural identity, individuals show a tendency to default to teleological

explanations for phenomena when placed under time pressure, which supports a dual process theory hypothesis that intentional explanations are largely due to inherent aspects of human cognition (Järnefelt et al., 2015). This may account for the apparent universality of both natural and supernatural belief systems across societies, leading the coordination among these various explanatory frameworks to be deemed a "general cognitive problem" (Evans et al., 2011, p. 114).

However, the process of grappling with these domains also appears to follow a developmental trajectory, with the influence of caregivers, community members, and other external sources of information holding different weight at different stages. In early childhood, exposure to religious ideas is correlated with children's tendencies to believe in, and invoke, supernatural explanations. Corriveau et al. (2015) found a sharp distinction between kindergarteners with and without systematic exposure to religion (through school or church), with the children raised in a religious environment conceiving of a notably broader range of plausible phenomena than their secular peers. This discrepancy – and the fact that secular children relied on references to religion as justification for deeming phenomena to be pretend – suggests that a religious upbringing seems to override children's natural tendencies to doubt unlikely causal phenomena (rather than the converse notion that a secular upbringing overrides a predisposition toward credulity). Additionally, in early childhood, the tendency to invoke creationist explanations for the origins of species corresponds to the child's religious background. In interviews with children and adults from fundamentalist and non-fundamentalist communities about the origins of various species, Evans (2008) found that children aged 5-7 provided a mix of responses categorized as spontaneous generationist (suggesting that the species simply appeared) or creationist (referencing a supernatural power), with children from fundamentalist communities providing a higher frequency of creationist responses.

By middle childhood, however, children are more likely to receive a diversity of messages from various sources, and they begin to formulate individual ideas about the world that may reflect new developmental capacities as well as their attempts to account for multiple explanatory frameworks. In the interview study with fundamentalist and non-fundamentalist individuals described above, 8–10-year-olds tended to endorse creationist ideas regardless of their community background. Evans (2008) suggests that at this age, children are beginning to confront existential questions (Evans et al., 2001) and are developing the ability to reason about the possible existence of an intelligent designer, whereas younger children are not likely to accept the premise that animals and artifacts are impermanent and therefore struggle to reason about origins. While this reasoning pattern does not reflect a scientific worldview, the ability to conceive of impermanence does indicate that children at this age may be prepared to begin thinking about evolutionary concepts if they are introduced (e.g., Kelemen et al., 2014), or at the very least, to recognize that there are multiple possible explanatory frameworks.

Grappling with Multiple Explanations

As children's worlds expand and they are exposed to ideas from a variety of sources, they begin to face the cognitive challenge of reconciling conflicting testimony. Memory research suggests that information – whether true or false – is filed in the brain "without being 'tagged' as to source or credibility" (DiMaggio, 1997, p. 267). When the information is later retrieved, the individual must therefore infer these features and make a determination about whether or not it is believable; this task becomes more challenging when multiple explanations must be weighed against each other and reconciled. Ultimately, an individual may choose to adopt one explanation over the other, or to permit both explanations to mentally coexist, either by compartmentalizing them or integrating them in some way. Both compartmentalization and integration are likely to require metacognitive abilities and cognitive adaptability (Legare et al., 2012).

Legare et al. (2012) refer to the process of holding multiple explanatory frameworks as *coexistence thinking*. There are a number of features that characterize concepts that tend to invoke

coexistence thinking, including the involvement of hidden or unobservable causal agents, association with strong emotions, and a relationship to existing cultural practices that pre-date formal science (Legare et al., 2012). Unsurprisingly, coexistence thinking occurs frequently with phenomena for which both natural and supernatural explanations are presented.

Individuals may invoke a variety of frameworks for reasoning about the coexistence of natural and supernatural explanations for a given phenomenon (Legare et al., 2012). In *target-dependent* thinking, the conflict remains unresolved in one's mind; one explanation or the other is recruited to account for a particular aspect of the phenomenon based on the context at hand. Elkana (1981) suggests that although people often use context to determine which source of knowledge is appropriate, "in the event of a serious clash, the knowledge source with the greatest personal legitimacy and value (scope and force) will prevail" (Cobern, 1996, p. 594-5). In *synthetic* thinking, on the other hand, the two different explanations are loosely integrated into one framework, though without explicit consideration of how they fit together. Finally, in *integrated* thinking, the two different explanations are more thoroughly interwoven, often in a model that relies on each domain for a different level of analysis (e.g., one might cite a natural proximate cause and a supernatural ultimate cause). Synthetic and integrated models, which are constructed to resolve a state of cognitive (and sometimes emotional) conflict, are likely closely held and may be particularly challenging to abandon or adjust (Evans et al., 2011). Evans and Lane (2011) argue that holding blended models also requires the activation of system 2 reflective processing (Stanovich & West, 2000; Kahneman, 2003), in that individuals who endorse a hybrid of scientific and religious conceptions are demonstrating the ability to "rapidly shift between different reasoning patterns" and ultimately taking an analytic (rather than purely intuitive) approach (p. 156).

Coexistence thinking can also arise out of a need to make sense of counterintuitive information. Evaluating counterintuitive information entails a great deal of cognitive load, as the individual must engage in the process of shifting back and forth between one's own perception of how things appear and the conflicting representation of how things are asserted to be (Lane & Harris, 2014). Lane and Harris (2014) note that most prominent models of belief formation (originating from philosophers such as Descartes and Spinoza) are based on the premise that the learner begins by creating a mental representation of a given claim. Thus, these models fail to account for scenarios in which the learner has difficulty developing a cognitive representation, such as with counterintuitive concepts. In these cases, the learner may exhibit a tendency to disbelieve the claim that is not easily represented. Lane and Harris (2014) posit that the tendency to accept counterintuitive explanations is influenced by the developmental capacity of an individual to produce these mental representations. This is supported by research demonstrating that young children are particularly skeptical of evidence that conflicts with their personal experience and beliefs (Lane & Harris, 2014). As such, children may struggle to reckon with testimony that presents an explanatory framework running counter to earlier explanations and/or first-hand experiences, which often occurs for children who are not exposed to scientific models until they enter school (Billingsley et al., 2014).

Epistemological Understanding

The Developmental Trajectory of Epistemological Understanding

Making sense of the relationship between scientific and religious explanatory frameworks as described above requires an understanding of each domain's epistemology – their conception of the nature of knowledge and knowing. The discussion of multiple epistemologies is not uncommon among academics and clergy, many of whom see it as a professional responsibility to acknowledge and respond to potential areas of conflict that arise from differences between the epistemological lenses of their domain and other ways of knowing (e.g., Gottlieb & Wineberg, 2012). While any given

discipline or domain tends to have some overarching unifying epistemological principles that distinguish it from other fields, individuals also hold their own conceptions of the nature of knowledge, what Burr and Hofer (2002) refer to as *personal epistemology*. Less research has been done about how individuals, especially those in the lay public, reason about epistemology (Evans et al., 2011), but the existing literature suggests that epistemological understanding follows a developmental trajectory, with children beginning to draw on multiple epistemological frameworks as early as 3-5 years of age (Legare et al., 2012).

In the literature, the earliest stage of epistemological development is typically described as a dualist or absolutist perspective, in which the individual believes in a sense of right and wrong and the notion that truth can be known with certainty. As most of the research on epistemological development has been conducted with adolescents and adults, little is known about the earliest stages of the developmental process or whether there are any stages that precede dualism. Some have posited that there is a pre-dualistic stage of naïve realism, in which children believe that there is no possible perspective other than their own. For instance, Burr and Hofer (2002) found that very young children (around age 3) struggle to complete an epistemology task in which they have to explain why a character lacks knowledge that they possess. Young children's difficulty with theory of mind tasks may also support the idea of a naïve realism stage (Burr & Hofer, 2002). However, in a review of the theory of mind literature, Wellman (2014) points to evidence that 3-year-olds do demonstrate the ability to distinguish between individuals holding different beliefs.

The ability to reason about categories of knowledge also improves developmentally. Even very young children comprehend the distinctions between factual and opinion-based judgments; they understand, for instance, that reasoning about the physical world involves a higher degree of certainty than reasoning about matters of aesthetic preference (Hofer et al., 2011). By age four, children begin to demonstrate the ability to make judgments about expertise that rely on cognitive schema representing abstract domain categories (Lutz & Keil, 2002). For instance, many children at this age can recognize that a doctor would be more likely to possess knowledge within the domain of biology, while an automotive technician would be more likely to possess knowledge within the domain of physical mechanics. However, four- and five-year-olds struggle to abstract knowledge clusters to broader disciplines when the experts in question are unfamiliar (e.g., an eagle expert or a bicycle expert). In a study of children in Kindergarten through Grade 6, Danovitch and Keil (2004) found that younger children tended to select expert consultants for a task based on their reported topic knowledge, while older children were more likely to select consultants based on their understanding of deeper disciplinary relationships. Children likely struggle to characterize knowledge by discipline because this task requires being sensitive to deep structural relationships between concepts rather than attending simply to surface-level features (Danovitch & Keil, 2004).

As children get older, their capability to reason about domain differences improves, but they still demonstrate different patterns of epistemological thinking than adults. For instance, children have different ideas about the relationship between knowledge or belief and the individual expressing that knowledge or belief. In a series of experiments, Heiphetz et al. (2014) presented adults and children aged eight to ten with a set of characters who made various factual, opinion-based, or religious statements. Participants were asked whether each statement offered more information about the world or about the person making the statement. Both children and adults reported that they learned more about the world than about the individual from statements of correct factual belief. However, upon hearing an individual make a statement about religious beliefs, adults reported that they had learned more about the individual making the statement than about the nature of the world, whereas children reported the reverse. Heiphetz et al. (2014) suggest that the difference between how children and adults perceive religious statements may stem from the fact that adults have had more exposure to religious diversity and disagreements, though they also note that children do seem to understand the concept of a lack of consensus around theological claims. The authors conclude that there is still

"much to learn … about how children situate religious beliefs within a larger epistemological framework" (Heiphetz et al., 2014, p. 27).

Implications of Epistemological Understanding for Science Learning

There is an extensive body of research on the nature of science that explores how students understand science as a way of knowing and considers the implications for how science is taught in the classroom (see Lederman, 1992 for a review of the literature). A number of studies have also specifically examined how students understand science in relationship to other ways of knowing, though most of the existing literature focuses on older learners. Several researchers have proposed typologies or frameworks to characterize how features such as knowledge, evidence, and certainty are viewed through scientific and religious epistemological lenses. For instance, Sinatra and Nadelson (2011) suggest that the epistemological assumptions promulgated by science and religion as institutions can be seen as existing at opposite ends of four continua: source of knowledge, justification of knowledge, certainty of knowledge, and structure of knowledge. Elsewhere, based on their research of science instruction in British secondary schools, Hanley et al. (2014) developed a typology to characterize student engagement with topics pertaining to science and religion. The typology was developed based on students' views across several dimensions, including the value they placed on evidence versus belief, their open-mindedness, and their tolerance of uncertainty. Though a focus group of teachers reported that their students did not hold any views that were irreconcilable with scientific explanatory frameworks, surveys and interviews with students about their understanding of the origin of life revealed that many did in fact hold epistemological stances that were serving as roadblocks to scientific understanding.

Shtulman and colleagues (e.g., Shtulman & Valcarcel, 2012; Shtulman, 2013; Shtulman & Harrington, 2016) have also conducted extensive research on how students, especially college students, reason about scientific principles that run counter to intuitive beliefs, as well as the students' explanations for why they hold particular conceptions. Shtulman (2013) found in a study of undergraduates that the most common form of justification for both scientific and supernatural beliefs was through deference to the opinions and conclusions of others, echoing the findings of Harris and Koenig (2006) with younger children. Moreover, individuals' reported confidence in their beliefs in both scientific and supernatural phenomena was more strongly associated with perception of consensus about the explanation than with the acknowledgement of available evidence. Shtulman's (2013) findings also reveal a correlation between students' understanding of the nature of science and their tendency to offer evidential justifications for their beliefs (as opposed to deferential or subjective justifications), though Shtulman suggests that more research is needed to understand the nature of this relationship.

Brain imaging research provides an interesting accompaniment to these findings. For instance, Fugelsang and Dunbar (2005) found that when people were presented with information that was consistent with their prior theories about a scientific concept, the parts of their brain associated with learning showed increased activity. In contrast, when people were given data that contradicted their prior theories, they showed activation in the parts of their brain involved in error detection, conflict monitoring, effortful processing, and working memory. As noted by Dunbar, Fugelsang and Stein (2007), the fact that information inconsistent with one's prior conceptions is neurologically processed as an error points to the significant challenges and complexity inherent in conceptual change.

One factor that may confound learners who are trying to make sense of scientific explanations is the many diverse uses of the terms *knowledge* and *belief* within science education and in everyday talk (Southerland et al., 2001). In particular, a number of researchers have argued that the common usage of the word belief, which in everyday language can imply the existence of doubt, causes confusion regarding the scientific approach to theories (e.g., Cobern, 2000; Smith, 1994; National Academy of

Sciences, 1998). For instance, a statement that scientists believe in the theory of evolution may be interpreted by a layperson to mean that this belief is tentative or uncertain (Southerland et al., 2001). Southerland et al. (2001) posit that much of science education research is based on the epistemological position of fallibility. Within a fallibilist epistemology (Siegel, 1998), certainty is not a condition of knowledge; the fallibilist stance maintains that explanations can be compared and judged for quality despite the premise that human knowledge is imperfect. Beliefs, in contrast, are held by fallibilists to be subjective, personal truths that do not rely on evidence and are often laden with emotion. Thus, Southerland et al. (2001) propose that drawing a distinction between knowledge and belief may lie in identifying the "type and number of warrants" that a person holds for a given piece of information (p. 336). In other words, if an individual produces a limited number of justifications, or if the justifications would be deemed weak by scientific epistemological standards (e.g., thinking something is true because a friend said so), then the piece of information should be considered a belief rather than knowledge.[3] Using this framework, one can understand how the same statement could be knowledge to one person and a belief to another.

To avoid conflating inaccurate ideas with ideas that are non-empirically based, some researchers advocate for the use of the term *alternative conception* (e.g., Wandersee et al., 1994) to refer to ideas that are not beliefs but rather incorrect, but empirically grounded, explanations (Southerland et al., 2001). Additionally, Smith and his colleagues have proposed that the term *acceptance* more appropriately represents the scientific process of evaluating evidence and concluding that a theory is the best possible explanation given the available information (Smith et al., 1995). This distinction between acceptance and belief foregrounds the epistemological lens of science, in which validity is based on the evaluation of evidence rather than personal opinion.

Many researchers and educators have made the distinction between understanding and belief as potential aims of science education, suggesting, for instance, that while students should be required to understand the theory of evolution, it is inappropriate and likely impossible to require them to believe it. Southerland et al. (2001) group acceptance with belief; though they acknowledge that the idea of acceptance implies more agency on the part of the learner than does belief, they argue that both agency and belief should be seen as goals of science education rather than requirements, as students cannot make an informed choice to believe or accept a given theory until they have achieved a deep understanding of the evidence.

While the goals of science education remain an open question in the literature, it seems safe to conclude that an awareness of epistemological assumptions inherent to science and how those differ from other ways of knowing is a necessary condition for understanding and evaluating conflicting explanatory frameworks. However, it is not sufficient to pursue this as a purely intellectual endeavor. In the following section, I will explore the social and affective components that factor into the process of engaging in thinking that runs counter to intuitive or culturally familiar ideas.

Science Learning in Context

The Need for "Hot Conceptual Change"

The research described in the sections above provides insight into the cognitive processes that occur as learners acquire and make sense of information derived from scientific and religious ways of knowing. Of course, learning happens in context, and the nature of the learning environment must factor in to any consideration of how conceptual understanding develops. Notably, learners undergo

[3] It is important to note that beliefs are typically based on rationales; the claim is simply that these rationales are not empirical (Southerland et al., 2001). They may instead be grounded in other types of reasoning, such as a community consensus or the reliance on a trusted authority figure.

a shift when they enter school and begin to receive formal science instruction. For any learner, thinking about science in a school setting may present certain challenges, but this transition can be particularly difficult for learners for whom the classroom approach to science is entirely novel or misaligned with their prior experience.

Geary (2008) describes formal schooling as "a central interface between evolution and culture" (p. 179): schools are a cultural innovation designed to close the gap between children's *folk knowledge* and the information required to be successful in adult society. For many students, this gap is particularly evident in science education, where intuitive ideas and early testimony provided by families and communities may regularly conflict with the concepts presented in the classroom. In addressing such conflicts, learners must decide whether to maintain or revise deeply held beliefs, and they must come to terms with the implications embedded in the new conceptions being presented, which are often both personal and existential.

The sense-making process that learners must undergo in order to grasp new scientific explanatory frameworks, especially those that are complex or counterintuitive, is often understood through the lens of conceptual change. New information does not automatically trigger conceptual change; instead, for a learner to adopt a new conception, she must acknowledge that there is a conflict between the explanation she currently holds and the new explanation being presented, and she must be willing to seek resolution for that conflict (Strike & Posner, 1982). Thus, a critical first step in the conceptual change process is to reveal the learner's present understanding in order to hold it up to a contrasting model. For concepts that sit at the boundary of science and religion, the conceptual change process presents a unique set of challenges. In the course of unearthing one's current understanding about concepts such as cosmology or human origins, the learner may encounter ideas that are deeply entrenched and emotionally charged. For instance, Evans (2008) notes that it is critical to consider the emotional components to teaching evolutionary theory, as the ideas of impermanence and mutability of kinds may lead to "existential angst" (p. 283) for both children and adults (though this may be more the case when confronting the idea of human origins than with other species). Other topics introduced in the science classroom may bear similar implications for human identity and mortality. They may also cause learners to confront their existing beliefs in supernatural entities and phenomena, as well as their personal affiliations with religious or cultural communities (Evans et al., 2011; Gelman, 2011).

For the reasons just described, some researchers have suggested that conceptual change is limiting as a framework for understanding how learners engage with new concepts. For instance, Long (2013) argues that there is a tendency to view the purpose of education as correcting misconceptions one student at a time, which he believes fails to account for the social nature of conceptual development, in which learners construct knowledge through the process of engaging with other individuals whose ideas and perspectives interact with their own in complex ways. More specifically to science education, Cobern (1996) found through a series of interviews with a student and her teacher that improving conceptual change tactics is insufficient as a method for helping a learner whose worldview is causing resistance to what is being taught. Hanley et al. (2014) suggest that conceptual change is inappropriate for viewing the teaching of evolutionary theory, because it diminishes the affective dimension of the learning and presents all beliefs not supported by conventional Western science as misconceptions.

Many traditional arguments in the conceptual change literature take the perspective that this is a process that is disconnected from emotional or social factors. However, other researchers have made the case for a more nuanced understanding of conceptual development that accounts for the contextual nature of learning. The phenomenon of "hot cognition" (Abelson, 1963) is widely referenced in the literature and refers to the idea that reasoning is impacted by an individual's emotional state. Pintrich et al. (1993) extend this to suggest a "hot" model of conceptual change, acknowledging that whether or not conceptual change occurs is influenced by a variety of "personal, motivational, social, and historical processes" (p. 170). Additionally, the literature on situated cognition

offers a lens for thinking about learning in the context of the physical setting where learning takes place and the community of practitioners who engage together in the learning process (Brown et al., 1989). Rather than relying on an approach to science education that views conceptual change as a process in which the learner abandons prior knowledge for another, more acceptable conception, some researchers in the situated cognition field have advocated for a model in which students learn to think and operate in both the formal science domain and their everyday notions of science, and to distinguish the contexts in which particular conceptions are appropriate (Hennessy, 1993).

Border Crossing and the Compartmentalization of Knowledge

For many students, the relationship between school science and the rest of their lives is complex, and navigating between these contexts does not always come easily. Cobern (1996) observes that there is an implicit argument that scientific literacy should be viewed as distinct from the "everyday world," despite the fact that this everyday world is presumably the context in which most people will make use of their scientific knowledge (p. 582). Yet, it is unwise to assume that students will naturally "approach their classroom learning with a rational goal of making sense of the information and coordinating it with their prior conceptions" (Pintrich et al., 1993, p. 173). In everyday life, individuals tend to satisfice, looking for information that will allow them to adequately explain and predict phenomena, rather than the optimal explanations and predictions that are sought through the process of scientific inquiry (Reif & Larkin, 1991). This everyday model of satisficing may more accurately represent the understanding that occurs in classroom contexts than the scientific conceptual change model, unless the classroom in question has a climate that encourages a commitment to deep understanding and is sensitive to the unique needs of the students present (Pintrich et al., 1993).

Research on the concept of worldviews informs the thinking about how students experience school science. Kearney (1984) defines worldview as "conceptually organized macrothought" (p. 1); an individual's worldview comprises the set of assumptions determining his or her behavior and decision making. Even when students do not experience a significant conflict between the various worldviews they have been presented, they will frequently compartmentalize *school knowledge* – especially school science – perceiving it as existing independently of their daily lives. They may retrieve the science they have learned in school as necessary for homework and exams, but do not think to apply it to situations in the outside world, and let go of it once the school requirements have been completed (Cobern, 1996). Moreover, students' prior knowledge may lead them to construct intentions and conclusions that do not align with the teacher's actual agenda (Hennessy, 1993). For instance, while science teachers tend to immediately evoke science when describing nature, students may more naturally conjure up "aesthetic, religious, pragmatic, and emotional concepts" (Cobern, 1996, p. 596).

The process of compartmentalization seems to be more pronounced for students who experience a discord between school science and their indigenous beliefs. For these students, the process of border crossing between the "microcultures" of their home life and the science classroom can be challenging and even traumatic; such students may go so far as to exhibit significant "creativity and intransigence" in order to avoid deep understanding or acceptance of science concepts (Aikenhead & Jegede, 1999, p. 275). Cobern (1996) argues that the goal often assumed in the science education literature of moving students toward a "scientific worldview" is problematic because it fails to acknowledge that for some students, this notion implies the need to reject their current deeply held conceptions. Instead, he suggests that the goal should be to help students develop a "scientifically compatible worldview," which accounts for the idea that an individual will only make use of scientific ideas if they align with how he already makes sense of himself and of the world.

Jegede (1995) puts forth the theory of collateral learning as a model that foregrounds the culture of the learner as critical to the process of understanding science. Though Jegede originally

employed the theory in the study of African learners engaging with Western notions of science, the principles are useful in understanding American classroom contexts as well. In the process of collateral learning, individuals construct an understanding of concepts taught in school alongside the prior understandings they have developed from their home communities. Different categories of collateral learning exist along a continuum. At one end, *parallel collateral learning* occurs when the learner encounters a new idea which is in opposition to his or her prior understanding, but does not perceive disequilibrium between the two concepts, possibly because the learner does not have enough understanding or experience to consider how they might conflict. On the other end is *secured collateral learning*, in which the learner grapples with the cognitive conflict between two conceptions and works toward reconciliation of them within his or her broader worldview. Jegede (1995) argues that effective science education requires understanding learning through a conceptual ecocultural paradigm, "a state in which the growth and development of an individual's perception of knowledge is drawn from the sociocultural environment in which the learner lives and operates" (p. 124).

In sum, as is the case with any other form of learning, science learning does not happen in a vacuum. The research sends a clear signal that the process of science learning cannot be understood without careful consideration of how the learners' prior knowledge and cultural background interact with the material presented during formal science instruction. Any learner is apt to experience some amount of discomfort when studying counterintuitive concepts with potentially existential implications. For students whose prior experience with these topics has been largely or solely through religious frameworks, encountering these concepts in the school science setting is likely to be particularly jarring. Without careful instruction that provides the necessary time and space to grapple with conflict, learners may consciously or subconsciously avoid deep understanding.

Implications for Pedagogy

Much of the research synthesized above comes from the fields of cognition and development, where researchers tend to remain largely agnostic regarding the practical implications of the work. However, in the literature that comes out of the science education research space (such as Jegede's work on collateral learning), a number of concrete recommendations for classroom practice have been put forth. Overall, researchers seem to agree that there is pedagogical value in incorporating discussions of learners' religious beliefs as they interact with the scientific concepts being introduced in the classrooms, though there are differences in the recommendations for how these conversations unfold. In this section, I will outline some notable conclusions drawn from the research and highlight important areas of disagreement.

Helping Students Draw Connections to Prior Knowledge and Beliefs

One clear message from the literature is that teachers have an important role to play in encouraging their students to reveal their initial understandings, and, as necessary, helping them to navigate the process of border crossing between the science classroom and the rest of their lives. Callanan et al. (2013) argue for the importance of making intentional and meaningful linkages between students' informal science experiences and the more formal science learning that happens in school. In particular, they suggest that children "may need guidance to recognize the rich background they themselves bring to the science classroom by virtue of their participation in conversations and activities from their everyday lives" (Callanan et al., 2013, p. 46). Rather than striving to simply convert students from their inherent beliefs to the acceptance of scientific explanations, Jegede (1995) argues that school science should aim to help students identify contexts in which their prior understandings are valuable. If this is not achieved, Jegede (1995) cautions, a student may maintain a barrier between

his or her various contexts, perhaps managing to perform successfully in school science without developing the inclination to apply these understandings outside the classroom.

Teachers can help their students constructively engage with topics at the boundary of science and religion by acting as a *culture broker* (Aikenhead & Jegede, 1999) who facilitates students' movement across domains. Of course, this requires teachers to deeply know their students, including those who may be in the silent minority (or even majority). Cobern (1996) argues that science educators must "understand the fundamental, culturally based beliefs about the world that students bring to class, and how these beliefs are supported by students' cultures; because, science education is successful only to the extent that science can find a niche in the cognitive and socio-cultural milieu of students" (p. 603). This task also entails establishing an environment in which students are comfortable sharing their ideas, even if they suspect that they may not align with scientifically accepted explanations. Hanley et al. (2014) suggest that science teachers should build classroom cultures that permit all students to participate "without risking self-censorship or estrangement" (p. 1225).

Considering Religion through the Lens of Epistemology

It is evident from the literature that culture and religion are critical mediating factors that must be considered in any analysis of how students interact with school science (Hanley et al., 2014). Over the years, a number of researchers have advocated for the explicit acknowledgement and exploration of religion through historical and cultural lenses, even in public school settings. Sinatra and Nadelson (2011) claim that in such a highly religious country as the United States, calls for a rejection of religion in order to improve science education (e.g., Dawkins, 2006) are both implausible and unnecessary, and Postman (1995) makes a strong argument for advancing religious education based on its prominence in daily life and its interaction with other domains, including science. More recently, Long (2013) has argued that providing students with formal education about religion encourages them to embrace inclusivity, whether they choose to personally adopt a religious tradition or not. For educators who take a radical constructivist approach to learning, the act of "relegat[ing] beliefs to the outskirts of instruction" fails to account for the many types of reasoning that learners bring to the table, and may lead students to ask, "if science can't answer my question about this, what is it good for?" (Southerland et al., 2001, p. 344).

Yet, the majority of researchers in science education do seem to caution that introducing ideas about religion must be done carefully and strategically, so as not to imply that scientific and religious ways of knowing are interchangeable. The clearest path forward seems to be an increased focus on the nature of science and its epistemological similarities and differences to other domains. Many researchers align with Gould's (1999) model of non-overlapping magisteria, arguing that science and religion are capable of coexisting because the set of assumptions embedded within each way of knowing is distinct. Rather than conceiving of science and religion as conflicting domains, the two "should be viewed as epistemologies that have different roles and explain different aspects of the human condition" (Sinatra & Nadelson, 2011, p. 175). Explicitly differentiating between these two ways of knowing can provide learners with "a place to stand" (Southerland et al., 2001). To be able to explain why science and religion purport differing views on origins, for instance, students need to possess a high level of "epistemic insight" (Billingsley et al., 2014). In order to move towards this greater insight, Billingsley et al. (2014) suggest that students should have more opportunities to "consider and compare the natures of science and religion" (p. 1729). Cobern (1996) also recommends that science should be taught in conjunction with other academic disciplines for the purposes of helping students develop a "coherence view of knowledge" (p. 601) that more closely aligns with how knowledge is organized and used in one's daily life.

Researchers disagree about the most appropriate time and place to have these comparative discussions. Some have proposed that religion should be addressed in school, but not during science

class. For instance, Evans et al. (2011) express a concern that incorporating discussions about religious explanatory frameworks into the science classroom may encourage students to construct inaccurate scientific models, though they do suggest that these conversations "might well have a role in the broader curriculum" (p. 131), given that children come to school with a wide variety of epistemological lenses. Sinatra and Nadelson (2011) suggest it is valuable to compare and contrast the epistemologies of science and religion, but they do not deem it appropriate for science teachers to present particular non-scientific explanations alongside scientific ones, as such an approach may lead students to believe that the alternative explanations are on par. However, they do propose that science teachers should welcome the discussion of historical and contemporary controversies *within* science (e.g., plate tectonics, the details of mass extinction events, etc.).

The critical exploration of these debates within science is likely to help students understand the nature and epistemology of the domain. On the other hand, in response to the fear that introducing the idea that some people might disagree with a particular concept will automatically undercut the science, Hanley et al. (2014) posit that a teachers' acknowledgement that a topic could be seen by some as controversial might provide an entry point into the discussion for certain students who would otherwise feel alienated. Others have argued that "quarantining" supernatural beliefs from the science classroom leads teachers and students to miss out on rich opportunities to explicitly consider the epistemological distinctions between the domains. Rather than being left out of classroom discussions, supernatural beliefs "should stand subject to the same kinds of empirical and theoretical scrutiny" as scientific beliefs (Shtulman, 2013, p. 208).

Of those who suggest that religious ideas can be productively acknowledged in science discussions, many recommend the strategy of "teaching the demarcation" – i.e., teachers should explore with students how science is in certain ways distinct from other ways of knowing and in other ways similar. As such, a critical understanding goal for science instruction should be that students are capable of identifying scientific approaches to a given topic, and distinguishing those from approaches that come from other domains (Ferrari & Taylor, 2010). Eflin et al. (1999) agree that science education should include the issue of demarcation, but they express concern that discussion of the subtle relationships between psychological, epistemological, and metaphysical issues "is likely to create more confusion than insight" for learners (p. 114).

Thus, while there seems to be some consensus around the idea that it is valuable to make some space for students' religious beliefs and supernatural explanations in a formal educational context, it remains inconclusive in the literature how this should be done or whether science classrooms are the appropriate location for these discussions – and given that every classroom is different, a universal set of *best practices* is unlikely to exist. However, I would argue that the research reviewed above makes a clear case against the status quo of acting as though students enter the classroom as blank slates without exposure to complex, and potentially conflicting, ideas about science and religion as ways of knowing.

Conclusions and Implications

Some additional insights and questions emerged from the literature that may hold promise for future research endeavors. First, and critically, more basic research is needed on religious and supernatural thinking, which seems to necessitate a change of mindset regarding the value of this work. Legare et al. (2012) express a hope to see future research that "treats supernatural cognition as an integral part of cognitive developmental theory and not as an early or primitive mode of thinking that is outgrown in the course of cognitive development" (p. 791). For instance, we do not yet have an understanding of why some children are better at developing integrated reasoning schemes than others. It is possible that some individual differences are due to influence from adults, but it is also plausible that that the differences are due to particular cognitive characteristics. Certain life events and

the explanations that are subsequently presented to children may also prompt them to seek more integrated frameworks (Legare et al., 2012). Future research that can tease apart these distinctions would be valuable to the field of cognitive development, and also of great use to educators seeking to understand how these cognitive processes could inform pedagogy.

Another important question to consider moving forward is how teacher development could be informed by a better understanding of how learners think about science and religion. Researchers have been recommending that pre-service teachers study the philosophy and history of science since the 1960s, after a number of studies (e.g., Miller, 1963; Schmidt, 1967) found evidence that teachers lacked a solid understanding of the nature of science – in some cases, demonstrating even less understanding than their students (Lederman, 1992). However, there have not been similar recommendations for teachers to study religion or its relationship to other academic domains; at present, there is no explicit focus on religion in an overview of the research on programs for teacher development and preparation (Abo-Zena & Mardell, 2015; Ball & Tyson, 2011). This is particularly noteworthy because, compared to other professions, the population of teachers in the United States is a highly religious one. Not only is education a popular choice of major for incoming American college students who identify as religious, but majoring in education actually appears to be associated with an increase in reported religiosity over time (Kimball et al., 2009). Thus, it seems that it would be of value for teachers, including science teachers, to reflect on how their own ideas about religion may influence their teaching practice. For instance, Evans and Lane (2011) posit that science teachers tasked with teaching evolutionary theory could develop greater confidence in dealing with the various theological stances that students may bring to the classroom – as well as any religious conceptions of origins that the teachers themselves possess – if such ideas were explicitly addressed in teacher preparation programs.

Additionally, it appears evident that there is value to beginning these conversations at an early age. For instance, in a study examining the effectiveness of a storybook intervention designed to teach evolutionary mechanisms, Kelemen et al. (2014) found that five- to eight-year-olds demonstrated growth in their understanding of adaptation at the population level, and the older children in particular were capable of generalizing beyond the narrative to other species. In light of these findings, Kelemen et al. (2014) argue that is best to introduce students to counterintuitive scientific concepts at a young age, when they are less beholden to alternative commonsense explanations. From the perspective of religious education, Abo-Zena and Mardell (2015) found through a case study of a kindergarten classroom that young children were capable of, and very interested in, exploring issues of religion and spirituality with their classmates. Their research has implications for how schools might work with families to engage in thoughtful discussion of sensitive topics. Yet, most of the research on young children's development of scientific and religious conceptions exists in the domain of cognitive psychology, where an extra step is required to infer implications for classroom practice and the conclusions that can be drawn are limited outside the laboratory. Meanwhile, the educational research that exists is focused on secondary and higher education and on teachers. Research that focuses on how young children make sense of science and religion in instructional contexts would address a large and important gap in the literature.

Finally, there is more work to be done in the exploration of how children's ideas about science and religion connect to deeper understanding and engagement at a broader level. Ferrari et al. (2010) argue for the practice of "teaching for wisdom" – that is, infusing the curriculum with issues that carry deep and personal significance for students. In particular, they advocate for science classrooms in which students "learn to be intellectually honest and sophisticated in their thinking about the natural world and the human condition, without denying deep existential questions that authentically matter to how they personally live their lives" (Ferrari et al., 2010, p. 253). Connecting science to other issues, they argue – such as policy, ethics, and philosophy – can allow for the teaching of a rigorous science

curriculum while simultaneously recognizing that "some ultimate mysteries remain beyond science" (Ferrari et al., 2010, p. 254).

Prior scholarship, mostly with older individuals, has pointed to the fruitfulness of using science to imbue learners with a sense of deeper meaning by emphasizing ideas like interconnectedness and the magnitude of time and space. In particular, recent research has indicated that leveraging learners' feelings of awe and wonder can be a powerful tool for engagement and motivation in science and can also facilitate the process of conceptual change (Cuzzolino, 2021; Gilbert & Byers, 2017; Valdesolo et al., 2017). Two powerful examples of this are the *Overview Effect* (White, 1998), a cognitive shift experienced by astronauts and cosmonauts who come to experience themselves and the world differently after viewing the Earth from space, and the *Science for Monks* program (Impey, 2014), in which His Holiness the Dalai Lama convened a group of Western scientists to introduce science to a class of Tibetan monks. In each of these cases, both experts and novices underwent a much more meaningful learning experience than they would have if the scientific principles without acknowledgement of their existential implications. It is intriguing to consider what would unfold if these same sorts of ideas were widely shared with young children. The research suggests that they are ready to learn.

The author received no financial support for the research, authorship, and/or publication of this manuscript.

Megan Powell Cuzzolino, Ed.D., (megan_cuzzolino@gse.harvard.edu) is the Senior Project Manager for the Next Level Lab, a research group at the Harvard Graduate School of Education (HGSE) that brings together expertise in the learning sciences and innovative learning design and technology to address emerging and urgent issues in K-12 and workforce development. In 2019, she received her doctorate in Human Development and Education from HGSE, where her research focused on the emotion of awe and its role in scientific learning and discovery. She was previously a K-8 science teacher and a Science Education Analyst at the National Science Foundation.

References

Abelson, R.P. (1963). Computer simulation of "hot cognition." In S. S. Tomkins & S. Messick (Eds.), *Computer simulation of personality: Frontier of psychological theory* (pp. 277- 302). New York, NY: Wiley.

Abo-Zena, M. M., & Mardell, B. (2015). When the children asked to study God, what did the parents say: Building family engagement around sensitive topics. *Religion & Education*, *42*(3), 289-307. https://doi.org/10.1080/15507394.2014.977716

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269-287. https://doi.org/10.1002/(SICI)1098-2736(199903)36:3<269::AID-TEA3>3.0.CO;2-T

Ball, A. F., & Tyson, C. A. (2011). *Studying diversity in teacher education*. Lanham, MD: Rowman & Littlefield.

Banerjee, K., & Bloom, P. (2014). "Everything happens for a reason": Children's beliefs about purpose in life events. *Child Development, 86*(2), 503-518. https://doi.org/10.1111/cdev.12312

Barbour, I. G. (1966). *Issues in science and religion*. Englewood Cliffs, N.J.: Prentice-Hall.

Barbour, I. G. (1988). Ways of relating science and theology. In R. J. Russell, W. R. Stoeger, & G. V. Coyne (Eds.), *Physics, philosophy, and theology: A common quest for understanding* (pp. 21-48). Vatican City: Vatican Observatory.

Billingsley, B., Riga, F., Taber, K. S., & Newdick, H. (2014). Secondary school teachers' perspectives on teaching about topics that bridge science and religion. *Curriculum Journal, 25*(3), 372-395. https://doi.org/10.1007/s11165-012-9317-y

Bloom, P., & Weisberg, D. S. (2007). Childhood origins of adult resistance to science. *Science, 316*(5827), 996-997. https://doi.org/10.1126/science.1133398

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32-42. https://doi.org/10.3102/0013189X018001032

Burr, J. E., & Hofer, B. K. (2002). Personal epistemology and theory of mind: Deciphering young children's beliefs about knowledge and knowing. *New Ideas in Psychology, 20*(2), 199-224. https://doi.org/10.1016/S0732-118X(02)00010-7

Callanan, M., Luce, M., Triona, L., Rigney, J., Siegel, D., & Jipson, J. (2013). What counts as science in everyday and family interactions? In B. Bevan, P. Bell, R. Stevens, & A. Razfar (Eds.), *LOST opportunities*: *Learning in out-of-school time* (pp. 29-48). Dordrecht, Netherlands: Springer.

Callanan, M.A., & Oakes, L.M. (1992). Preschoolers' questions and parents' explanations: Causal thinking in everyday activity. *Cognitive Development, 7*(2), 213-233. https://doi.org/10.1016/0885-2014(92)90012-G

Callanan, M., Valle, A., Luce, M., & Rigney, J. (2014). Discussions of moral issues emerging in family conversations about science. In C. Wainryb & H. Recchia (Eds.), *Talking about right and wrong: Parent-child conversations as contexts for moral development* (pp. 193-216). Cambridge, UK: Cambridge University Press.

Cobern, W. W. (1996). Worldview theory and conceptual change in science education. *Science Education, 80*(5), 579-610. https://doi.org/10.1002/(SICI)1098-237X(199609)80:5<579::AID-SCE5>3.0.CO;2-8

Cobern, W. W. (2000). The nature of science and the role of knowledge and belief. *Science & Education, 9*(3), 219-246. https://doi.org/10.1023/A:1008747309880

Coleman, R. J. (2014). *State of affairs: The science-theology controversy*. Eugene, Oregon: Cascade Books.

Corriveau, K. H., Chen, E. E., & Harris, P. L. (2015). Judgments about fact and fiction by children from religious and nonreligious backgrounds. *Cognitive Science, 39*(2), 353-382. https://doi.org/10.1111/cogs.12138

Crowley, K., Callanan, M. A., Jipson, J. L., Galco, J., Topping, K., & Shrager, J. (2001). Shared scientific thinking in everyday parent-child activity. *Science Education*, *85*(6), 712-732. https://doi.org/10.1002/sce.1035

Cuzzolino, M. P. (2021). "The awe is in the process": The nature and impact of professional scientists' experiences of awe. *Science Education*, *105*(4), 681-706. https://doi.org/10.1002/sce.21625

Danovitch, J. H., & Keil, F. C. (2004). Should you ask a fisherman or a biologist?: Developmental shifts in ways of clustering knowledge. *Child Development, 75*(3), 918-931. https://doi.org/10.1111/j.1467-8624.2004.00714.x

DiMaggio, P. (1997). Culture and cognition. *Annual Review of Sociology, 23*(1), 263-287. https://doi.org/10.1146/annurev.soc.23.1.263

Dunbar, K., Fugelsang, J., & Stein, C. (2007). Do naïve theories ever go away? Using brain and behavior to understand changes in concepts. In M.C. Lovett & P. Shah (Eds.), *Thinking with data* (pp. 193-206). Mahwah, NJ: Lawrence Erlbaum Associates.

Eflin, J. T., Glennan, S., & Reisch, G. (1999). The nature of science: A perspective from the philosophy of science. *Journal of Research in Science Teaching*, *36*(1), 107. http://dx.doi.org/10.1002/(SICI)1098-2736(199901)36:1<107::AID-TEA7>3.0.CO;2-3

Elkana, Y. (1981). *A programmatic attempt at an anthropology of knowledge*. Dordrecht, Netherlands: Springer Netherlands.

Evans, E. M. (2000). Beyond Scopes: Why Creationism is here to stay. In K. Rosengren, C. N. Johnson, & P. L. Harris (Eds.), *Imagining the impossible: The development of magical scientific and religious thinking in contemporary society* (pp. 305-333). Cambridge, UK: Cambridge University Press.

Evans, E. M. (2008). Conceptual change and evolutionary biology: A developmental analysis. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 263-294). New York, NY: Routledge.

Evans, J. H., & Evans, M. S. (2008). Religion and science: Beyond the epistemological conflict narrative. *Annual Review of Sociology*, *34*(1), 87-105. https://doi.org/10.1146/annurev.soc.34.040507.134702

Evans, E. M., & Lane, J. D. (2011). Contradictory or complementary? Creationist and evolutionist explanations of the origin(s) of species. *Human Development, 54*(3), 144-159. https://doi.org/10.1159/000329130

Evans, E. M., Legare, C., & Rosengren, K. (2011). Engaging multiple epistemologies: Implications for science education. In M. Ferrari & R. Taylor (Eds.), *Epistemology and science education: Understanding the evolution vs. intelligent design controversy* (pp. 111-139). New York, NY: Routledge.

Evans, E. M., Mull, M., & Poling, D. (2001, April). Confronting the existential questions: Children's understanding of death and origins. *Biennial Meeting of the Society for Research in Child Development.* Minneapolis, MN.

Ferrari, M. & Taylor, R.S. (2010). Teach the demarcation: Suggestions for science education. In M. Ferrari & R. Taylor (Eds.), *Epistemology and science education: Understanding the evolution vs. intelligent design controversy* (pp. 271-285). New York, NY: Routledge.

Ferrari, M., Lee, P., & Taylor, R.S. (2010). Teaching evolution in a historical context: From the wisdom of the ancient Greeks to genetic algorithms. In M. Ferrari & R. Taylor (Eds.), *Epistemology and science education: Understanding the evolution vs. intelligent design controversy* (pp. 243-267). New York, NY: Routledge.

Fugelsang, J. A., & Dunbar, K. N. (2005). Brain-based mechanisms underlying complex causal thinking. *Neuropsychologia*, *43*(8), 1204-1213. https://doi.org/10.1016/j.neuropsychologia.2004.10.012

Gauchat, G. (2015). The political context of science in the United States: Public acceptance of evidence-based policy and science funding. *Social Forces, 94*(2), 723-746. https://doi.org/10.1093/sf/sov040

Geary, D. C. (2008). An evolutionarily informed education science. *Educational Psychologist, 43*(4), 179-195. https://doi.org/10.1080/00461520802392133

Gelman, S. A. (2011). When worlds collide – or do they? Implications of explanatory coexistence for conceptual development and change. *Human Development, 54*(3), 185-190. https://www.jstor.org/stable/26765004

Gilbert, A., & Byers, C. C. (2017). Wonder as a tool to engage preservice elementary teachers in science learning and teaching. *Science Education*, *101*(6), 907-928. https://doi.org/10.1002/sce.21300

Gottlieb, E., & Wineberg, S. (2012). Between *veritas* and *communitas*: Epistemic switching in the reading of academic and sacred history. *The Journal of the Learning Sciences, 21,* 84-129. https://doi.org/10.1080/10508406.2011.582376

Gould, S. J. (1999). *Rocks of ages: Science and religion in the fullness of life*. New York: Ballantine Publishing Group.

Grotzer, T. A., & Solis, S. L. (2015). Action at an attentional distance: A study of children's reasoning about causes and effects involving spatial and attentional discontinuity. *Journal of Research in Science Teaching*, *52*(7), 1003-1030. https://doi.org/10.1002/tea.21233

Haden, C. A. (2010). Talking about science in museums. *Child Development Perspectives*, *4*(1), 62-67. https://doi.org/10.1111/j.1750-8606.2009.00119.x

Hanley, P., Bennett, J., & Ratcliffe, M. (2014). The inter-relationship of science and religion: A typology of engagement. *International Journal of Science Education, 36*(7), 1210-1229. https://doi.org/10.1080/09500693.2013.853897

Harris, P.L. (2002). What do children learn from testimony? In P. Carruthers, S. Stitch, & M. Siegal (Eds.), *The cognitive basis of science* (pp. 316-334). Cambridge, UK: Cambridge University Press.

Harris, P. L., & Giménez, M. (2005). Children's acceptance of conflicting testimony: The case of death. *Journal of Cognition and Culture*, *5*(1), 143-164. https://doi.org/10.1163/1568537054068606

Harris, P. L., & Koenig, M.A. (2006). Trust in testimony: how children learn about science and religion. *Child Development*, *77*(3), 505-524. https://doi.org/10.1111/j.1467-8624.2006.00886.x

Heiphetz, L., Spelke, E. S., Harris, P. L., & Banaji, M. R. (2014). What do different beliefs tell us? An examination of factual, opinion-based, and religious beliefs. *Cognitive Development, 30,* 15-29. https://doi.org/10.1016/j.cogdev.2013.12.002

Hennessy, S. (1993). Situated cognition and cognitive apprenticeship: Implications for classroom learning. *Studies in Science Education, 22*(1), 1-41.

Hofer, B. K., Lam, C. F., & DeLisi, A. (2011). Understanding evolutionary theory: The role of epistemological development and beliefs. In M. Ferrari & R. Taylor (Eds.), *Epistemology and science education: Understanding the evolution vs. intelligent design controversy* (pp. 95-110). New York: Routledge.

Impey, C. (2014). *Humble before the void: A Western astronomer, his journey East, and a remarkable encounter between Western science and Tibetan Buddhism.* West Conshohocken, PA: Templeton Press.

Järnefelt, E., Canfield, C. F., & Kelemen, D. (2015). The divided mind of a disbeliever: Intuitive beliefs about nature as purposefully created among different groups of non-religious adults. *Cognition, 140,* 72-88. https://doi.org/10.1016/j.cognition.2015.02.005

Jegede, O. J. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics education in Africa. *Studies in Science Education, 25,* 97-137. https://doi.org/10.1080/03057269508560051

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *The American Economic Review, 93*(5), 1449-1475. https://doi.org/10.1257/000282803322655392

Kearney, M. (1984). *Worldview.* Novato, CA: Chandler & Sharp Publishers.

Kelemen, D. (2004). Are children "intuitive theists"? Reasoning about purpose and design in nature. *Psychological Science*, *15*(5), 295-301. https://doi.org/10.1111/j.0956-7976.2004.00672.x

Kelemen, D., Emmons, N. A., Schillaci, R. S., & Ganea, P. A. (2014). Young children can be taught basic natural selection using a picture-storybook intervention. *Psychological Science, 25*(4), 893-902. https://doi.org/10.1177/0956797613516009

Kimball, M. S., Mitchell, C. M., Thornton, A. D., & Young-Demarco, L. C. (2009). Empirics on the origins of preferences: The case of college major and religiosity. NBER working paper, no. 15182. Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w15182

Koul, R. (2006). Religious outlook and students' attitudes towards school science. *Journal of Beliefs & Values, 27*(3), 251-267. https://doi.org/10.1080/13617670601000936

Lane, J. D., & Harris, P. L. (2014). Confronting, representing, and believing counterintuitive concepts navigating the natural and the supernatural. *Perspectives on Psychological Science, 9*(2), 144-160. https://doi.org/10.1177/1745691613518078

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331-359. https://doi.org/10.1002/tea.3660290404

Legare, C. H., Evans, E. M., Rosengren, K. S., & Harris, P. L. (2012). The coexistence of natural and supernatural explanations across cultures and development. *Child Development, 83*(3), 779-793. https://doi.org/10.1111/j.1467-8624.2012.01743.x

Lesser, H. (1977). The growth of perceived causality in children. *The Journal of Genetic Psychology*, *130*(1), 145-152. https://doi.org/10.1080/00221325.1977.10533241

Long, D. E. (2013). Finding Jesus's magic pineapple: Or, improving science education by improving religious education. *Cultural Studies of Science Education, 8*(2), 389-398. https://doi.org/10.1007/s11422-013-9491-x

Luce, M. R., Callanan, M. A., & Smilovic, S. (2013). Links between parents' epistemological stance and children's evidence talk. *Developmental Psychology, 49*(3), 454-461. https://doi.org/10.1037/a0031249

Lutz, D. J., & Keil, F. C. (2002). Early understanding of the division of cognitive labor. *Child Development, 73*(4), 1073-1084. https://doi.org/10.1111/1467-8624.00458

Miller, P.E. (1963). A comparison of the abilities of secondary teachers and students of biology to understand science. *Iowa Academy of Science, 70,* 510-513.

National Academy of Sciences (1998). *Teaching about evolution and the nature of science.* National Academy Press, Washington, DC.

National Academy of Sciences. (2008). *Science, evolution, and creationism.* Washington, DC: National Academy Press.

NGSS Lead States. (2013). *Next generation science standards: For states, by states.* Washington, DC: The National Academies Press.

Nussbaum, J. (1985) The earth as a cosmic body. In R. Driver, E. Guesne, & A, Tiberghian (Eds.), *Children's ideas in science* (pp. 170-192). Philadelphia: Philadelphia Open University Press.

Pew Forum. (2009). *Public praises science; Scientists fault public, media.* Retrieved from http://www.people-press.org/2009/07/09/public-praises-science-scientists-fault-public-media/.

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, *63*(2), 167-199. https://doi.org/10.3102/00346543063002167

Postman, N. (1995). *The end of education.* New York: Alfred A. Knopf.

Reif, F., & Larkin, J. H. (1991). Cognition in scientific and everyday domains: Comparison and learning implications. *Journal of Research in Science Teaching*, *28*(9), 733-760. https://doi.org/10.1002/tea.3660280904

Schmidt, D.J. (1967). Test on understanding science: A comparison among school groups. *Journal* of *Research in Science Teaching, 5*(4), 365-366. https://doi.org/10.1002/tea.3660050411

Scopes Case, 289 S.W. 363, 154 Tenn. 105, 154 Tennessee 105 (Supreme Court 1927).

Shtulman, A. (2013). Epistemic similarities between students' scientific and supernatural beliefs. *Journal of Educational Psychology, 105*(1), 199-212. https://doi.org/10.1037/a0030282

Shtulman, A., & Harrington, K. (2016). Tensions between science and intuition across the lifespan. *Topics in Cognitive Science, 8*, 118-137. https://doi.org/10.1111/tops.12174

Shtulman, A., & Valcarcel, J. (2012). Scientific knowledge suppresses but does not supplant earlier intuitions. *Cognition, 124*, 209-215. https://doi.org/10.1016/j.cognition.2012.04.005

Siegel, H. (1998). Knowledge, truth, and education. In D. Carr (Ed.), *Education, knowledge and truth: Beyond the postmodern impasse* (pp. 19-36). London, UK: Routledge.

Sinatra, G. M., & Nadelson, L. S. (2011). Science and religion: Ontologically different epistemologies? In M. Ferrari & R. Taylor (Eds.), *Epistemology and science education: Understanding the evolution vs. intelligent design controversy* (pp. 173-193). New York, NY: Routledge.

Smith, M. U. (1994). Counterpoint: Belief, understanding, and the teaching of evolution. *Journal of Research in Science Teaching, 31*(5), 591-597. https://doi.org/10.1002/tea.3660310512

Smith, M. U., Siegel, H., & McInerney, J. D. (1995). Foundational issues in evolution education. *Science & Education*, *4*(1), 23-46. https://doi.org/10.1007/BF00486589

Southerland, S. A., Sinatra, G. M., & Matthews, M. R. (2001). Belief, knowledge, and science education. *Educational Psychology Review*, *13*(4), 325-351. https://doi.org/10.1023/A:1011913813847

Stanovich, K.E. and West, R.F. (2000). Individual differences in reasoning: Implications for the rationality debate? *Behavioral and Brain Sciences, 23*(5), 645–665. https://doi.org/10.1017/S0140525X00003435

Strike, K. A., & Posner, G. J. (1982). Conceptual change and science teaching. *European Journal of Science Education*, *4*(3), 231-240. https://doi.org/10.1080/0140528820040302

Valdesolo, P., Shtulman, A., & Baron, A. S. (2017). Science is awe-some: The emotional antecedents of science learning. *Emotion Review, 9*(3), 215-221. https://doi.org/10.1177/1754073916673212

Vlach, H. A., & Noll, N. (2016). Talking to children about science is harder than we think: characteristics and metacognitive judgments of explanations provided to children and adults. *Metacognition and Learning, 11*, 317-338. https://doi.org/10.1007/s11409-016-9153-y

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive psychology*, *24*(4), 535-585. https://doi.org/10.1016/0010-0285(92)90018-W

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science. *Handbook of research on science teaching and learning*, *177*, 210.

Wellman, H.M. (2014). *Making minds: How theory of mind develops.* New York: Oxford University Press.

White, F. (1998). *The overview effect: Space exploration and human evolution.* AIAA.

Wilson, E.O. (1998). *Consilience: The unity of knowledge.* New York: Knopf.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 34-42

Overlapping Magisteria: Motivated Cognition and the Places Where Science and Religion Mingle

Jonathan Morgan
University of Colorado, Colorado Springs

ABSTRACT

Scientific insights can help us better understand ourselves, others, and the world we share. These insights can also radically challenge our sense of who we are, our place in the universe, and the very nature of the universe. When science communicators venture into this metaphysical terrain they quickly encounter dearly held religious beliefs. Where these two meaning-making systems overlap can often become places of friction as communicators and audiences alike are asked to balance our need for accuracy with our needs for psychological security, all while humbly considering the limitations of scientific inference. This paper brings together research on motivated cognition and science communication in order to better understand these challenges and to offer a way to navigate this potentially fraught terrain.

Keywords: science and religion, motivated cognition, metaphysics, science communication

Editors' Comment

*In this manuscript, **Jonathan Morgan, Ph.D., (2015-2017 Fellow)**, revisits Gould's portrayal of science and religion as non-overlapping magisteria (NOMA) and rightfully reminds the reader that they often fail to stay within their boundaries. In the science classroom, studying neurobiology can evoke questions of free will just as exploring the vastness of the universe can cause us to question our own importance in the great scheme of things. Such questions are not easily answered by science alone and extend into the realm of the metaphysical. Learners often have preconceived ideas about concepts such as these - often informed by their religious backgrounds; what they bring to the classroom will certainly impact their ability to engage in the content. Morgan suggests that current research into motivated cognition could help educators better navigate the metaphysical space between science and religion to more effectively engage students.*

Introduction

The great science communicator Stephen Jay Gould (1997) coined the now infamous phrase *nonoverlapping magisteria* (NOMA) to try and broker a détente in the conflict between science and religion. While the name was novel, the idea is old: science has teaching authority over facts while religion's domain of authority covers values (the fancy word "magisteria" comes from the Latin for teacher: *magister*). Or as Galileo put it, the purpose of religion "*is to teach us how one goes to heaven, not how heaven goes*" (1615, para. 25). The idea may be old, but it is also quite current. The National Academy of Sciences (2021) still uses a version of this idea to argue that religion and science are compatible:

> Science and religion are based on different aspects of human experience. In science, explanations must be based on evidence drawn from examining the natural world... Religious faith, in contrast, does not depend only on empirical evidence, is not necessarily modified in

> the face of conflicting evidence, and typically involves supernatural forces or entities… In this sense, science and religion are separate and address aspects of human understanding in different ways. Attempts to pit science and religion against each other create controversy where none needs to exist. (para. 3)

This statement expands the focus of religion from values to anything extra-empirical, but the spirit is the same. If we could all just abide by this simple boundary then the border skirmishes between religion and science would settle down, right?

As intuitive and crisp as NOMA might be, it does not appear to be how we actually engage the meaning-making systems of religion and science. Religions clearly deal with non-empirical content and it may be tempting to try and fence that terrain off. But, these supernatural entities are conceived of as directly interacting with very physical experiences, such as illnesses (Laird et al., 2017), working conditions (Taussig, 1980), or even the most ordinary parts of one's everyday life (Luhrmann, 2012). Where then should we put the fence? Faith without any material consequence is not going to be satisfying to most religious people. Most of the critiques of NOMA have focused on this side of the overlap– religions clearly deal with domains that we consider empirical (e.g., Dawkins, 1998; Jacoby, 2010; Stenger, 2007).

The focus of this essay is on the other direction. Science may profess to restrict itself to matters of empirical evidence. But scientists and the public alike rarely stay confined to the intersubjectively verifiable. Neurocognitive studies show us how substance use impacts our dopamine system (Leshner, 1997; Volkow & Li, 2005), but we then take that evidence and leap to conclusions about metaphysical subjects such as free-will (Greene & Cohen, 2004). The complexity and distance of that inferential leap is huge and lands well beyond the territory of facts. When we look at how people actually engage with scientific and religious meaning-making systems, it is not just religion that ventures onto scientific turf, science regularly ventures into the metaphysical terrain that NOMA supposedly ceded to religion.

There are many fronts on which scientific research is taken as evidence of metaphysical positions. Gods (Dawkins, 2008), dualism (Crick, 1994), teleology (Krauss, 2017), morality (Harris, 2010), free-will (Coyne, 2014), etc.– these are just a few of the metaphysical positions which some science communicators are attempting to annex into the domain of empirical facts. The relevance of empirical evidence on these matters is philosophically complicated, to say the least. Belief or disbelief in God and free-will, for example, are two of the antinomies that Kant (1781/1999) argued cannot be grounded by empirical reason. Plenty of work has been done since Kant, of course, but I think we can agree that the move from focused scientific studies to metaphysical claims is far from straightforward.

Rather than attempt to chart some path or erect some boundary here, I think it is helpful to stick with the practical reality that we all move quite readily between questions of fact and questions of morality, value, and metaphysics. When we recognize that we are all exploring this rocky terrain, then we can begin to ask different sorts of questions. Instead of asking whether or not neurocognitive evidence denies free-will, we can begin to wonder why some people believe it does while others do not? If we can leave behind the idea that these are purely rational debates, then we can more clearly see why this terrain is so contested.

In this paper, I suggest that research on motivated cognition can help us navigate this metaphysical borderland between religion and science. Not only does this research help us see why and how people move within this terrain, it can also (hopefully) foster a sense of humility and compassion as we recognize that our movements are pulled by more than just the pursuit of truth. My hope is that recognizing the other needs that shape how we process information will equip us to explore this ambiguous space together rather than stake it out as a battleground.

Motivated Cognition

The way we process information is shaped by various goals other than accuracy (Kruglanski, 1996; Pyszczynski & Greenberg, 1987). While this may seem, and is, psychologically complex, the effects are quite ordinary. Think of watching a basketball game with a friend who supports the opposing team. Your judgments about the referees' calls are almost certainly going to be different from your friends. Sure, it would be nice to think that she is the one being biased, but neither of you are trying to be objective about this. You are both motivated to interpret the calls in a certain light. This is motivated cognition.

In the sports example we may be playfully aware of our bias and jokingly defend our opinions while knowing we are biased. But often the goals that shape how we process information are working without our awareness and are far from joking matters. For example, Kahan (2017) has built a research program looking at the way motivated reasoning influences how people think about climate change, vaccinations, and the disposal of nuclear waste. Similar to the sports example, how people interpret evidence that weighs on these issues depends heavily on their social identity. The motivation that guides reasoning here is the motivation to maintain affiliation with one's group. As Kahan (2017) puts it, *"[we] have a bigger personal stake in fitting in with important affinity groups than in forming correct perceptions of scientific evidence"* (p. 1). In other words, our need to belong exerts a stronger pull on the way we process information than our need to be correct.

While we may be tempted to shake our heads at the irrationality of this behavior, doing so would miss the ways in which motivated cognition is deeply rational. Holding and expressing different beliefs from your social network can be very risky– it risks being marginalized within that network and having less access to the material and emotional support our groups provide (Over, 2016). In other words, prioritizing our need to belong over our need to be right is a rational assessment of the situation. Perhaps more importantly, bemoaning the irrationality of motivated cognition also tempts us to avoid recognizing that the way we scientists process information is also drawn by needs other than accuracy.

Metaphysical Motivations

The social goal of belonging is not the only motivation that shapes our thought processes. The field of experimental existential psychology (Pyszczynski et al., 2010) has shown that our needs for a sense of autonomy, self-worth, meaning, certainty, control, and continuity after death all shape our thoughts, attitudes, and actions (Hart, 2014). For example, when people's sense of control and security is threatened, they tend to lean more strongly on the cultural systems that have provided them with felt security in the past (Kay et al., 2008). Similarly, disruptions in one's sense of self-esteem can often lead to a compensatory defense of their in-group (Sherman & Cohen, 2006). In other words, people act and interpret information in order to preserve their sense that these psychological needs are being met.

Importantly, these *existential needs* are not wholly distinct from the social motivation to belong. Metaphysical positions on issues, ranging from agency to meaning are deeply interwoven with the communities to which we belong. For Protestants in the US, a strong position on free-will may be a key part of their worldview, but in other cultural contexts this belief may be less central. Rather than see these existential motivations as a distinct domain, we can think of them as particularly sensitive issues that tie together a sense of who we are, to whom we belong, and what the world is like.

Rather than consider all of these diverse metaphysical concerns, each of which likely has its own psycho-social dynamics, let us focus on the issue of free-will. Debates about the nature or existence of free-will go back thousands of years. More recently, psychologists have shifted the question from the character of free-will to the determinants of belief in free-will (Baumeister, 2008;

Baumeister & Monroe, 2014). The studies that have grown out of this shift reveal that whether or not we believe in free-will is largely influenced by factors other than philosophical reflection and that this belief may address important personal and social needs.

Taking up the first of these points, the degree to which someone believes in free-will appears to vary depending on contextual and personal factors. Some evidence suggests that the belief may be the majority position cross-culturally (Sarkissian, 2010), but researchers in the US found that religious and conservative individuals tend to be more confident in their beliefs in free-will (Baumeister & Monroe, 2014; Carey & Paulhus, 2013). There is also evidence that belief in free-will increases when people are confronted with antisocial behaviors (Clark et al., 2014) and decreases when people are confronted with their own desires (Ent & Baumeister, 2014). In other words, the strength with which we hold this metaphysical position ebbs and flows with our changing social and subjective circumstances.

The belief in free-will also serves important functions. For example, Vohs and Schooler (2008) found that priming students to disbelieve in free-will led to increased student cheating on academic tests within the experiment. Subsequent similar studies found that participants who were encouraged to reject the belief in free-will were less helpful and more aggressive in social settings (Baumeister et al., 2009). Conversely, experimentally bolstering one's sense of free-will has been found to increase volunteering (Stillman & Baumeister, 2010) and foster more reflection on one's past misdeeds (Alquist et al., 2015). There are also more personal functions served by this belief. Crescioni et al. (2016) found that belief in free-will corresponded with lower stress, greater happiness, more experiences of meaning in life, greater self-efficacy, higher self-worth, and stronger commitment in close relationships. This correlational evidence is backed up by experimental studies finding that reduced belief in free-will tended to impact people's willingness to exercise self-control (Rigoni et al., 2012). In short, the belief in free-will appears to be functionally linked with important social and personal outcomes.

What I am suggesting is that the fluctuation and the function of this belief are connected. Bolstering one's belief in free-will may provide people with a way to signal their social affiliations, nurture their sense of self-control and efficacy, preserve an experience of social cohesion, and perhaps regain a sense of meaning. Not everyone will relate to this belief in the same way, but for those people whose sense of agency is interwoven with these positive outcomes then it is likely that they will be highly motivated to maintain that belief.

From the perspective of motivated cognition, the psycho-social needs met by metaphysical beliefs such as free-will suggests that we are not going to be neutral in our judgments about these matters. Rather than dispassionately weighing the evidence for or against the issue, we are going to be drawn towards the positions that help meet our needs at any given moment.

Consequences for Science Communication and Education

This matters for science communication and education because it is often scientists that are attempting to take possession of these metaphysical areas (e.g., Bargh, 2005; Kaufman & Baumeister, 2008; Wegner, 2017). For example, the experimental designs used in the studies mentioned above regularly use some form of science communication as the anti-free-will condition. Vohs and Schooler (2008) used a quote from Francis Crick claiming that "who you are is nothing but a pack of neurons" (1994, p. 3) This is typical of the designs as Baumeister and Monroe (2014) describe: "participants are randomly assigned to read a series of statements that either deny the reality of free will (e.g., '*Science has demonstrated that free will is an illusion*') or that express scientific facts irrelevant to free will (e.g., 'Oceans cover 71% of the Earth's surface')" (p. 16, emphasis added). Why is science being used as the authority here when this is a metaphysical claim?

The effectiveness of these experimental designs reveals a common association between science and the belief that free-will is an illusion. As Vohs and Schooler put it: "rational, high-minded people

- including, according to Crick, most scientists - now recognize that actual free will is an illusion" (Vohs & Schooler, 2008, p. 50). This is not an unwarranted association. As I have noted throughout, many prominent science communicators and educators, from neuroscientists (Libet et al., 1983) to biologists (Coyne, 2014), to secular proselytizers (Harris, 2012), all argue that science disproves free-will. It is no surprise therefore to regularly see headlines such as "free will could all be an illusion, scientists suggest after study shows choice may just be brain tricking itself" (Griffin, 2016) or "There's no such thing as free will" (Cave, 2016). In other words, this is not an obscure association limited to a small community of philosophical scientists. Instead it is a deliberately public example of science advocates attempting to stake out terrain that was supposedly ceded to religion. With motivated cognition in mind, what do we expect to be the consequences of this incursion?

Motivated cognition cuts both ways here. Simply because we are researchers, does not mean we are immune to the pull of needs and goals on our thought processes. As science increasingly becomes not just a method of inquiry but a social identity (Carlone & Johnson, 2007; Kim & Sinatra, 2018), it also becomes increasingly easy for those of us who adopt that identity to accept what is touted as scientific fact without full scrutiny. In other words, it is easy to adopt beliefs that are presented as part of the scientific worldview, even if the evidential grounds for those beliefs are somewhat shaky.

Conversely, if you do not see science as part of your identity, or have experienced science as adversarial, then the beliefs presented by scientists are likely to be rejected without full or fair scrutiny. Consider Kahan's (2017) description of how people engage with scientific information that diverges from their group's beliefs: "What they are doing instead [of objectively weighing evidence] is using the consistency of new evidence with their groups' positions to determine whether that evidence should be given any weight at all" (p. 3). In other words, when scientists present metaphysical opinions as scientific conclusions, it obstructs any engagement with the actual evidence among those who disagree.

In order to navigate these dynamics in the classroom and lecture halls, it is crucial to prioritize relationships over information. Establishing trust by demonstrating integrity and benevolence alongside your expertise (see Hendriks et al., 2016 and Mayer et al., 1995), is a necessary precondition for avoiding this epistemic polarization, especially for those students who do not necessarily see scientists as trustworthy authorities.

The risk here is not that people will simply reject arguments about free-will. Instead, when science communicators venture onto metaphysical grounds, they risk threatening broad swaths of the public who hold different theological views. In early research on motivated cognition, Kahan and colleagues (2011) found that when people were presented with a highly credentialed scientist who was advocating for a position with which they disagreed, they were significantly less likely to rank that scientist as an expert. In other words, they did not dismiss the argument, they dismissed the source.

When science communicators are representing capital "S" Science while staking out metaphysical disagreements with religious worldviews, they risk undermining a broader sense of trust in the expertise of science. This is risky because there are plenty of other issues around which scientists are making well-founded inferences that people may still dislike–evolution, climate change, and vaccinations are among the most well studied. We make it more difficult for public buy-in on these contentious issues when science communicators are also making threatening incursions onto terrain where they cannot actually stand on solid empirical ground.

The Challenge and Opportunity of Motivated Cognition.

My hope is that thinking about this through the lens of motivated cognition helps to remove the judgment of some audiences as stubbornly irrational. Instead, we can direct our attention to the ways in which what may seem like a rational or irrational engagement with the facts is being shaped by various needs that we all have. If people perceive those facts—or the position those facts are being used to support—as threatening to their sense of self or their sense of belonging, then they are very

rationally going to prioritize those needs over their need for accuracy. This is true for *them*, but it is also true for *us* as scientists. Try as we might, none of us are neutral assessors of data.

As science communicators and educators, our aim is often to help people. Whether that is through sharing useful information or simply trying to share a sense of wonder and curiosity, I believe that one of our core goals is for our students or audience to have a slightly richer life after our meeting. All too often, however, we run into pitfalls. The atmosphere of wonder becomes a contentious arena of debate. One of the ways in which we can be the most helpful is to prioritize the person over the information. If we can humbly recognize the way our own sense of self and belonging is wrapped up within our research, then perhaps we can also begin to see how others are navigating their own needs as they engage with that same research.

In Gould's essay proposing NOMA, he recognizes that the reality differs from crisp separation of facts and values:

…this resolution might remain all neat and clean if the nonoverlapping magisteria (NOMA) of science and religion were separated by an extensive no man's land. But, in fact, the two magisteria bump right up against each other, interdigitating in wondrously complex ways along their joint border. Many of our deepest questions call upon aspects of both for different parts of a full answer. (p. 19)

Our deepest questions lie within that metaphysical terrain between the magisteria of religion and science. To suggest that either meaning-making system has sole claim to these questions is to provoke conflict and preclude any genuinely collaborative inquiry into what it means to be human. If, however, we can recognize that our journeys in this terrain are pulled by more than our need for accuracy, then perhaps we can humbly and compassionately explore this land together.

This work was supported by the SS-SM Foundation.

Jonathan Morgan, Ph.D., (jmorgan9@uccs.edu) is a post-doctoral researcher at UCCS studying the psychological dimensions of science communication. His current research focuses the way existential motivations influence our attitudes towards science and how we engage with scientific information.

References

Alquist, J. L., Ainsworth, S. E., Baumeister, R. F., Daly, M., & Stillman, T. F. (2015). The making of might-have-beens: Effects of free will belief on counterfactual thinking. *Personality and Social Psychology Bulletin*, *41*(2), 268–283. https://doi.org/10.1177/0146167214563673

Baer, J., Kaufman, J. C., & Baumeister, R. F. (2008). *Are we free? Psychology and free will*. Oxford University Press.

Bargh, J. A. (2005). Bypassing the will: Toward demystifying the nonconscious control of social behavior. In *The new unconscious* (pp. 37–58). Oxford University Press.

Baumeister, R. F. (2008). Free will in scientific psychology. *Perspectives on Psychological Science*, *3*(1), 14–19. https://doi.org/10.1111/j.1745-6916.2008.00057.x

Baumeister, R. F., Masicampo, E. J., & DeWall, C. N. (2009). Prosocial benefits of feeling free: Disbelief in free will increases aggression and reduces helpfulness. *Personality and Social Psychology Bulletin*, *35*(2), 260–268. https://doi.org/10.1177/0146167208327217

Baumeister, R. F., & Monroe, A. E. (2014). Recent research on free will: Conceptualizations, beliefs, and processes. In J. M. Olson & M. P. Zanna (Eds.), *Advances in Experimental Social Psychology* (Vol. 50, pp. 1–52). Academic Press. https://doi.org/10.1016/B978-0-12-800284-1.00001-1

Carey, J. M., & Paulhus, D. L. (2013). Worldview implications of believing in free will and/or determinism: Politics, morality, and punitiveness. *Journal of Personality*, *81*(2), 130–141. https://doi.org/10.1111/j.1467-6494.2012.00799.x

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Cave, S. (2016, May 17). There's no such thing as free will. *The Atlantic*. https://www.theatlantic.com/magazine/archive/2016/06/theres-no-such-thing-as-free-will/480750/

Clark, C. J., Luguri, J. B., Ditto, P. H., Knobe, J., Shariff, A. F., & Baumeister, R. F. (2014). Free to punish: A motivated account of free will belief. *Journal of Personality and Social Psychology*, *106*(4), 501.

Coyne, J. A. (2014). *Faith Versus fact: Why science and religion Are incompatible*. Penguin Books.

Crescioni, A. W., Baumeister, R. F., Ainsworth, S. E., Ent, M., & Lambert, N. M. (2016). Subjective correlates and consequences of belief in free will. *Philosophical Psychology*, *29*(1), 41–63. https://doi.org/10.1080/09515089.2014.996285

Crick, F. (1994). *The astonishing hypothesis: The scientific search for the soul*. Scribner.

Dawkins, R. (1998, April 1). When religion steps on science's turf. *Free Inquiry*, *18*(2). https://secularhumanism.org/1998/04/when-religion-steps-on-sciences-turf/

Dawkins, R. (2008). *The God delusion* (Reprint edition). Mariner Books.

Ent, M. R., & Baumeister, R. F. (2014). Embodied free will beliefs: Some effects of physical states on metaphysical opinions. *Consciousness and Cognition*, *27*, 147–154. https://doi.org/10.1016/j.concog.2014.05.001

Galilei, G. (1615). *Letter to the Grand Duchess Christina of Tuscany*. https://sourcebooks.fordham.edu/mod/galileo-tuscany.asp

Gould, S. J. (1997). Nonoverlapping magisteria. *Natural History*, *106*, 16–22.

Greene, J., & Cohen, J. (2004). For the law, neuroscience changes nothing and everything. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *359*(1451), 1775–1785. https://doi.org/10.1098/rstb.2004.1546

Griffin, A. (2016, May 3). Free will could all be an illusion, scientists suggest after study shows choice may just be brain tricking itself. *The Independent*. https://www.independent.co.uk/news/science/free-will-could-all-be-illusion-scientists-suggest-after-study-shows-choice-could-just-be-brain-tricking-itself-a7008181.html

Harris, S. (2010). *The moral Landscape: How science can determine human values*. Free Press.

Harris, S. (2012). *Free will* (1st edition). Free Press.

Hart, J. (2014). Toward an integrative theory of psychological defense. *Perspectives on Psychological Science*, *9*(1), 19–39. https://doi.org/10.1177/1745691613506018

Hendriks, F., Kienhues, D., & Bromme, R. (2016). Trust in science and the science of trust. In B. Blöbaum (Ed.), *Trust and communication in a digitized world: Models and concepts of trust research* (pp. 143–159). Springer International Publishing. https://doi.org/10.1007/978-3-319-28059-2_8

Jacoby, S. (2010). The myth of separate magisteria. *Big Questions Online*. http://www.bigquestionsonline.com/columns/susan-jacoby/the-myth-of-separate-magisteria

Kahan, D. M. (2017). *Misconceptions, misinformation, and the logic of identity-protective cognition* (SSRN Scholarly Paper ID 2973067). Social Science Research Network. https://doi.org/10.2139/ssrn.2973067

Kahan, D. M., Jenkins-Smith, H., & Braman, D. (2011). Cultural cognition of scientific consensus. *Journal of Risk Research*, *14*(2), 147–174. https://doi.org/10.1080/13669877.2010.511246

Kant, I. (1999). *Critique of pure reason* (P. Guyer & A. W. Wood, Eds.). Cambridge University Press. (Original work published 1781)

Kay, A. C., Gaucher, D., Napier, J. L., Callan, M. J., & Laurin, K. (2008). God and the government: Testing a compensatory control mechanism for the support of external systems. *Journal of Personality and Social Psychology*, *95*(1), 18–35. https://doi.org/10.1037/0022-3514.95.1.18

Kim, A. Y., & Sinatra, G. M. (2018). Science identity development: An interactionist approach. *International Journal of STEM Education*, *5*(1), 51. https://doi.org/10.1186/s40594-018-0149-9

Krauss, L. M. (2017). *The greatest story ever told--so far: Why are we here?* Atria Books.

Kruglanski, A. W. (1996). Motivated social cognition: Principles of the interface. In *Social psychology: Handbook of basic principles* (pp. 493–520). The Guilford Press.

Laird, L. D., Curtis, C. E., & Morgan, J. R. (2017). Finding spirits in spirituality: What are we measuring in spirituality and health research? *Journal of Religion and Health*, *56*(1), 1–20. https://doi.org/10.1007/s10943-016-0316-6

Leshner, A. I. (1997). Addiction is a brain disease, and it matters. *Science*, *278*(5335), 45–47. https://doi.org/10.1126/science.278.5335.45

Libet, B., Gleason, C. A., Wright, E. W., & Pearl, D. K. (1983). Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). The unconscious initiation of a freely voluntary act. *Brain: A Journal of Neurology*, *106 (Pt 3)*, 623–642. https://doi.org/10.1093/brain/106.3.623

Luhrmann, T. M. (2012). *When god talks back: Understanding the American evangelical relationship with god*. Vintage.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review*, *20*(3), 709–734. https://doi.org/10.5465/amr.1995.9508080335

National Academies of Sciences. (2021). *Evolution resources at the national academies: Compatibility of science and religion*. National Academy of Sciences. https://www.nationalacademies.org/evolution/science-and-religion#sl-three-columns-b1a4c46c-4011-44b4-ac76-876803643217

Pyszczynski, T., & Greenberg, J. (1987). Toward an integration of cognitive and motivational perspectives on social inference: A biased hypothesis-testing model. *Advances in Experimental Social Psychology*, *20*, 297–340.

Pyszczynski, T., Greenberg, J., Koole, S., & Solomon, S. (2010). Experimental existential psychology: Coping with the facts of life. In S. T. Fiske, D. T. Gilbert, & G. LIndzey (Eds.), *Handbook of social psychology* (pp. 724–757). John Wiley & Sons, Inc. https://doi.org/10.1002/9780470561119.socpsy001020

Rigoni, D., Kühn, S., Gaudino, G., Sartori, G., & Brass, M. (2012). Reducing self-control by weakening belief in free will. *Consciousness and Cognition*, *21*(3), 1482–1490. https://doi.org/10.1016/j.concog.2012.04.004

Sarkissian, H., Chatterjee, A., Brigard, F. D., Knobe, J., Nichols, S., & Sirker, S. (2010). Is belief in free will a cultural universal? *Mind & Language*, *25*(3), 346–358. https://doi.org/10.1111/j.1468-0017.2010.01393.x

Sherman, D. K., & Cohen, G. L. (2006). The psychology of self-defense: Self-affirmation theory. *Advances in Experimental Social Psychology*, *38*, 183–242.

Stenger, V. J. (2007). *God: The failed hypothesis - How science shows that God does not exist*. Prometheus.

Stillman, T. F., & Baumeister, R. F. (2010). Guilty, free, and wise: Determinism and psychopathy diminish learning from negative emotions. *Journal of Experimental Social Psychology*, *46*(6), 951–960. https://doi.org/10.1016/j.jesp.2010.05.012

Taussig, M. T. (1980). *The devil and commodity fetishish in South America*. University of North Carolina Press.

Vohs, K. D., & Schooler, J. W. (2008). The value of believing in free will: Encouraging a belief in determinism increases cheating. *Psychological Science*, *19*(1), 49–54. https://doi.org/10.1111/j.1467-9280.2008.02045.x

Volkow, N. D., & Li, T.-K. (2005). Drugs and alcohol: Treating and preventing abuse, addiction and their medical consequences. *Pharmacology & Therapeutics*, *108*(1), 3–17. https://doi.org/10.1016/j.pharmthera.2005.06.021

Wegner, D. M. (2017). *The illusion of conscious will*. MIT Press.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 43-48

Zoonotic Pandemics and Judaism's Early-Modern Turn to Science

Rabbi Jonathan K. Crane
Emory University

ABSTRACT

For thousands of years Jewish law was based on revelation and precedent. God's will, as revealed in scripture, was determinative: it demarcated what was permitted, required and prohibited. A contemporary rabbi could offer only a slight emendation of precedents. The early modern period, however, witnessed a dramatic shift in Jewish norm-making. A new source of knowledge, empirical evidence, became both valid and persuasive. Indeed, it could even override both revelation and precedent. What's so fascinating about this watershed moment in Jewish norm deliberation is that it spawns from an ancient concern about zoonotic diseases arising from pigs.

Keywords: science and religion, pandemics, judaism

Editors' Comment

Rabbi Jonathan K. Crane, Ph.D., (2019-2021 Fellow) *serves as the Raymond F. Schinazi Scholar in Bioethics and Jewish Thought in the Center for Ethics at Emory University, is a Professor of Medicine in the Department of Medicine, and is the founding director of the Food Studies and Ethics initiative at Emory. In this manuscript he shares excerpts from the Talmud from as far back as the 2nd century where descriptions of how pig-borne zoonotic diseases informed religious behavior among early Jewish peoples. The importance of this revelation on science education is profound. It demonstrates that far from the western view of science as conflicting with religion, science (in its very early form) has been embraced by religious leaders and used to inform religious tradition. Making such historical complementarity evident in the classroom just might prepare students with strong religious ideology more receptive to considering science in a less threatening way.*

Introduction

For thousands of years Jews discerned what to do based on revelation and precedent. God's will, as revealed in scripture, was determinative: it demarcated what was permitted, required, and prohibited. To do anything else would flirt with heresy, exposing one to ridicule, isolation, excommunication, or worse. Jews also looked to prior rulings, promulgated by earlier rabbis, for instructions on what to do. A contemporary rabbi could offer a slight emendation of those precedents but was constrained, for the most part, from being an "activist" legist forging wholesale novel practices.

The early modern period (starting in the 16th-17th Centuries), however, witnessed a dramatic shift in Jewish norm-making.[1] Instead of relying on revelation and precedent, a new source of knowledge became both valid and persuasive. Indeed, it could even override the other sources.

[1] This history is much more complicated, of course. Mysticism, rationalism, and many other schools of thought, including from other religious traditions, influenced Jewish thinkers in varying ways and degrees.

What's so fascinating about this watershed moment in Jewish norm deliberation is that it spawns from an ancient concern about zoonotic diseases arising from pigs.

Classic Concerns

Concern about pig-borne zoonotic diseases first emerged in the Babylonian Talmud, where a small vignette speaks of Rabbi Judah HaNasi, the greatest sage in 2nd Century Palestine, who was famous for acknowledging that animals indeed suffer.[2] This vignette tells of his colleagues coming to inform him of an impending public health issue:

> They said to Rabbi Judah: There is pestilence among the pigs. Rabbi Judah decreed a fast. Let us say Rabbi Judah maintains a plague affecting one species affects all species. No; pigs are different, as their organs are similar to [those of] humans'.[3]

Rabbi Judah takes the news of a pandemic arising among pigs so seriously that he immediately declares a fast.[4] His colleagues try to discern the rationale behind this move. Was it because all diseases move across species? No. It is because pigs are biologically similar enough to humans that how they fare, so do humans.[5] What's more, Rabbi Judah appears to think that diseases can cross over from pigs to humans!

This idea that diseases can cross over from one species to humans came into vogue only in the latter part of the 19th Century. Despite a few prior naturalists who played with this idea, it was Robert Koch and Louis Pasteur's germ theory that made intelligible the notion that diseases can move, invisibly, between species. How incredible, then, that nearly 1700 years before them Rabbi Judah makes such a recommendation. And not just him. Subsequent generations of rabbis studied the Talmud, including this vignette, and offered their own comments, questions, explanations, and expansions.[6] Though many added details and nuance, they all agreed that the best course of action in the face of a zoonotic pandemic arising from pigs is fasting. Dissention to this plan ultimately appeared in the early modern period. Why and on what grounds were those disagreements based?

Medieval Advice

Before we can understand the shift away from fasting, we should pause in the medieval period (approximately 9th-14th Centuries) to appreciate what comes next. The 12th Century physician, philosopher, theologian, and legist, Moses Maimonides was so famous and trusted that Salah al-Din, the first sultan of the Ayyubid dynasty ruling Egypt, Syria, Mesopotamia, Yemen, and other parts of the Maghreb, hired him to be his personal physician. During the last two decades of his life, Maimonides wrote many treatises on medicine, drawing from classic Greek and contemporary Arabic medical and philosophical tracts. For him, knowledge is best based on rational criticism formed from direct observation. Maimonides put this method to use in two essays known as "Regimen of Health," that advise Salah al-Din regarding the best ways to stay healthy and, if needed, recuperate from illness and injury (Maimonides, 1964).

Though he does not address pandemics in these essays, much less zoonotic diseases, Maimonides nonetheless stresses that "diseases demand study" (29) and that those who wish to

---

2 Babylonian Talmud (BT), *Bava Metzia* 85a.

3 BT *Ta'anit* 21b. This story occurs in a larger discussion about pestilential pandemics spreading among humans.

4 Fasting in the face of a pandemic was a common strategy from the 2nd Century onward. See Crane (2020).

5 Rabbi Shlomo ben Yitzhaki (Rashi) in 11th Century France explains that pigs, like humans, have but one stomach whereas other farmed animals have more (Rashi, BT *Ta'anit* 21b, s.b., *ma'ayehu*).

6 For a survey of this lengthy conversation, see Crane (Forthcoming 2022).

practice the healing arts should take this study seriously. When they do, physicians have the potential to offer extraordinary succor to those who ail and, if heeded adequately and early enough, can prevent ill-health from arising in the first place. On his view, physicians and not theologians know from observation and direct experience what can heal. Hence, Maimonides advises Salah al-Din:

> For these reasons kings gather numerous physicians and select from among them those endowed with wisdom, and those of long experience, for perhaps by coming together of such minds they will be saved from error (21).

Maimonides repeatedly refers to the knowledge that physicians possess with such phrases as "all physicians have cautioned against," "it is known to all physicians," "physicians prescribe," "the consensus of the physicians," and the like. Such invocations of what physicians *know* and *do* demonstrate that knowledge and practices *beyond the realm of religion* are valid, pertinent, and actionable.

He also suggests that it is possible to develop such knowledge. In regard to raising hens and roosters, Maimonides promotes keeping them outside, feeding them only periodically, and ensuring that their foods are diverse. "These things have already been tested, and their value is manifest" (37). That something has been *tested* is profound. It means that the practice so prescribed emerged not from revelation or legal precedent but from trial and error. On the role of hydromel, a primitive mead, he says, "This is a most excellent drink, beneficial in strengthening the stomach and the heart, improving the digestion, dilating the spirit, and easing the egress of the two superfluities [urine and feces] with good effect. We have tested it, as have others, time and again" (38). Testing, at least in the realm of personal and animal health, is thus a legitimate means to develop valid, pertinent, and actionable information.

Early Modern Evidence

Insofar as knowledge beyond the realm of religion is valid, and trial and error a legitimate means to develop knowledge, these come together in the early modern period in the case of zoonotic pandemics arising from pigs. For example, the leader of 16th Century Eastern European Jewry, Rabbi Mordecai ben Avraham Yoffe, writes in his ten-volume codification of Jewish law this expansion of the original Talmudic vignette:

> When there is pestilence among pigs we fast, because their organs are similar to humans'. For when this pestilence is investigated to be so among them, there is danger/fear that it will also spread to the stomach of people. All the more so this is the case if there is pestilence among gentiles and not Jews: we are to fast, so that it will not spread to their stomach. Heaven forfend![7]

Yoffe's insistence that *investigating* (מתדבק) the nature and extent of the pestilence among pigs indicates a new era in how norms may be generated among Jews, at least in regard to public health. Whereas Rabbi Judah relied upon hearsay, and subsequent sages relied upon his precedent, Yoffe now requires not just surveillance or corroboration but confirmation. Though earlier sages spoke of anxiety or fear

[7] Levush Malchut, *Oraḥ Ḥayim* 576.3. He concludes with a reference to Joseph Karo's *Shulḥan Aruḥ* (1563), the definitive medieval compilation of Jewish law. That source refers to mourning practices, to who is obliged to mourn for whom, when and how. It concludes with a gloss by Moses Isserles (16th C): "Some say that during the time of a pandemic one does not observe mourning rites out of fear, and I have heard that some have adopted this practice" (Mapa on Shulḥan Aruḥ (SA), *Yoreh De'ah* 374.11).

that a disease would spread from pigs or other humans, he now provides justification for that worry: evidence.

This turn to evidence is huge, not just for Jews and their norms but for European society generally. The scientific revolution had begun spinning rapidly from the middle of the 16th Century. It challenged long-held assumptions about earth's location in the cosmos and humanity's stature therein. It championed inductive reasoning by relying on observations of nature to generate knowledge. This meant that deductive reasoning based on confirming prior assumptions no longer sufficed. Empiricism, experience, and experimentation were both valid forms of knowledge and legitimate means to produce it. In short, evidence became the hallmark signature of the Enlightenment.

Evidence matters, especially when confronting a pandemic. Rabbi Abraham Gabimer in 17th Century Poland, writes,

> Now we do not do a general fast during the time of a pandemic since it has been tested that when one does not eat or drink, [the body] absorbs [more/easier] (Heaven forfend!) the changed air."[8]

For Gabimer, and several subsequent sages who copied this ruling, testing (מנוסה) is a legitimate means to ascertain the protective qualities of fasting.[9] It has been found through testing that fasting is not ideal; it renders the body even more vulnerable to the ravages of the invisible diseases. This evidence suffices to justify altering the response to a pandemic: one should not fast. How did they know this? By Gabimer's time, the bubonic plague had been decimating Europe and Western Asia for centuries, especially in the last few decades of the 17th Century. There had been plenty of time to observe which measures protected people and to what degree, and which rendered them more susceptible. Fasting, they observed – which also means tested – failed in this regard.

By the late 19th Century, Lithuanian Rabbi Yechiel Michael Epstein integrates this turn to science with the longstanding concern about zoonotic pandemic diseases.

> If it is found that there is no pestilence among Jews but there is among other humans – we are to fast. There is one [prior scholar] who says that Satan cannot rule over two nations, but no decisor cites this. If there is pestilence among beasts, we only fast if it is among pigs, because their organs are similar to humans'. But they wrote that now we do not decree a fast on account of pestilence, for it is an examined and tested [fact] that [pestilential] air is absorbed [by the body] in the absence of feeding and watering.[10]

Epstein apparently disregards the earlier position that fasting fails to protect Jews from pandemics spreading among humans. And he rejects the ruling by an earlier (14th C) scholar that references Satan. He does accept, though, the earlier reasoning that fasting is appropriate only when pigs are the source of the pandemic, not when just any farmed animal is. It is in his conclusion that he turns aside from these conflicting precedents to render his own ruling. On his account, we do not call for a fast today because it is an *examined and tested* (בדוק ומנוסה) fact that fasting makes the body more vulnerable, not less, to a pandemic.[11] This phrase is significant.

---

[8] *Magen Avraham* 576.2.

[9] See Be'er Hetev (17th C), *Oraḥ Ḥayim* 576.2; Ma'aseh Rokeach (17th-18th C), *Ta'anit* 2.6.1; Mishnah Berurah (19th-20th C) 576.2.

[10] Aruch HaShulḥan, *Oraḥ Ḥayim* 576.9.

[11] 19th Century British and American governments apparently did not give much weight to such evidence. They still promoted fasting as appropriate national responses to pandemics. See Tuan (1979) and Federer (n.d.).

The earliest this dual-verb expression "investigating and testing" appears is in the first part of the 17th Century when the Polish Rabbi Yaakov Moshe ben Avraham Ashkenazi Helin used this phrase in a discussion about determining which oil and wine are superior and may be used for ritual and consumptive purposes.[12] A few decades later, Rabbi David Halevi Segal deploys this phrase to ascertain the integrity of a vessel's seal.[13] That this phrase does not exist prior to the early 17th Century suggests the advent of a new epistemological method as the Enlightenment sped up. Investigating and testing would, by Epstein's time a few centuries later, become legitimate methods to develop valid, pertinent and actionable knowledge, even in and for Jewish communities.

Embracing Scientific Knowledge

As already evident with Maimonides in the medieval period, Jews accepted knowledge beyond the realm of Judaism. By the early modern period, it should be no surprise, then, that Jews both embraced that exogenous knowledge as well as the emerging means to discover and develop it.[14] Indeed, by the 16th Century, rabbinic sages even encouraged their minions to study the natural world. They could do so by taking advantage of the new scientific instruments being invented, the explosion of printing technologies, and opportunities to study in universities. Though these early medically-trained Jewish physicians rarely made significant contributions to cutting-edge biomedical knowledge, they nonetheless imbibed the ethos of the age: evidence matters most![15]

To be precise, scientific method and evidence matter when it comes to physical issues like medicine and public health. In regard to Jewish metaphysical, philosophical or religious concerns, however, science and evidence had little to say, much less influence.[16] This all-too-brief survey of Judaic responses to zoonotic diseases arising from pigs demonstrates the possibility, perhaps even the necessity, of religious norm-making taking scientific evidence seriously. It shows that knowledge beyond the realm of religion need not be threatening to religionists but in fact embraced. What's more, such knowledge may justify overturning prior norms and save innumerable lives.

It remains to be seen whether non-religious knowledge is valid and persuasive in domains not religious at their core (for example, aesthetics, psychology, history, economics). For now, though, it suffices to acknowledge that at least in regard to something as complex as a zoonotic pandemic, scientifically-tested and developed knowledge is religiously welcome and decisive.

Conversely, this brief essay also suggests that science would do well not to ignore religious resources, especially when it regards issues of public health. Many religions, like Judaism, have been around for thousands of years and their textual traditions are repositories rich with observations of practices that work and do not work to protect people from diseases. Indeed, science education may find that so-called cutting-edge ideas, like zoonotic pandemic diseases, are in fact quite old and have long been deliberated, though, admittedly, not in contemporary scientific terms. For perhaps, should science take religion more seriously, the public's health will be better off.

The author received no financial support for the research, authorship, and/or publication of this manuscript.

---

12 Yedei Moshe on *Shir HaShirim Rabbah*, 1.3.2.

13 Turei Zahav on SA, *Yoreh De'ah* 202.6.

14 For more on this, see Ruderman (1995).

15 See Brown (2013) for a similar Jewish turn to scientific evidence in the field of astronomy at about the same time.

16 For more on this, see Samuelson (2009), who argues that though Jews were great physicians, Judaism as such made little contribution to the study of medicine, and conversely, Jewish thought has not adequately wrestled with the philosophical implications raised by the healing arts – specifically on the questions of suffering, race, and the specifics of what constitutes life and what death (see chapter 4, especially).

Jonathan K. Crane, Ph.D., Rabbi, (jkcrane@emory.edu) serves as the Raymond F. Schinazi Scholar in Bioethics and Jewish Thought at Emory's Center for Ethics. A Professor of Medicine and Director of the Food Studies and Ethics Initiative, Crane is a past president of the Society of Jewish Ethics, founder and co-editor of the Journal of Jewish Ethics, and author or editor of several books, including Narratives and Jewish Bioethics (2013), The Oxford Handbook of Jewish Ethics and Morality (2013), Beastly Morality: Animals as Ethical Agents (2015), Eating Ethically: Religion and Science for a Better Diet (2018), and Judaism, Race, and Ethics: Conversations and Questions (2020).

References

Brown, J. (2013). *New Heavens and a New Earth: The Jewish Reception of Copernican Thought.* New York: Oxford University Press.

Crane, J. K. (2020). Jewish Ethics in COVID-19. *Journal of Jewish Ethics, 6*(1):1-29.

Crane, J. K. (Forthcoming 2022). Cross-Over and Constructions of Difference Through Pigs and Pandemics in Jewish Sources. *Review of Rabbinic Judaism, 25(*2). Accepted for publication on January 22, 2021.

Federer, W. (n.d.). https://myemail.constantcontact.com/Cholera-Epidemic-President--recommended-a-Day-of-Fasting--Humiliation---Prayer---Zachary-Taylor.html?soid=1108762609255&aid=gbBTPNChobQ

Maimonides, M. (1964). Regimen of Health / *Fī Tadbīr Al-Ṣiḥḥah* and *Maqālah fī Bayān Baʿḍ al-Aʿraḍ wa-al-Jawāb ʿanhā.* Trans. Ariel Bar-Sela, Hebbel E. Hoff, and Elias Faris. *Transactions of the American Philosophical Society, 54*(4), 3-49.

Ruderman, D. (1995). *Jewish Thought and Scientific Discovery in Early Modern Europe.* New Haven: Yale University Press.

Samuelson, N. (2009). *Jewish Faith and Modern Science: On the Death and Rebirth of Jewish Philosophy.* Lanham, MD: Rowman and Littlefield Publishers, Inc.

Tuan, Y. (1979). *Landscapes of Fear.* Minneapolis: University of Minnesota Press.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 49-53

Reducing Scientific Skepticism

John ZuHone
Center for Astrophysics | Harvard & Smithsonian

ABSTRACT

Many people with strong religious beliefs in the United States struggle with trusting the pronouncements of scientists. This is primarily because they have come to believe that science offers a perspective on ultimate questions such as origins and life after death that conflicts with their own. Education and public outreach efforts by scientists can go a long way towards persuading religious believers that they can trust the results of the scientific process, especially if that outreach is led by scientists who share their beliefs. In this article, I discuss how astronomy and space science can be an ideal entry point for religious believers to understand how science works, why it can be trusted to yield true information about the world, and to engage in critical thinking about how to understand their faith in light of scientific discoveries, and vice-versa.

Keywords: Science and religion, scientific skepticism, astronomy, space science, NOS

Editors' Comment

John ZuHone, Ph.D., (2013-2015 Fellow) *is a staff scientist at the Center for Astrophysics at Harvard & Smithsonian in Cambridge, Massachusetts. His research interests are clusters of galaxies, cosmology, X-ray astronomy, and computational astrophysics. He writes and gives talks on the interface between science and religion. In Reducing Scientific Skepticism, ZuHone draws upon his deep knowledge of astrophysics as well as his own religious commitment to describe how education, public outreach, and popularization efforts in astronomy and space science can be an ideal opportunity for scientists and religious believers to engage with each other, and ideally result in greater public confidence in science. His recommendations could inform our own science teaching with profound implications, especially among our students who hold strong religious commitments.*

Introduction

The COVID-19 pandemic has highlighted, in a vivid way, the importance of maintaining public trust in science and scientists. In the face of a deadly respiratory virus, the medical and scientific communities mobilized to provide public guidance on the most effective ways to stop the spread. The public has been famously polarized on believing in the effectiveness of mitigations such as mask wearing and lockdowns. More alarmingly, vaccine hesitancy is widespread, and one factor that appears to influence the decision to be vaccinated is religious affiliation. At the time of writing, a recent study by the Pew Research Center (2021) has shown that white evangelical Protestants evidence more vaccine hesitancy than any other religious group in the United States.

There is no doubt that many factors play important roles in determining if one is more likely than not to trust the views of the scientific community. However, religion has long been an important factor. At the risk of oversimplification, the world's religions, varied as they are, share the common characteristic that they serve for many as the most authoritative source of knowledge and wisdom

about matters of *ultimate concern*, such as origins, the meaning and purpose of one's life, morality, and the possibility of life after death. Since the Enlightenment, science has increasingly been seen as an authoritative voice on many of these questions, and often as one that is seen to be in direct conflict with religious voices.

If one strongly believes that their religious perspective provides comforting answers to the questions of origins, the meaning of life, and the ultimate fate of oneself and the universe as a whole, and a scientist comes along and provides what is seen (and often presented) as an alternative story entirely contradictory to one's own, the result is often a hardening of one's established religious view and a rejection of the authority of the scientist. Often, the rejection can broaden beyond the elements of the scientific account that appeared to contradict the religious view and expand to more peripheral but important issues. As an example, if one becomes convinced that believing in science requires abandoning Christian faith because the former contradicts the creation story in Genesis, then it is often the case that skepticism about other, seemingly unrelated issues such as climate change and vaccines will follow.

This is a state of affairs with profound implications for the future. In a democratic society such as ours, buy-in from the general public to marshal resources to combat issues such as climate change and future pandemics is essential. Religious believers need to be just as convinced of the ability of the scientific enterprise to produce truthful and actionable information as anyone else.

I am a professional astrophysicist and a practicing evangelical Anglican Christian. Therefore, I have vested interests in seeing both the scientific enterprise succeed in terms of convincing more people of its ability to discern truths about our world, and in religious communities (in particular the church) become more scientifically minded and thus make their worldviews more robust. In my (admittedly biased) view, astronomy and space science are ideal entry points for educating religious believers about how science works and that it can be trusted. These fields directly engage with the same kinds of *ultimate questions* that the world's religions are concerned with, and at the same time have historically captivated the public's imagination across partisan and religious identification. One only needs to note the popularity of NASA in the United States to see this. In the remainder of this article, I will argue that public outreach and popularization of astronomy can provide unique opportunities for scientists and religious believers to have constructive engagements about science and religion, which can result in religious believers becoming less skeptical about science.

Made from Stardust

As a staff scientist, I have participated in education and public outreach (EPO) events related to our science intended for the general public. One of the astrophysical phenomena that we present at these events is that of supernova explosions, which are the deaths of massive stars. During the life of a star, it maintains pressure against gravitational collapse by generating energy from thermonuclear fusion, which takes lighter elements and produces heavier ones from them. For the most massive stars, at some point the star is no longer able to continue the process of fusion, and catastrophic gravitational collapse ensues, followed by a powerful explosion that can be seen from millions of light-years away. During the explosion itself, other heavier elements are also formed by nuclear reactions. A significant portion of the periodic table appears to have been built up by previous generations of stars generating various elements and exploding them out into space at the end of their lives, which then get incorporated into clouds of gas and dust, eventually serving as the building blocks for stars and planets.

The story just outlined is very fascinating and exciting, and at these events we scientists press its relevance to the general public by highlighting the fact that this means that many of the elements which make up our own bodies were once inside a massive star, experiencing unfathomable temperatures of millions and billions of degrees.

Being "made of starstuff", as astronomer Carl Sagan put it in his book and TV series *Cosmos* (Sagan 1980, p. 190), is an arresting and humbling thought. But for many, it can be seen as potentially threatening. If I believe that God made me from the "dust of the ground," as the book of Genesis states (The Holy Bible: New International Version [NIV], 1978/1984, Genesis 2.7), then this story certainly seems to contradict that at face value. More to the point, the origin story as presented in Genesis provides me with meaning and purpose, since it communicates the involvement of a wise and loving Creator in my beginnings. On the other hand, if I am made of stardust originally formed in a supernova explosion, it can seem as if I am instead an unintended byproduct of the complex interplay between the fundamental forces of nature on a cosmic scale.

This sense is often affirmed and enhanced by scientists themselves who write for the public at a popular level. Sagan also stated in *Cosmos* that "The cosmos is all that is or ever was or ever will be" (Sagan 1980, p. 1). What is often the result of being confronted with statements like this by the religiously devout? Many decide that science is not a worthwhile pursuit or interest for them or their children, and abide a deep skepticism about the pronouncements of scientists.

Must this be so? The scientific evidence that we are made from material that was once inside the interior of a star is overwhelming and should not be in serious doubt. But what implications does this hold for religious faith? It would be too simple to say that there are no implications, as strong versions of the *non-overlapping magisteria* framework ("Non-overlapping magisteria", 2021) of the relationship between science and religion would suggest. But it would be saying more than the science can to suggest that the fact of my stellar composition rules out of court the belief that I am an intentional creation by God.

Similar considerations apply in the realm of cosmology. All of the available evidence points strongly to an origin of the known universe in an event nearly 14 billion years ago known as the Big Bang. At this point, the universe had zero (or at least *nearly* zero) volume, and has been expanding outward from that moment ever since. According to Big Bang cosmology, not only is the universe very old, but it is also very large.

To the religious believer, being confronted with this information may be troubling. As is well known, many conservative Christians believe that the Bible unequivocally states that the universe and Earth cannot be more than 10,000 years old at most, far short of what both Big Bang cosmology and the astronomical evidence indicate. Also, the sheer vastness of the universe, with its hundreds of billions of galaxies each containing hundreds of billions of stars, seemingly renders our significance rather small. Along these lines, Physicist Steven Weinberg, in his book *The First Three Minutes* describing Big Bang cosmology, opined in the last chapter that "the more the universe seems comprehensible, the more it seems pointless" (Weinberg 1993, p. 154).

Faced with statements like these from prominent scientists, it is no wonder that many religious believers adopt an adversarial attitude towards science and scientists—instead of marveling at the wonders of the cosmos, they feel as if their worldview is on the defensive.

The Importance of Personal Encounters

In my own experience, personal encounters can make all of the difference. At one of these EPO events mentioned above, after I excitedly described the process of stellar death and the formation of heavy elements, as well as their incorporation into our origins, the person I was speaking to noted that these ideas had profound religious implications. She then described herself as a Christian believer and spoke of the tension she was feeling. I immediately noted to her that I was taking off my *scientist* hat for the moment and putting on my personal, *religious* one. We then had a delightful conversation about how impressive the Creator must be to craft such an amazing process to forge the elements needed for our existence. She walked away that day with both her faith and her appreciation for science strengthened.

Similarly, when discussing Big Bang cosmology with believers who may be inclined to see it as conflicting with their beliefs, I emphasize the consonance of the idea of the universe having a beginning with the biblical concept of creation, while being careful not to suggest that Big Bang cosmology *proves* the Genesis 1 creation account or any other religious text (a category mistake which has often been made). With regard to the vastness and age of the universe, I emphasize how these reflect the power, might, and glory of the Creator—to my mind far more than the puny geocentric cosmos of ancient times ever could.

One obvious question arises, however. It is quite easy for myself, as a person of faith, to speak to other believers who are wrestling with science and faith questions. But what about those believers who encounter non-religious or even areligious scientists? These scientists cannot speak to religious concerns in the same way as a believer, and nor should they try, for the sake of honesty. But scientists in general can adopt a posture of openness towards the possibility of rapprochement between science and religion, while leaving it up to the audience to sort out those details with their clergyperson or others in their religious community. They can emphasize the commonality between science and religion in that they both are human responses to the wonder of the universe. They should adopt a humble posture towards ultimate questions, recognizing that most of the questions that religious believers are really worried about (e.g., the existence of God, the afterlife, one's own purpose and destiny) are not the proper subjects of science. Finally, the scientific community can and should highlight the existence of people of many faiths and no faith among their ranks, emphasizing that science is a fundamentally human endeavor that all can take part in. If scientists want first and foremost for everyone to be as captivated by scientific discovery as they are, find the results convincing, and support further study, we should go out of our way to not leave religious believers with the impression that the story we are telling is fundamentally incompatible with theirs.

It is important to note what is *not* being said here. Scientific theories supported by strong evidence can and do directly contradict particular religious beliefs. For example, young-earth creationism is flatly contradicted by many lines of evidence from astronomy and geology. When speaking to the public, scientists should not downplay these facts for fear of offending believers. However, it is entirely possible to communicate these evidences without adopting an antagonistic or hostile response to people of faith or their overall worldviews.

Why Astronomy?

The positions I have outlined here would be relevant for public engagement with any scientific field. Why do I believe that astronomy and space science are uniquely positioned to make inroads with religious believers who may be skeptical about science and scientists? Three reasons come to mind. The first, as I mentioned above, is that astronomy is a popular subject. Nearly everyone, regardless of religious persuasion, is fascinated by the night sky, tunes in when a man lands on the moon or a robot lands on Mars, and enjoys speculating about the possibility of alien life. Secondly, as I have laid out, astronomy engages with big and important questions about our origins, providing opportunities for science and religion to come into contact. This can and often does provoke conflict, but it can also be an occasion for fruitful and creative thinking. Thirdly, though it does deal with the subject of origins, astronomy does so in a way that is less immediately personal than other fields, and thus less likely to elicit a defensive response from the beginning. For example, the study of human origins is a far more sensitive subject from the perspective of religious belief. I submit that for these reasons using astronomy as a springboard to discuss matters of science and religious faith can provide an opportunity to show how powerful the scientific method is, which then can be translated to other fields of study.

Conclusions

I thus submit that education, public outreach, and popularization efforts in astronomy and space science can provide opportunities for scientists and religious believers to engage with each other, and ideally result in greater public confidence in science. I have personally seen up close how religious communities, when faced with difficult scientific questions with an open mind, have used the overlap of science and religion to constructively engage and resolve tensions between scientific discoveries and interpretations of the world offered by their faith perspectives. The result is that leaders of these communities, seen as important authorities within them, have been able to project a message of confidence in science, incorporation into their worldview, and a lessening of the perceived threat of science to their belief system.

It is sometimes argued that the solution to the problems discussed in this essay is to simply try harder to convince the public that science deserves to be a unique arbiter in the pursuit of truth, to the diminishment or even elimination of other perspectives, including religious ones. I suspect that this strategy will likely backfire most of the time. Leaving aside the question of the veracity of religious truth claims, it is highly unlikely that religion will not continue to be a significant force in the lives of millions for the foreseeable future. Rather, I suggest that the best outcome for continued support for the scientific community by the public would be that all people, regardless of their religious outlook, were convinced of the ability of science to provide true information about the nature of the universe.

The author received no financial support for the research, authorship, and/or publication of this manuscript.

Author's Comment

The views expressed in this article are my own and do not represent those of the Smithsonian Institution or the Center for Astrophysics.

John ZuHone, Ph.D., (jzuhone@gmail.com) received his B.Sc. in Physics at the University of Illinois at urbana-Champaign, and his M.Sc. and Ph.D. in Astronomy and Astrophysics at the University of Chicago. Following postdoctoral appointments at the Center for Astrophysics | Harvard & Smithsonian, NASA/Goddard Space Flight Center, and the Massachusetts Institute of Technology, John is now a staff astrophysicist at the Center for Astrophysics | Harvard & Smithsonian in Cambridge, Massachusetts. He works on the operations team for the *Chandra* X-ray Observatory and his main research interest is clusters of galaxies.

References

Pew Research Center (2021, March 22). *Intent to get vaccinated against COVID-19 varies by religious affiliation in the U.S.* https://www.pewresearch.org/fact-tank/2021/03/23/10-facts-about-americans-and-coronavirus-vaccines/ft_21-03-18_vaccinefacts/

Sagan, C. E. (1980). *Cosmos.* Ballantine Books.

The Holy Bible: New International Version. (1984). International Bible Society. (Original work published 1973)

Non-overlapping magisteria. (2021, May 11). In *Wikipedia.* https://en.wikipedia.org/w/index.php?title=Non-overlapping_magisteria&oldid=1022591388

Weinberg, S. (1993). *The First Three Minutes: A Modern View of the Origin of the Universe.* (2nd ed.). Basic Books.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 54-61

Sustainability for Secular and Spiritual Groups: A Framework from University and Community Education

Ashlynn Stillwell
University of Illinois Urbana-Champaign

ABSTRACT

Education around the concept of sustainability, encompassing the environment, economy, and society, presents challenges of context among diverse groups. I present a framework for sustainability education based on experience with educating secular groups in a university context and educating spiritual groups in a community context. This sustainability education framework highlights three drivers for student learning: passion, experience, and uncertainty. Examples from education of secular and spiritual groups illustrate the importance of projects, challenges, and dialogue. Sustainability education can reveal common ground between science and religion.

Keywords: sustainability, university education, community education, science and religion

Editors' Comment

Ashlynn S. Stillwell, Ph.D., (2017-2019 Fellow) *is an Associate Professor and the Elaine F. and William J. Hall Excellence Faculty Scholar in Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign. In this article, she shares a framework for sustainable education that is suited for both secular and spiritual groups. Considering the existential threat of climate change, along with the growing scientific skepticism among religious groups, there has never been a greater need for effective education for sustainability. Her focus on passion, experience, and uncertainty provides a different perspective on how science educators can connect with students.*

Introduction

The concept of sustainability has become an important part of STEM education; however, defining sustainability remains as a challenge that depends on the context within which a system resides. We often understand when one approach or solution is more or less sustainable than another, yet we cannot quantify sustainability objectively on its own. Consequently, teaching sustainability requires more than a mathematical formulation or a balanced chemical reaction. Sustainability education includes both the traditional classroom and the broader community, encompassing both secular and spiritual aspects of learning (Ashford, 2004; Bielefeldt, 2013; Chuvieco, 2012; Crossman, 2011; Podger et al., 2010). Here, I present a framework for sustainability education based on my experience teaching both secular and spiritual groups. Building on this experience, I draw connections between university-level engineering education and faith community education on sustainability topics, situated in the broader dialogue between science and religion.

Background: Conceptualizing Sustainability

Sustainability is often represented as a transition or a process, with many literature references describing an uncertain journey towards a future goal (Clark & Dickson, 2003; Kates et al., 2001; NRC, 2013; Parris & Kates, 2003). Beyond this transition, definitions of sustainability typically focus on interlocking crises based on the three pillars (or "broad areas of concern" as originally labeled in the Brundtland et al. (1987) report) of environment, economy, and society. Many sustainability definitions also include language to promote positive change rather than simply minimizing negative impacts (Dovers, 1996; Kemp & Martens, 2007; Kemp et al., 2005; Marshall & Toffel, 2005; Pope et al., 2004; Sexton & Linder, 2014; Spangenberg, 2011; Swart et al., 2004).

Of the three pillars of sustainability (environment, economy, society), the social elements of sustainability often receive the least attention. Vallance et al. (2011) presented a typology for social sustainability including *development sustainability* (addressing basic human needs), *bridge sustainability* (promoting changes in human behavior), and *maintenance sustainability* (preserving socio-cultural characteristics). In focusing on human behavior, bridge sustainability in particular can enable a transition to advance sustainability goals through an environmental ethics lens. Vallance et al. (2011) label these behavior changes as *non-transformative* approaches of simply learning about sustainability actions versus *transformative* approaches that actually change the relationship between humans and the environment. Enabling transformative behavior requires education, both formal and informal, and knowledge regarding sustainability and the likely outcomes from one's actions.

Both individual and collective actions are necessary to achieve sustainability goals, including local challenges, such as renewable energy or alternative water supply investments, and the global challenge of climate change. Effective climate mitigation and adaptation depends on both personal actions and policy approaches (Attari et al., 2019). In faith communities, the religion-environment connection is relevant for personal behavior, including ways of living and ethical or moral values (Chuvieco, 2012), and many religions include aspects of sustainability in faith beliefs and practices. Consequently, the whole-person approach to educating for sustainability, based on an example of Baha'i faith-inspired service learning, can have more benefits than traditional behavioral education approaches (Podger et al., 2010). Research on business practices has illustrated the synergies between spiritual and environmental leadership (Crossman, 2011), and these synergies can also be relevant in an educational setting in preparation for the workforce and/or as continuing education. Formal and informal sustainability education has a role to play in informing personal actions and forming the knowledge base for policy and governance approaches.

A Framework for Sustainability Education

Sustainability is an inherently interdisciplinary subject such that no one single pedagogical approach or education framework encompasses the whole of the concept. The following sustainability education framework is based on my experience in higher education teaching students in Civil and Environmental Engineering and my experience sharing sustainability and environmental concepts with faith communities through Faith in Place (www.faithinplace.org), a non-profit organization that connects people of faith around care for the environment and the Illinois affiliate of Interfaith Power and Light. Here, I refer to student learning in general, where 'student' includes individuals from both of these groups.

Sustainability in these two contexts, secular and spiritual groups, encompasses different characteristics of STEM education. Formal sustainability education in the context of a university classroom is often focused on knowledge acquisition, concept mastery, skills development, and workforce preparation. On the other hand, informal sustainability education in the context of spiritual groups tends to focus on translating knowledge to individual and collective action for the broader

societal good. However, these secular and spiritual contexts are not necessarily in conflict; both contexts offer perspective for effective sustainability education.

I formulate this sustainability education framework from my own perspective (Figure 1) around three drivers of student learning in the context of sustainability: passion, experience, and uncertainty.

Figure 1
A Proposed Framework for Sustainable Education

Sustainability Education		
Passion	**Experience**	**Uncertainty**
• Understanding problem context • Intrinsic motivation	• Critical analysis • Systems thinking • Formulating and testing solutions	• Quantifying tradeoffs and externalities • Decision making

Passion

While a large portion of sustainability builds on math and science fundamentals, passion and attitude are arguably a more important foundation for learning success. When a student has passion for sustainability-related topics, they often are intrinsically motivated to learn more about problems and possible solutions. Passion can also lead the student to conduct their own research to more fully understand the particular sustainability problem of interest and the broader context, moving toward *understanding* in Bloom's taxonomy.

Experience

Through direct experience with sustainability problems, students develop a core knowledge base around sustainability concepts. This problem-based learning can help students leverage passions to investigate sustainability problems deeper. Sustainability experience can come from critical analysis of a problem, using systems thinking approaches that quantify and evaluate interconnections and feedbacks between systems. With critical analysis and systems thinking tools, students can formulate and test solutions, simulating different states of the world and possible outcomes. This experiential, problem-based learning moves toward *analyzing* and *evaluating* in Bloom's taxonomy.

Uncertainty

The wicked problems in the context of sustainability typically have no 'right' answer, though there might be several 'wrong' answers. The non-deterministic nature of sustainability leads to significant uncertainty regarding systems, inputs, outputs, and results. Through deeper consideration of uncertainty, students learn to quantify tradeoffs and externalities associated with a simulated solution. Across the three pillars of sustainability, tradeoffs are inevitable such that the 'right' answer depends on context, and problem-specific conditions. Learning to make decisions under uncertainty is an aspect of sustainability education that can deepen learning mastery and support further analysis, moving toward the goal of *creating* new or original work in Bloom's taxonomy.

Sustainability Education in a Secular University Context

My experience in formal sustainability education is in the context of Civil and Environmental Engineering at a secular university. In one of my classes, Energy and Global Environment, undergraduate students learn the fundamentals of energy and environmental systems by evaluating multiple impacts of engineering decisions.

Many Civil and Environmental Engineering students already have a passion for sustainability and sustainable development. Engineering education regarding sustainable development often focuses on teaching students the skills necessary to successfully initiate change processes (Fenner et al., 2005), particularly systems change (Ashford, 2004) and bridging across fields. However, this bridge across fields can be perceived as trading off depth for breadth in the knowledge base. While aiming for both depth and breadth in engineering education, Ashford (2004, p. 239) comments on fragmentation in the engineering knowledge base, "leading to myopic understanding of fundamental problems." Essentially, engineering students with passion for sustainability might find that branching out into diverse and broad topics leads to less depth of technical knowledge in core areas, which then undermines the breadth of education also.

This depth-for-breadth tradeoff can be mitigated through experiential education (Bielefeldt, 2013), using immersive, authentic experiences in the educational approach to support students in critical analyses and actionable science. In my class, students learn to evaluate impacts of engineering systems through two projects: the first rigid in structure but flexible in location, and the second open-ended in subject matter. For example, the structured project focuses on selecting the most appropriate walling material for constructing housing in low-income countries. This 'most appropriate' walling material decision is based on total cost (including labor and materials), transportation energy, materials embodied energy, water consumption, air emissions, and health risks, all quantified for a student-selected low-income country location, where data are often scarce. Though every group in the class is examining the same basic question (i.e., What is the best walling material?), recommended solutions often vary widely due to the country-specific context and relevant environmental, economic, and social factors.

Leveraging the knowledge and skills gained from the first structured project, students then complete a second open-ended project comparing two infrastructure systems, with 'infrastructure' broadly defined. In this student-led, open-ended project, groups often form around topics of interest and passion on diverse subjects. Previous projects have evaluated commuter rail vs. ferries, conventional vs. green roofs, nuclear vs. renewable energy, omnivorous vs. vegan diets, and many other systems. While students often go into their projects with initial thoughts regarding the 'best' system, tradeoffs and externalities almost always emerge such that the 'best' system is not immediately obvious and requires consideration of context, uncertainties, and priorities. Those uncertainties extend beyond purely mathematical uncertainty quantification to include uncertainty in prioritizing environmental needs over societal needs, for example. Students often come to the same conclusion as Peter (1982) in his popular quote, "Some problems are so complex that you have to be highly intelligent and well informed just to be undecided about them."

Sustainability Education in a Faith Community Context

My experience in informal sustainability education has been in the context of Faith in Place through outreach and engagement with Green Teams at houses of worship. These Green Teams, composed of adults of many diverse faiths, come together at the Annual Green Team Summit, with opportunities for education and exchange of ideas and experiences.

Faith communities often have unique perspectives regarding sustainability. In Judeo-Christian contexts, for example, the competing themes of dominion over versus stewardship of the Earth

emerge as attitudes toward the environment (Konisky, 2018). Despite Pope Francis's encyclical *Laudato Si': On Care for our Common Home*, there is little evidence of a "greening" of Christianity with increased concern for the environment. In analyzing longitudinal data, Konisky (2018) showed that some evidence suggests Christians have less concern for the environment over time. However, in a study of social identity and in-group norms of Christians, framing around stewardship led to significant increases in pro-environmental and climate change beliefs (Goldberg et al., 2019). Consequently, linking faith and beliefs with concern for the environment in spiritual groups can ignite passion for sustainability.

Process cues from clergy and academic experts can affect trust and attitudinal ambivalence (Djupe & Calfano, 2009), such that faith communities and their leaders can play a significant role in beliefs and actions around sustainability. Linking spiritual beliefs with sustainability can support personal action and experience around care for the environment. For example, one of Faith in Place's core programs is Sustainable Food & Land Use, emphasizing the combined challenges of shrinking native landscapes and growing hunger and inaccessibility of healthy food options. Through the Just Eating curriculum revision, Faith in Place staff and volunteers created material to emphasize the cultural importance of food, highlight the challenges of hunger and healthy food inaccessibility, and foster dialogue around possible solutions. This material was presented at the 2019 Faith in Place Green Team Summit. Each lesson of the 'Revisiting Just Eating' curriculum includes an experiential element, such as keeping a food diary or preparing a meal using only ingredients from a convenience store, with a follow-up reflection. These learning-by-doing approaches help illuminate the context around food systems sustainability challenges.

In response to different values, experiences, and contexts related to food and faith, many participants in the 'Revisiting Just Eating' discussion expressed uncertainty regarding solutions. This uncertainty included acknowledging tradeoffs between affordability and nutrition, inequality around access to fresh produce, the role of food in religious observances (e.g., Jewish Passover Seder), and different resource contexts for constructing community- or congregationally-supported agriculture farms. Despite uncertainties regarding solutions, people of faith did come together in the context of sustainable food and land use, linking environmental and systems science and religion around care of the Earth and the humans inhabiting it.

Discussion: Sustainability in the Broader Science-Religion Dialogue

In the context of sustainability, we have entered the Anthropocene era, where humans and the Earth are "intertwined, so that the fate of one determines the fate of the other" (Zalasiewicz et al., 2010, p. 2231). A similar concept arises in Buddhism, that of *interdependent co-arising*, where "things which may seem to exist independently of other things are in fact dependent for their existence and their character on other things" (Wright, 2017, p. 202). This intimate linkage between humans and the environment is relevant in the context of both sustainability science and religion. Advances in science and engineering can enable advances in Earth ethics (Schmidt & Peppard, 2014); for example, quantifying groundwater depletion via the Gravity Recovery and Climate Experiment (GRACE) satellites (Richey et al., 2015) can support more sustainable groundwater extraction and consumption.

Sustainability is often defined as meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland et al., 1987, p. 15 paragraph 3), which can resonate with both spiritual and secular individuals. In their survey studying reasons to reduce climate change, Goldberg et al. (2019) found the most important reason selected was "Provide a better life for our children and grandchildren," selected by 28% of Americans and 29% of Christians surveyed. Acknowledgement and care for future generations through care and action for the environment illustrates synergies between science and religion in practice. Moving forward, sustainability education and sustainable development require learning, dialogue, and action around

common goals. While science and religion are often viewed in conflict, sustainability presents a common ground. As Archbishop Emeritus Desmond Tutu once said, "We have enough that conspires to separate us; let us celebrate that which unites us, that which we share in common" (Tutu, 2011, p. 7).

Sustainability is a broad concept encompassing the environment, economy, and society, and it presents challenges in education through tradeoffs between breadth and depth of knowledge. The intersection of and dialogue between science and religion presents an opportunity to reach diverse groups with sustainability education, leveraging passion and experience to inform decisions and positive action amidst uncertainty. Experiential learning in both university and community settings can deepen knowledge and emphasize sustainability concepts through projects, challenges, and dialogue, and that learning through the whole-person approach to educating for sustainability (Podger et al., 2010) can lead to greater benefits overall. This figurative common ground of sustainability education can help inspire action to protect the literal common ground of Earth.

Acknowledgements

Inspiration for this work came from engaging in dialogue through the Sinai and Synapses Fellowship (2017-2019), supported in part by the Issachar Fund. The university sustainability education components of this work are based on efforts funded by the National Science Foundation, grant CBET-1847404; the opinions, findings, and conclusions or recommendations expressed here at those of the author and do not necessarily reflect the views of the National Science Foundation.

Thanks to the Faith in Place Staff and Board of Directors for their continued work with diverse people of all faiths sharing the commitment to care for the Earth. Additional thanks to my former students in CEE 340: Energy and Global Environment at the University of Illinois at Urbana-Champaign for their engagement in learning about sustainability; I am grateful for the many lessons I learned from them.

The author received no financial support for the research, authorship, and/or publication of this manuscript.

Ashlynn Stillwell, Ph.D., (ashlynn@illinois.edu) is an Associate Professor and the Elaine F. and William J. Hall Excellence Faculty Scholar in Civil and Environmental Engineering at the University of Illinois Urbana-Champaign. Her research focuses on creating sustainable water and energy systems in a policy-relevant context. She earned a B.S. in Chemical Engineering from the University of Missouri (2006), and an M.S. in Environmental and Water Resources Engineering (2010), M.P.Aff in Public Affairs (2010), and Ph.D. in Civil Engineering (2013) from The University of Texas at Austin.

References

Ashford, N. A. (2004). Major challenges for engineering education for sustainable development: What has to change to make it creative, effective, and acceptable to the established disciplines? *International Journal of Sustainability in Higher Education, 5*(3), 239-250.

Attari, Shahzeen Z., David H. Krantz, and Elke U. Weber. (2019). Climate change communicators' carbon footprints affect their audience's policy support. *Climatic Change, 154*, 529-545.

Bielefeldt, Angela R. (2013). Pedagogies to Achieve Sustainability Learning Outcomes in Civil and Environmental Engineering Students. *Sustainability, 5*(10), 4479-4501.

Brundtland, Gro Harlem, Mansour Khalid, Susanna Agnelli, Saleh A. Al-Athel, Bernard Chidzero, Lamine Mohammed Fadika, Volker Hauff, Istvan Lang, Ma Shijun, Margarita Marino d Botero, Nagendra Sing, Paulo Nogueira-Neto, Saburo Okita, Shridath S. Ramphal, William D. Ruckelshaus, Mohamed Sahnoun, Emil Salim, Bukar Shaib, Vladimir Sokolov, Janez Stanovnik, Maurice Strong, and Jim MacNeill. (1987). Our Common Future. The World Commission on Environment and Development. Reprinted 2009 by Oxford University Press.

Chuvieco, Emilio. (2012). Religion approaches to water management and environmental conservation. *Water Policy, 14*, 9-20.

Clark, William C., and Nancy M. Dickson. (2003). Sustainability science: The emerging research program. *Proceedings of the National Academy of Sciences of the United States of America, 100*(14), 8059-8061.

Crossman, Joanna. (2011). Environmental and Spiritual Leadership: Tracing the Synergies from an Organizational Perspective. *Journal of Business Ethics, 103*(4), 553-565.

Djupe, Paul A., and Brian R. Calfano. (2009). Justification Not by Faith Alone: Clergy Generating Trust and Certainty by Revealing Thought. *Politics and Religion, 2*, 1-30.

Dovers, Stephen R. (1996). Sustainability: Demands on Policy. *Journal of Public Policy, 16*(3), 303-318.

Fenner, Richard A., Charles M. Ainger, Heather J. Cruickshank, and Peter M. Guthrie. (2005). Embedding sustainable development at Cambridge University Engineering Department. *International Journal of Sustainability in Higher Education, 6*(3), 229-241.

Goldberg, Matthew H., Abel Gustafson, Matthew T. Ballew, Seth A. Rosenthal, and Anthony Leiserowitz. (2019). A Social Identity Approach to Engaging Christians in the Issue of Climate Change. *Science Communication, 41*(4), 442-463.

Kates, Robert W., William C. Clark, Robert Corell, J. Michael Hall, Carlo C. Jaeger, Ian Lowe, James J. McCarthy, Hans Joachim Schellnhuber, Bert Bolin, Nancy M. Dickson, Sylvie Faucheux, Gilberto C. Gallopin, Arnulf Grübler, Brian Huntley, Jill Jäger, Narpat S. Jodha, Roger E. Kasperson, Akin Mabogunje, Pamela Matson, Harold Mooney, Berrien Moore III, Timothy O'Riordan, and Uno Svedin. (2001). Sustainability Science. *Science, 292*(5517), 641-642.

Kemp, René, Saeed Parto, and Robert B. Gibson. (2005). Governance for sustainable development: moving from theory to practice. *International Journal of Sustainable Development, 8*(1/2), 12-30.

Kemp, René, and Pim Martens. (2007). Sustainable development: how to manage something that is subjective and never can be achieved? *Sustainability: Science, Practice, & Policy, 3*(2), 5-14.

Konisky, David M. (2018). The greening of Christianity? A study of environmental attitudes over time. *Environmental Politics, 27*(2), 267-291.

Marshall, Julian D., and Michael W. Toffel. (2005). Framing the Elusive Concept of Sustainability: A Sustainability Hierarchy. *Environmental Science & Technology, 39*(3), 673-682.

National Research Council (NRC). (2013). Our Common Journey: A Transition Toward Sustainability. Board on Sustainable Development, National Academy of Sciences. Washington, D.C.

Parris, Thomas M., and Robert W. Kates. (2003). Characterizing a sustainability transition: Goals, targets, trends, and driving forces. *Proceedings of the National Academy of Sciences of the United States of America, 100*(14), 8068-8073.

Peter, Laurence J. (1982). Peter's Almanac. William Morrow & Co: New York, NY.

Podger, Dimity Margaret, Elena Mustakova-Possardt, and Anna Reid. (2010). A whole-person approach to educating for sustainability. *International Journal of Sustainability in Higher Education, 11*(4), 339-352.

Pope, Jenny, David Annandale, and Angus Morrison-Saunders. (2004). Conceptualising sustainability assessment. *Environmental Impact Assessment Review, 24*(6), 595-616.

Richey, Alexandra S., Brian F. Thomas, Min-Hui Lo, John T. Reager, James S. Famiglietti, Katalyn Voss, Sean Swenson, and Matthew Rodell. (2015). Quantifying renewable groundwater stress with GRACE. *Water Resources Research, 51*(7), 5217-5238.

Schmidt, Jeremy J., and Christiana Z. Peppard. (2014). Water ethics on a human-dominated planet: rationality, context and values in global governance. *WIREs Water, 1*, 533-547.

Sexton, Ken, and Stephen H. Linder. (2014). Integrated Assessment of Risk and Sustainability in the Context of Regulatory Decision Making. *Environmental Science & Technology, 48*(3), 1409-1418.

Spangenberg, Joachim H. (2011). Sustainability science: a review, an analysis and some empirical lessons. *Environmental Conservation, 38*(3), 275-287.

Swart, R. J., P. Raskin, and J. Robinson. (2004). The problem of the future: sustainability science and scenario analysis. *Global Environmental Change, 14*(2), 137-146.

Tutu, Desmond Mpilo. (2011). God Is Not a Christian And Other Provocations. (John Allen, Ed.). HarperOne: New York, NY.

Vallance, Suzanne, Harvey C. Perkins, and Jennifer E. Dixon. (2011). What is social sustainability? A clarification of concepts. *Geoforum, 42*(3), 342-348.

Wright, Robert. (2017). Why Buddhism Is True: The Science and Philosophy of Meditation and Enlightenment. Simon & Schuster: New York, NY.

Zalasiewicz, Jan, Mark Williams, Will Steffen, and Paul Crutzen. (2010). The New World of the Anthropocene. *Environmental Science & Technology, 44*(7), 2228-2231.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 62-67

Wonder as an Invitation to Engage in Environmental Justice

Ruth Shaver
PATHWAYS Theological Education, Inc.

ABSTRACT

Environmental justice, a phrase first used in reference to the activism of a community in Warren County, NC in the late 1970s, is a broad category of work at the intersection of caring for nature and caring for people. Residents of the majority black county sought relief from the impending designation of a landfill site in the county as a dumping site for toxic chemicals. This effort was supported by the NAACP and both local congregations and national staff of the United Church of Christ (UCC). Their efforts led to the first true national attention on what has become known as "environmental racism." In this article, I describe additional ways the UCC continued to play a key role in the environmental justice movement. I then describe the current effort to develop a certificate program in environmental justice by PATHWAYS Theological Education, Inc and the role wonder has played throughout all of these efforts.

Keywords: science and religion, wonder, environmental justice, environmental racism, PATHWAYS Theological Education

Editors' Comment

Rev. Ruth Shaver, DMin, (2017-2019 Fellow) *is the Interim Pastor at The Congregational Church of Mansfield in Mansfield, MA. In Wonder as an Invitation to Engage in Environmental Justice, Rev. Dr. Shaver shares a curriculum specifically developed for educating religious communities about environmental justice issues and emphasizing that environmental care is an essential part of following one's religious faith. She describes the process in developing this program for communities who typically don't have a strong science background. Her intention is for this program to help participants become involved in environmental justice. This article can help science educators see other ways to reach those who have less interest in science, but still hold a sense of wonder.*

Introduction

Environmental justice is a broad category of work at the intersection of caring for nature and caring for people. The US Environmental Protection Agency defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA). According to the American Association for the Advancement of Science (AAAS) Dialogue on Science, Ethics & Religion (DoSER) group, environmental justice is a multidisciplinary endeavor that unites people of "different socioeconomic backgrounds, nationalities, religious communities, and races" (Sloane-Barrett, 2021, para. 1).

The term 'environmental justice' was first used in reference to the activism of a community in Warren County, North Carolina, in the late 1970s. Residents of the majority black county sought relief from the impending designation of a landfill site in the county as a dumping site for toxic

polychlorinated biphenyls (PCBs). Working with the NAACP, members of the national staff of the United Church of Christ (UCC) led by the Rev. Benjamin Chavis and local congregations of the denomination challenged the designation of the landfill up to and past the day the first load of toxic waste arrived in 1982. Community members and activists from around the country staged a 'lie-in' across the access road to the dump over six days, which resulted in 523 arrests and the first true national attention on what has become known as "environmental racism" (Skelton & Miller, 2021).

"Environmental racism" is a subcategory of environmental justice that focuses on the disproportionate effect of industrial pollution on people of color and communities with average household incomes close to or below the poverty level. Other subcategories of environmental justice include climate change mitigation, land reclamation, waterway restoration, and air quality improvement. Evidence of environmental racism often plays a role in the ways that climate change mitigation, land reclamation, and other forms of environmental justice projects are developed, whether such evidence is presented as part of the need for these projects or discovered as these projects are envisioned and planned.

The ongoing efforts to stop the Dakota Access Pipeline are aimed at preventing egregious degradation of land and water resources belonging to Native Americans in the American Midwest, a group historically subjected to racial discrimination and among the poorest ethnic groups in the United States. The Standing Rock Sioux tribe issued a call for support in preventing the contamination of their reservation lands and water sources by potential spills from a pipeline from the shale oil fields. The route of the pipeline extends from North Dakota to a terminal in Illinois, including the contentious section of the pipeline that crosses under the Missouri River a few miles upstream of the tribe's riverfront land. The tribe contends even now that the pipeline puts their traditional food sources as well as water supplies at risk. In 2016 and 2017, in response to a call from its Council for American Indian Ministry, regional bodies of the UCC and national UCC staff gathered with the Standing Rock tribe to protest the pipeline. UCC leaders from South Dakota, North Dakota, and Colorado were instrumental in gathering an ecumenical and interfaith coalition of religious leaders to join them; those religious leaders in turn partnered with secular organizations such as 350.org and the Sierra Club to increase the visibility of the protests and raise awareness of this particular instance of environmental racism (UCC, 2021). The protests succeeded in delaying action by the Obama administration, but the Trump administration allowed the project to go forward. Before any completed segments of the pipeline officially opened in June 2017, more than 184 gallons of oil had already leaked in three separate areas. Each spill was cleaned up with no permanent environmental damage; however, tribal officials have pointed to these incidents as evidence that their fears are grounded in reality (Associated Press, 2017). The final status of the pipeline is awaiting a decision from the Biden administration and the US Army Corps of Engineers concerning its safe operation (Frazin, 2021).

At its 2017 General Synod, where delegates and visitors from all 50 states, several US territories, and international partners gathered for celebration and deliberation, the UCC recognized the Water Protectors of the Standing Rock Reservation for their dedication to the cause of environmental preservation. I was privileged to be in attendance for that ceremony and also to have a conversation with a group of delegates from Gulf Coast states, two of whom worked in the oil and gas industry. One, a chemical engineer, admitted that he had never given much thought to the potential pollution that could result from pipelines traversing a landscape. He had assumed the danger was primarily at the beginnings and ends of pipelines, where people were the likely cause of accidents. The other was a technician for an oil company whose specialty was mitigation of oil spills on land. He openly wondered if he could be using his skills for a better purpose than the profits of a fossil fuel company. His wondering came after having an hour-long conversation with one of the Water Protectors, who himself was an engineer. I do not know if either delegate acted on his newfound revelation, but I was heartened to see people of faith actively engaging with new information on both

intellectual and spiritual levels as the dialogue between the Water Protector and the technician moved between technology and the importance of caring for the creation both accepted as a gift from God.

PATHWAYS Theological Education, Inc.

I find that curiosity and wonder go hand-in-hand, whether it is about how things work (science) or about the larger issues in life such as who wrote the laws that make things work (faith). For an ordained pastor who is by nature driven to teach, this wonder is a gift. Sometimes it is the wonder of a preschool child who asks where God lives that elicits both laughter and thoughtful, childlike answers. At other times, it is the more complicated wonder of an adult who wants to understand how the Bible can contain seemingly contradictory messages about God. While 1 John 4:8 presents God as 'love', Judges 11 describes the story of Jeptha who offered up his own daughter as a burnt sacrifice to God in exchange for his own success in battle over the Ammonite – such conflicting views can lead to serious wondering about the nature of God. Both wonderings (of the child and the adult) are theological, but the questions that adults generate are more complex and can be answered in different ways by different fields. Sometimes, especially when the questions involve elements of the natural world, science can help provide answers.

Most Christian congregations are not set up with the kind of staffing to provide classes for adults who really want to dig into the dichotomy between passages like 1 John and Judges. I am fortunate to be part of an online, asynchronous education program that invites progressive Christians to explore topics of faith with more rigor and depth than a typical congregation can provide. This education program is PATHWAYS Theological Education Inc. In this program, we explore contradictory passages, as well as content like the history of worship and preaching with confidence. As a course facilitator and writer for PATHWAYS Theological Education, Inc., I have the opportunity to watch wonder grow as our participants encounter answers to their initial wonderings, as well as new information that sparks more curiosity and a desire to keep learning.

Courses Offered by PATHWAYS

One course we provide regularly is *The History and Polity of the United Church of Christ (H&P)*. Most people who sign up for this course are taking it to fulfill an ordination requirement. However, in my first experience facilitating this class, about half the participants were taking the course out of a sense of wonder about what the UCC is beyond their local congregation. I watched as the candidates for ordination–seminarians nearing graduation and recent graduates who admitted to a sense of *just-get-this-done* at the beginning of the term—were caught up in the wonder of the '*newbies'* who had not yet studied systematic theology, church history, or Biblical hermeneutics. The more experienced participants engaged with the newcomers to share knowledge and to admit that some of the questions the newcomers asked would never have occurred to them at that point in their training. At the end of the course, one candidate for ordination thanked the newcomers for restoring her ability to be in awe of God's work again, especially as it pointed her to a topic she is now passionate about: environmental justice.

In one week of the H&P course, a newcomer presented a short paper on the beginnings of the environmental justice movement in Warren County, North Carolina. In her reply to the paper, the candidate for ordination wrote that she was *'entranced'* by the opportunities presented by environmental justice, but worried that neither she nor the members of the church community in which she will be ordained have enough scientific background to know where to begin such work in their area. She is not wrong. Within progressive Christian communities, many adults have limited experience with the

basic practices of science, both for environmental justice work and for creation care[1]—the practice of sustaining and preserving our environment for future generations—more broadly.

For members of the UCC and many of our interfaith partners, creation care is an essential part of our call to live out our faith. Some of our interfaith and inter-philosophical partners do not have creation care *per se* in their tenets, but still see caring for our home as essential to following their beliefs or way of living. I include *'inter-philosophical'* partners because not all of our partners practice a faith but do live by a philosophy that prioritizes care of the Earth as part of being a good person. Before the exchange mentioned above even happened, the leadership of PATHWAYS had discerned the need for a certificate in environmental justice as one part of creation care. As an essential part of our faith, the environmental justice movement makes it all the more imperative that we as people of faith be knowledgeable about the practices of science because it is science that guides repair and restoration initiatives.

The common root of faith exploration and scientific inquiry is an experience of wonder, or what naturalist Raymo (2008) says is that which causes us to say, *'I don't know'* and then investigate the mystery (p. 29-30). This planned environmental justice certificate will engage participants in wonder on both fronts. While participants develop competency in the faith-based theological, Biblical, and historical underpinnings of environmental justice work as a practice of Christian faith, they will also practice doing science through daily observation journals. In each of the six courses, observational journal assignments will invite participants to think scientifically about the world around them. Assignments in the courses promote the generation of hypotheses and where possible, the testing and analysis of those hypotheses. Environmental justice work includes the work of scientific observation, analysis of data, preparation of reports regarding polluted sites, identification of remote sources of contamination, and systemic discrimination in the zoning and regulation of industrial plants that process known pollutants. Equipping religious community leaders with an understanding of the details of environmental justice would allow them to work with experts in the field and the affected community, thereby making environmental justice efforts more successful. Scientists often take the lead on plans for physical remediation of contaminated sites and should be instrumental in the development of forward-thinking policy but having a group of people who can *'translate'* for the wider community can enhance the trust among partners and assure that both the big picture and the minutiae are given due attention.

Two courses have been developed and are planned as offerings beginning in Fall 2021. The first course is titled *Environmental Literacy in God's Creation*. The daily journal assignments invite participants to chronicle their interactions with the habitat around their homes, with the focus on one particular species. Each week's journal links their observations to the vocabulary and contexts of the readings and other course material. One assignment in this course is to use as many terms as possible from the science materials provided to write a psalm of praise about the habitat they are observing. This assignment was inspired by an activity from the curriculum I wrote for my dissertation that asked participants to use their scientific observations to write a proverb in the style of Proverbs 8:22-31. Another assignment at the end of the course asks participants to formulate an hypothesis about an environmental issue that is evident in the habitat they have studied, summarize the evidence for that hypothesis, and propose an experiment to test the hypothesis using notes from their journals. They are then asked to infer from their process how a group of citizens they have read about in a course assignment may have collected evidence and provided substantial proof that a change to the source of their city's water supply caused a surge in the amount of lead in drinking water.

[1] "Creation" is a term most often used in Jewish, Christian, and Muslim theology to denote the traditional belief that God created the earth and all life thereon, irrespective of the exact timeline and mechanism. In many faith communities, "creation care" might be an easy way to connect a known principle with a new idea, whether that new idea is the reality of climate change or a proposed landfill that could negatively affect the community imminently.

The second course, *Centering Creation in Love*, invites participants to use all five senses to wonder about the world. Each *wondering* begins with a verse from the Bible and poses questions that evoke further wondering: is this experience available to everyone or is it limited to people of means (income, transportation, education, etc.)? Is this human-made or natural? What words describe your experience? What memories are associated with this experience and why? A reflection assignment about midway through the course asks participants to categorize their observations by human-made and natural, to notice any patterns that emerge, and then to prepare a devotional based on their observations for their congregation. At the end of the course, they are asked to prepare a worship service incorporating the theology they have learned reading *Ecotheology: A Christian Conversation* (Jorgenson & Padgett, 2020) and their insights from their wondering journal.

PATHWAYS Moving Forward

The leadership of PATHWAYS knows, based on inquiries over the past year, that there is desire for courses like this in our constituency and beyond. We anticipate a cohort of 8-10 participants to enroll in the first course in October. We do not yet know how these courses, or completion of the certificate program itself, will influence congregations to undertake environmental justice projects of their own. Will trained religious community leaders (lay or ordained) help congregations develop partnerships with other agencies (e.g., Interfaith Power and Light) that are already involved in environmental justice work? Does the combination of scientific practice with theological and Biblical grounding make individual leaders more likely to take on a leadership role in a project that is already in process? Certainly, a measure of success for us would be the creation of new congregation-based projects. Yet, another measure may be more important: do participants in these courses and the certificate program undertake *any* involvement in environmental justice work in their communities? As I have been a part of the research team for the writing of all six courses in the initial certificate, I have learned that there is not a community in the country that is unaffected by some form of environmental degradation and few, if any, where that degradation does not affect communities of color and poorer communities disproportionately. More starkly, there really is not a community in the United States without a need for some form of environmental justice work. If we, at PATHWAYS, can help even a few communities in the process of addressing and correcting environmental concerns, we will have played a part in changing the world…all because of a few people's wonderings.

About PATHWAYS Theological Education, Inc.:
PATHWAYS is an online, asynchronous institute for leadership development in and for communities of faith. The organization uses andragogical (adult) methods which are competency-based and include a variety of learning activities specific to the objectives of each course. Participants can combine courses to meet their own specific needs, they can enroll in a certificate program in a topic of interest, or they can commit to a three-year course of instruction for ministerial preparation. PATHWAYS responds to the educational needs of an evolving world by continually striving to create innovative, online progressive theological learning and discovery that promote justice, peace, and mutual understanding.

The author received no financial support for the research, authorship, and/or publication of this manuscript.

The Reverend Doctor Ruth Shaver (revdrruthucc@icor1348.com) is the Academic Council Chairperson and Secretary of the Board of Directors of PATHWAYS Theological Education, Inc., where she is also a course facilitator and course writer. Her Doctor of Ministry thesis at Lancaster Theological Seminary was "I Wonder…Scientific Exploration and Experimentation as a Practice of Christian Faith," an intergenerational science curriculum based on Proverbs 8:22-31 and Psalm 8. She

is an alumna of the 2017-2019 Sinai and Synapses cohort; that experience gave her the confidence to serve as a resource for fellow clergy who were trying to understand how scientific discoveries guided decision making about community safety during the SARS-CoV-2/COVID-19 pandemic. The Rev. Dr. Shaver currently serves as the Interim Pastor of The Congregational Church of Mansfield, United Church of Christ, in Mansfield, Massachusetts.

References

Associated Press. (2017, May 22). Dakota Access pipeline and a feeder line leaked more than 100 gallons in March. *The Guardian*. https://www.theguardian.com/us-news/2017/may/22/dakota-access-pipeline-oil-leak-energy-transfer-partners

Environmental Protection Agency. (n.d.). *Environmental justice*. https://www.epa.gov/environmentaljustice

Frazin, R. (2021, April 13). Tensions emerge between green groups and Biden over Dakota Access Pipeline. *TheHill*. https://thehill.com/policy/energy-environment/548071-tensions-emerge-green-groups-biden-dakota-access-pipeline

Jorgenson, K. A., & Padgett, A. G. (2020). *Ecotheology: a Christian conversation*. William B. Eerdmans Publishing Company.

Raymo, C. (2008). *When God is gone everything is holy: The making of a religious naturalist*. Sorin Books.

Skelton, R., & Miller, V. (2021, February 24). *The environmental justice movement*. NRDC. https://www.nrdc.org/stories/environmental-justice-movement

Sloane-Barrett, L. (2021, March 22). *Science, religion, and community partnerships improve environmental justice efforts*. AAAS - DoSER. https://sciencereligiondialogue.org/resources/science-religion-and-community-partnerships-improve-environmental-justice-efforts/

United Church of Christ. (2021, March 23). *Stand with Standing Rock*. https://www.ucc.org/what-we-do/justice-local-church-ministries/justice/faithful-action-ministries/environmental-justice/ucc_stand_with_standing_rock/

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 68-76

Terror Management and Religious Literacy in the Classroom

Isaac Alderman
Catholic University of America

Kendra Holt Moore
Bethany College

ABSTRACT

Over the past decade, Terror Management Theory (TMT) has been widely studied for its role in conflict management and in shaping the behavior of target populations, including in the classroom. Emerging from research on the importance of self-esteem, TMT submits that much of our behavior is driven by death anxiety and its effects are particularly evident when one's "worldview" is threatened by another, incompatible "worldview." When a student is threatened by learning about a topic that is incompatible with their worldview, their response is more contingent upon their sources of self-esteem and meaning than upon the reception of straightforward information on the topic itself. Their religious identities provide yet another layer of framing for self-esteem and belonging that may or may not interfere with their learning. This paper urges educators to recognize the importance of religious literacy when incorporating the insights of TMT into their pedagogical strategies when teaching topics that may be incompatible with the worldview of many of their students.

Keywords: climate change, conflict management, pedagogy, religious diversity, Terror Management Theory

Editors' Comment

***Isaac Alderman, Ph.D.**, instructor at Baruch College, City University of New York, and **Kendra Holt Moore**, Ph.D. candidate Boston College and Assistant Professor of Religion at Bethany College **(both 2017-2019 Fellows)** introduce Terror Management Theory (TMT) from social psychology as a useful tool for understanding how accepting students may or may not be to the frightening truth of anthropogenic climate change. They remind us that students' beliefs are are oftentimes more shaped by their personal experiences rather than facts and emphasize the importance of understanding students' identifies, especially their religious identities, when teaching science that has religious or political implications.*

Introduction

One of the facts of science education is that students quickly see religious and political implications when their own views, or that of their community, are at odds with scientific consensus. The challenge for science educators is how to navigate these students' realizations without unintentionally furthering conflict or cynicism towards science. The difficulties of this challenge are clearly seen with topics such as human evolution, sex education, women's health, and climate change. As educators, we want to allow students to be validated in their deeply held convictions, and we hate

closing down dialogue by saying, "*you are wrong*." It can, in fact, feel like we are criticizing a student's very identity or religious beliefs when we do so. It is difficult, unpleasant, and often results in adverse and confrontational responses when we try to explain to students why their deeply held view is at odds with scientific consensus or factually incorrect.

The National Science Teachers Association position statement on climate science highlights many of these challenges and recognizes that students' deeply held values and cognitive biases can be a roadblock to learning:

> Belief systems do not necessarily arise from logic and evidence... [but from one's] faith, family, and personal emotional experiences. An individual's desire to be a part of a specific community or group will inform his or her beliefs and affect his or her ability to change their beliefs based on the pressures applied by the community or group they belong to or wish to join (NSTA, 2018, p. 4).

The deeply held values and sense of identity can cause the student to reject the course material and lead to discouragement on all sides and even conflict in the classroom. More than one in four science teachers recently surveyed reported that they sought to mitigate classroom conflict by giving "equal time to perspectives that raise doubt that humans are causing climate change" (Plutzer et al., 2016, p. 18).

It is not surprising that teachers all over the country are trying different approaches, attending workshops, reading research, and talking with peers about how to reduce this tension in ways better than teaching the controversy. Beyond publishing examples of best practices, researchers and educators are looking to fields such as cognition and psychology to apply various theoretical frameworks to generate useful approaches (Drewes & Henderson, 2020). Some are focusing on first teaching the nature of science to overcome misconceptions at that foundational level before moving on to those more controversial topics (Carter & Wiles, 2014). Others are making use of and modifying methods and insights gained from psychologists to help better understand the ways in which teaching about climate science is rejected and to improve upon failing approaches (Armstrong et al., 2018). Cognitive scientists have also joined this cause, finding ways to apply the insights from their own disciplines to help expand and improve climate science education (Aron, 2019). For example, we find attempts to improve receptivity to climate science through better visual representation, based on our understanding of the processing of such information (Jordan et al., 2016). In other areas, we find research on the role of cognitive style in climate skepticism (Trémolière and Djeriouat, 2021).

Another approach that has been gathering attention is drawn from social psychology's Terror Management Theory (TMT), which identifies the influence and sources of death anxiety in the conscious and unconscious mind. Some educators have found TMT to be a useful toolkit for understanding and anticipating student concerns and resistance to learning about climate science (Dickinson, 2009; Wolfe & Tubi, 2019; Van Kessel 2020). By building on the research demonstrating that TMT enables educators to see the impact of classroom content intersecting with student identities, we suggest that educators also pay special attention to the importance of student religious identities. Our goal is to highlight the need for religious literacy in educational spaces, since religion is a substantial force that can both encourage and hinder the learning objectives in a science classroom.

Terror Management Theory

TMT emerged in the 1980s from research into the evolutionary foundations of self-esteem and the corporate drive for ideological dominance. From the very first iterations of TMT, these researchers drew on the earlier work of Ernest Becker, specifically his 1973 book *The Denial of Death* (Greenberg et al., 1986). In it, Becker argues that the most powerful force driving human action is the anxiety brought about by the human knowledge of mortality and finitude. Culture is a construction that is organized as a way to allow us to redirect our attention; Instead of being anxious about our

own impending death, we can focus on meaningful world views which give us a sense of enduring purpose that mitigates our own sense of finitude.

Terror management theorists posit self-esteem as being generated when a person sees themself as defending and properly functioning within their inherited worldview. While the term worldview is both used and resisted in different ways in other social sciences, for TMT it is a broad bucket that encompasses a number of world-building possibilities including religion, politics, culture, and ideologies. For Terror Management theorists, becoming enmeshed in a meaningful worldview keeps death anxiety at bay by increasing one's self-esteem and sense of belonging, and self-esteem in turn creates a feeling that continued participation and devotion to the worldview is right and good (Solomon et al., 2015). We know that people can easily become defensive, combative, and unreceptive to new ideas when they feel that their core ideals and identity are being attacked. This is not the result of political polarization, media bubbles, or fake news; rather, it is a trait that has evolved in humans as a way for both individuals and societies to manage existential concerns. If a person is presented with opinions, views, or actions that threaten the ideals of their worldview, it becomes for them an existential moment in which they either allow themselves to experience greater death anxiety, or they bolster their self-esteem and keep that death anxiety at bay by defending their worldview and closing themselves off to the outside information. Ultimately, the goal of the individual is to suppress death-related thoughts to the extent that psychological equilibrium is possible, making day-to-day living possible without overwhelming anxiety about one's insignificance and impermanence.

If Terror Management theorists are correct, then we should be able to find demonstrable support for their position. Hundreds of studies over the last several decades strongly support three primary hypotheses (for a fuller description, see Alderman, 2020). First, the mortality salience (MS) hypothesis predicts that if an element of one's worldview increases self-esteem and thereby creates a buffer against death-related anxiety with the comforts of belonging and transcendent significance, then attempts to remind a person of their mortality through death-reminders will increase the need for the self-esteem bolstering worldview element. For example, when a group of Christians was split in half to evaluate a group of Jews, the half who answered questions about their own death (thereby increasing MS) were found to be harsher judges than the half without MS priming (Rosenblatt, et al., 1989). In other words, the Christians who reflected on what they thought would happen to their bodies upon death experienced the subtle psychological threat that death is a reality to contend with. The conscious and unconscious means to address this threat generally leads people to re-center their own cultures, communities, and identities as the most important. Therefore, the mortality salient Christians in the study judged Jews more harshly, which Terror Management theorists say is an attempt to re-center Christianity as the right way, separating it from other competing religious identities. The assumption behind such a study is that worldviews—especially religious ones—are a zero-sum game. One cannot persist unbothered in their views about morality, God, and afterlife when competing perspectives introduce the possibility that an individual may be wrong about what has been centrally located in their meaning-making anchors. A response is required, which sometimes leads to a determined ignoring or erasing of the other and sometimes leads to violence against the other. Because reflections on death are threatening to survival, whether in a literal sense or in the sense of one's ego, the defensive response is to double down on the cultural and religious systems that dictate truth and order for the subject so that a psychological equilibrium can be maintained.

Second, the anxiety buffer hypothesis predicts that if a self-esteem generating worldview creates protection from death anxiety, then strengthening the worldview will buffer against future death anxiety. The anxiety buffer hypothesis is the inverse of the MS hypothesis. For example, participants in one study filled out a survey about their personality and goals and were later given personalized feedback about themselves based on answers to the previous survey. Some participants received feedback insisting they had weaknesses in their personality and unrealistic goals, while others received positive feedback insisting they possessed strong personalities and realistic goals. Participants

were then shown a clip about death. What researchers found was that those who received the positive feedback reported lower anxiety after watching the clip than those who had received negative feedback (Solomon, et al., 2015). While the MS hypothesis shows the power of death reminders on an individual's psyche, the anxiety buffer hypothesis demonstrates the power of self-esteem as a psychological buffer.

Lastly, the death-thought accessibility (DTA) hypothesis predicts that if a worldview creates protection against death anxiety, then weakening that worldview will cause death-related thoughts to be increasingly accessible in an individual's unconscious. One way to measure the accessibility of these death-related thoughts is with word completion exercises, in which a person is given incomplete words such as COFF__ or SK _ L_ , which could be completed as either death-related (COFFIN and SKULL) or non-related (COFFEE and SKILL). The primes for this experiment can take the form of an essay that attacks the subject's religious, scientific, or political worldviews. For example, a study on Canadian subjects demonstrated that reading a website critical of Canada increased DTA (Schimel, et al., 2007).

The decades of evidence amassed in TMT studies demonstrate promising potential for science educators by offering insight into how these aforementioned values, beliefs, and emotions are deeply seated in the unconscious and not easily changed by the presentation of basic factual information from a disinterested party. TMT shows us that we more strongly defend elements of our worldview and identity when we are reminded of our death (MS), that we experience a decrease in anxiety when our views are reinforced, and that death comes closer to the surface (DTA) when our worldview is attacked.

For example, we can see how the examples in these studies are clearly applicable to teaching climate science (see van Kessel, 2020, for a much fuller explanation of the relationship). First, the discussion of climate change can prime MS. Discussions of extinctions, the erosion of coasts and underwater coastal cities, human displacement and hunger, all serve to increase the listener's awareness of mortality. Second, some in the United States have a worldview that is skeptical toward climate science. This has the effect that the discussion of climate change is perceived as a threat to their worldview, which needs to be defended in order to prevent increased anxiety.

For our task here, we are particularly interested in those researchers that have looked at climate change in the context of TMT (Wolfe & Tubi, 2019; additional work can be found in their extensive bibliography). While this is in some ways a recent use of TMT, in other ways the concerns of climate change have always been part of the understanding of TMT. For example, it has been known for more than a decade that the disasters brought about by climate change functions to prime MS, an insight that is now being utilized in the hopes of improving climate science education (Motyl et al., 2018). Moreover, very early in TMT research, it was recognized that mortality salience increased conspicuous and harmful consumption, which is counterproductive to many of the aims of climate change mitigation and climate science education (Solomon et al., 2015; see also, Mandel & Heine, 1999).

Though many are recognizing the implications for TMT and discourse on climate change, the work of Catherine van Kessel deserves particular notice as she is working specifically on how TMT can be utilized to improve climate science education (van Kessel, 2020; van Kessel, Heyer, & Schimel, 2020; van Kessel & Burke, 2018). One of van Kessel's useful insights is that teaching the climate crisis often activates two TMT triggers, working both as an MS prime and an attack on a worldview. These triggers can lead students to deploy defensive barriers and strategies to defend themselves against these perceived attacks, including decreased reading comprehension, increased in-group/out-group dynamics, and other strategies (defensive compensatory reactions) leading up even to actual violence (van Kessel, 2020). Van Kassel seeks to make science educators aware of these triggers and their implications, so that they can manage their classroom in such a way as to mitigate these defensive barriers and strategies. She elaborates on pedagogical strategies of "providing conceptual tools, narrating cascading emotions, carefully using humor to diffuse anxiety, employing language and

phrasing that does not overgeneralize divergent groups, and priming the idea of tolerance" (van Kessel, 2020, p. 129).

We find van Kessel's work extremely compelling and recommend it. We would like to build on work such as hers by noting a lack of emphasis on what we consider to be a very important aspect, namely the important role of religion in the construct of the worldview that so often contributes to climate skepticism (van Kessel, 2020). The goal of this short article is to assert that science educators can make even greater use of the insights of TMT in the classroom setting by also adding religious literacy to the mix, in an attempt to better mitigate the negative responses to climate science.

Looking Forward: Religious Literacy in the Classroom

Despite the progress science educators are making by applying theoretical models such as TMT to their pedagogies, religious literacy remains lacking from educational strategies on a large scale. TMT theorists have recognized for decades that religion plays a role in the dynamics of mortality salience and self-esteem striving, as the small example from above with the Christians and Jews demonstrates. Religious identities are often such a force of belonging and meaning-making that those who strongly identify as religious tend to have lower levels of death anxiety, which is consistent with the anxiety buffer hypothesis (Jong et al., 2018). Religions provide resources for people to belong to something greater than themselves, and sacred texts, rituals, and beliefs provide concrete structures for religious adherents to understand both the world around them and themselves. Additionally, and importantly, some religions provide a strong source of self-esteem and anxiety buffering because they promise a literal immortality in addition to, or in lieu of, various cultural and symbolic immortalities (Vail et al., 2010). A cultural system that offers the opportunity to live a life that will never die physically or symbolically is alluring because it protects against many forms of death or impermanence while also anchoring the person as both a member of a community as well as a significant part of the cosmic order (Vail et al., 2010). When those systems are challenged, whether religious or not, the sense that death and meaninglessness looms large strikes again, activating a defensiveness that often leads to tighter boundaries between in-group and out-group as well as increased engagement and adherence to one's own religious traditions.

Regardless of the high promise religion offers to become a cure-all for death anxiety, some religious people are more affected than others, and religious identity is not always the greatest source of security. For educators, understanding *when* religious identity might be threatened is more important than merely understanding that religious identity *is* a source of security. While this research still requires more robust cross-cultural data, there is some evidence demonstrating that the relationship between religiosity and death anxiety is curvilinear (Jong et al., 2018). In other words, those with the lowest levels of death anxiety tend to be both the most religious and the most non-religious, which leaves those caught between the certain and secure commitments of the religious and nonreligious with the highest levels of death anxiety. The implication of this finding reveals that religious people draw varying amounts of security, identity, and value from their religious traditions, and it warns educators who wish to gain knowledge of their religious students not to make unilateral assumptions about the value students draw from such traditions.

With the above caveat in place, another finding draws attention to one kind of religious person more likely to be affected by material in a classroom on science education: religious fundamentalists (RF). Even though we in the United States know that white Christian fundamentalists (often termed evangelicals) are the group most resistant to climate change, the term fundamentalist here is not exclusively about the historical tradition of Christian fundamentalism originating from the late 19th century (for a discussion about the relationship between climate change, theology, and political identity, see Jenkins et al., 2018). In psychological research, fundamentalism signals a more general position of cognitive inflexibility with regards to religious commitments (Altemeyer & Hunsberger,

1992; Hood et al., 2005). For example, much of the research on RF's examines the correlation between fundamentalism and prejudice. It is rather intuitive in light of TMT to see that many of these results show RF's have higher prejudice towards minority groups or those deemed deviant from the religious norm, such as LGBTQ people in conservative religious spaces. In other words, when there is a challenge to the norm of a fundamentalist perspective, the individual is more prone to defensive behaviors, which in many instances manifests as prejudice (Johnson et al., 2011).

What is the connection then between RF, TMT, and science education? Students who possess more RF perspectives may be more resistant to education that challenges the theology informing their own understandings about climate science, as well as other topics such as evolution, women's health, and sex education. Educators have seen this happening for a long time already (Roberts, 1988; Lindberg & Numbers, 2008). As for the example of climate science education outlined above, moving beyond any obstacles religious perspectives may pose first requires that educators understand how religion is connected to the issue. For climate science, adding to one's pedagogical strategy might mean understanding how some conservative strains of Christian theology argue that climate action is not warranted because God promised he would never destroy the Earth after the biblical flood (Vox, 2017). In contrast to this, there is the stewardship model based on the Genesis account of God granting humans dominion over creation, and concerned students who ask questions or come to office hours might be more receptive knowing there are ways to integrate science education into their theological perspective (Prothero, 2008).

Arguing for religious literacy in the public school system, Stephen Prothero makes note of how Americans lack the most basic knowledge about world religions, including their own traditions. He started to notice this trend in the classroom over years of teaching, realizing that students over time could not follow lectures that were contingent upon knowing basic information such as what the New Testament is, or that Buddhism is a world religion. Prothero does not advocate for religious literacy for its own sake, but rather believes religious illiteracy has costs worth avoiding (Prothero, 2008). For example, George W. Bush was unaware of the differences between Sunni and Shiite Muslims, which contributed to the mismanagement of U.S. foreign policy in the Middle East in the early 2000s. For Prothero, religious literacy is actually a civic duty, and one which ideally would reduce life-threatening conflicts. Borrowing from this line of reasoning, we can say there are risks in science education when religious literacy is not built in to the broader education system, risks that lead to science skepticism and exacerbate issues of public communication about the significance of science. For some educators, the thought of being overly concerned with student religious identities may feel burdensome and unnecessary, especially when those identities are not shared by teachers in the room. Regardless of how educators feel about the relevance, silliness, severity, or veracity of religious beliefs and practices, the fact remains that educators will be contending with these aspects of their students whether or not educators are aware of a student's commitments.

In the end, what does the religious layer of identity mean for science educators, and what are we asking of them? The goal of this essay is not to articulate particular strategies for incorporating religious literacy, nor is it to ask science educators to fulfill a chaplain-like role to comfort students in light of what science has to say about the world and its hazards to human life and meaning. The goal here is to raise awareness of the important puzzle piece of religious identity for science educators, especially for those who already understand the working mechanisms of TMT in their classrooms. While understanding mortality salience and its influence on unconscious fears is insightful for any particular classroom, the burden of implementing religious literacy and other insights from TMT should not fall solely to individual educators, but rather it must be a systemic change in which the current education system places more value on understanding the role of culture on student learning. Learning never happens in a vacuum.

For science educators perhaps already taking into account the terror management dynamics within their classrooms, taking the additional step to integrate religious literacy into their terror

management literacy will build upon the steady foundation of insight TMT already offers. What this looks like across classrooms will differ, but being honest and open about conflicts between religion and science without foreclosing options for students who want both scientific literacy and committed religiosity is a crucial step. At its best, a religion-informed TMT toolkit can enable teachers to anticipate the needs and fears of students while granting teachers a deeper effectiveness in their own pedagogies. TMT researchers have demonstrated that when people feel they have solutions to address death anxiety after a death reminder, they are less likely to fall into the patterns of defensiveness that TMT research generally shows (Solomon et al., 2015). The key is making clear to students that accepting scientific findings is not diametrically opposed to religion itself. Teachers, and especially college instructors, may ask students and even themselves to bracket out various moral, religious, and ethical commitments while in the classroom trying to engage a new idea for the sake of learning. This kind of bracketing out of one's personal commitments can lead to rich, empathic learning, but personal bracketing has its limitations. Not every student or every teacher will at all times be able to set aside core elements of their cultures to become objective observers when considering topics in the classroom that directly challenge those commitments and ways of being in the world. In fact, evidence from studies on cognition and implicit bias suggest that total and conscious personal bracketing is nearly impossible because input from the environment is constant and much of it happens unconsciously (Northcote, 2004; Banaji & Greenwald, 2016). In the end, the practical outcome of taking religion seriously during science education is that educators will understand more deeply the source of religious students' anxieties, confusion, and even anger. As it turns out, the source of resistance in these cases – the deep roots of religion and culture – will not be changed with a basic presentation of more facts and figures.

The authors received no financial support for the research, authorship, and/or publication of this manuscript.

Isaac Alderman, Ph.D., (isaac.alderman@gmail.com) is an adjunct instructor at Baruch College, City University of New York. His writing focuses on examining ways in which people engage religious texts, such as examining artistic interpretations of religious scenes or even how the mind works while reading. His book, *The Animal at Unease with Itself* (Fortress Academic, 2020) uses Terror Management Theory to examine how death anxiety shapes creation stories. He is also lead author on an annotated edition of the book of Jonah, *Is it Good for You to be Angry?* (Peeters, 2022).

Kendra Holt Moore (kendraholtmoore@gmail.com) is Assistant Professor of Religion at Bethany College in Lindsborg, Kansas. Her dissertation work examines the nature of awe experiences and whether they trigger death anxiety among other downstream effects on behavior. Situated in the psychology of religion literature, Kendra draws primarily from work in Terror Management Theory and the study of emotions.

References

Akil, H., Robert-Demontrond, P., & Bouillé, J. (2018). Exploitation of mortality salience in communication on climate change. *Recherche et Applications En Marketing (English Edition)*, *33*(1), 2–29. https://doi.org/10.1177/2051570717745839

Altemeyer, B., & Hunsberger, B. (1992) Authoritarianism, Religious Fundamentalism, Quest, and Prejudice, The International Journal for the Psychology of Religion, 2:2, 113-133,DOI: 10.1207/s15327582ijpr0202_5

Armstrong, A. K., Krasny, M. E., & Schuldt, J. P. (2018). *Communicating climate change: A guide for educators*. Comstock Publishing Associates, an imprint of Cornell University Press.

Aron, A. R. (2019). The Climate Crisis Needs Attention from Cognitive Scientists. *Trends in Cognitive Sciences*, *23*(11), 903–906. https://doi.org/10.1016/j.tics.2019.08.001

Banaji, M. R., & Greenwald, A. G. (2016). *Blindspot: Hidden biases of good people*.

Becker, E. (1973). *The denial of death*. Free Press.

Carter, B. E., & Wiles, J. R. (2014). Scientific consensus and social controversy: Exploring relationships between students' conceptions of the nature of science, biological evolution, and global climate change. *Evolution: Education and Outreach*, *7*(1), 6. https://doi.org/10.1186/s12052-014-0006-3

Dickinson, J. L. (2009). The People Paradox: Self-Esteem Striving, Immortality Ideologies, and Human Response to Climate Change. *Ecology and Society*, 17.

Harold, J., Lorenzoni, I., Shipley, T. F., & Coventry, K. R. (2016). Cognitive and psychological science insights to improve climate change data visualization. *Nature Climate Change*, *6*(12), 1080–1089. https://doi.org/10.1038/nclimate3162

Henderson, J. A., & Drewes, A. (Eds.). (2020). *Teaching climate change in the United States*. Routledge, Taylor & Francis Group.

Hu, S., Zheng, X., Zhang, N., & Zhu, J. (2018). The Impact of Mortality Salience on Intergenerational Altruism and the Perceived Importance of Sustainable Development Goals. *Frontiers in Psychology*, *9*, 1399. https://doi.org/10.3389/fpsyg.2018.01399

Jenkins, W., Berry, E., & Kreider, L. B. (2018). Religion and Climate Change. *Annual Review of Environment and Resources*, *43*(1), 85–108. https://doi.org/10.1146/annurev-environ-102017-025855

Johnson, M. K., Rowatt, W. C., Barnard-Brak, L. M., Patock-Peckham, J. A., LaBouff, J. P., & Carlisle, R. D. (2011). A mediational analysis of the role of right-wing authoritarianism and religious fundamentalism in the religiosity–prejudice link. *Personality and Individual Differences*, *50*(6), 851–856. https://doi.org/10.1016/j.paid.2011.01.010

Jong, J., Ross, R., Philip, T., Chang, S.-H., Simons, N., & Halberstadt, J. (2018). The religious correlates of death anxiety: A systematic review and meta-analysis. *Religion, Brain & Behavior*, *8*(1), 4–20. https://doi.org/10.1080/2153599X.2016.1238844

Lindberg, D. C., & Numbers, R. L. (2008). *When Science and Christianity Meet*. University of Chicago Press. http://public.eblib.com/choice/publicfullrecord.aspx?p=485958

Mandel, N., & Heine, S. J. (1999). Terror Management and Marketing: He Who Dies with the Most Toys Wins. *Advances in Consumer Research*, *26*, 527.

Motyl, M., Hart, J., & Pyszczynski, T. (2010). When animals attack: The effects of mortality salience, infrahumanization of violence, and authoritarianism on support for war. *Journal of Experimental Social Psychology*, *46*(1), 200–203. https://doi.org/10.1016/j.jesp.2009.08.012

National Science Teachers Association (NSTA). (2018). NSTA Position Statement: The Teaching of Climate Science. https://www.nsta.org/nstas-official-positions/teaching-climate-science

Northcote, J. (2004). Objectivity and the supernormal: The limitations of bracketing approaches in providing neutral accounts of supernormal claims. *Journal of Contemporary Religion*, *19*(1), 85–98. https://doi.org/10.1080/1353790032000165131

Plutzer, E., Hannah, A. L., Rosenau, J., McCaffrey, M., Berbeco, M., & Reid, A. H. (2016). Mixed messages: how climate change is taught in America's public schools. Oakland, CA: National Center for Science Education. http://ncse.com/files/MixedMessages.pdf

Prothero, S. R. (2008). *Religious literacy: What every American needs to know--and doesn't*.

Religious Literacy Project. (2020). Harvard University. https://rlp.hds.harvard.edu

Roberts, J. H. (1988). *Darwinism and the divine in America: Protestant intellectuals and organic evolution, 1859-1900*. University of Wisconsin Press.

Rosenblatt, A., Greenberg, J., Solomon, S., Pyszczynski, T., & Lyon, D. (1989). Evidence for terror management theory: I. The effects of mortality salience on reactions to those who violate or uphold cultural values. *Journal of Personality and Social Psychology*, *57*(4), 681–690. https://doi.org/10.1037/0022-3514.57.4.681

Schimel, J., Hayes, J., Williams, T., & Jahrig, J. (2007). Is death really the worm at the core? Converging evidence that worldview threat increases death-thought accessibility. *Journal of Personality and Social Psychology*, *92*(5), 789–803. https://doi.org/10.1037/0022-3514.92.5.789

Solomon, S., Greenberg, J., & Pyszczynski, T. A. (2015). *The worm at the core: On the role of death in life* (First edition). Random House.

Trémolière, B., & Djeriouat, H. (2021). Exploring the roles of analytic cognitive style, climate science literacy, illusion of knowledge, and political orientation in climate change skepticism. *Journal of Environmental Psychology*, *74*, 101561. https://doi.org/10.1016/j.jenvp.2021.101561

Vail, K. E., Rothschild, Z. K., Weise, D. R., Solomon, S., Pyszczynski, T., & Greenberg, J. (2010). A Terror Management Analysis of the Psychological Functions of Religion. *Personality and Social Psychology Review*, *14*(1), 84–94. https://doi.org/10.1177/1088868309351165

Van Kessel, C. (2020). Teaching the Climate Crisis: Existential Considerations. *Journal of Curriculum Studies Research*, *2*(1), 129–145. https://doi.org/10.46303/jcsr.02.01.8

Van Kessel, C., & Burke, K. (2018). Teaching as an Immortality Project: Positing Weakness in Response to Terror: Teaching as an Immortality Project. *Journal of Philosophy of Education*, *52*(2), 216–229. https://doi.org/10.1111/1467-9752.12301

Van Kessel, C., Den Heyer, K., & Schimel, J. (2020). Terror management theory and the educational situation. *Journal of Curriculum Studies*, *52*(3), 428–442. https://doi.org/10.1080/00220272.2019.1659416

Vox, L. (2017). Why don't Christian conservatives worry about climate change? God. *The Washington Post*. https://www.washingtonpost.com/posteverything/wp/2017/06/02/why-dont-christian-conservatives-worry-about-climate-change-god/

Wolfe, S. E., & Tubi, A. (2019). Terror Management Theory and mortality awareness: A missing link in climate response studies? *Wiley Interdisciplinary Reviews: Climate Change*, *10*(2). https://doi.org/10.1002/wcc.566

Zheng, X., & Zhu, J. (2018). The Impact of Mortality Salience on Intergenerational Altruism and the Perceived Importance of Sustainable Development Goals. *Frontiers in Psychology*, *9*, 9. https://doi.org/10.3389/fpsyg.2018.01399

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 77-82

Communicating with Skeptical Audiences

Matthew Groves
Harpeth Hall, Nashville, Tennessee

ABSTRACT

As a science teacher and youth minister from a predominantly white evangelical community in rural Appalachia, I have had many opportunities to teach the science of global warming to climate change deniers. In this manuscript, I share some of the lessons I have learned to make my presentations less contentious and help those I teach be more accepting of accepted science content. Specifically, I focus on the importance of language, the prioritization of feelings over facts, and the fact that there is no single effective way to communicate climate change to all learners.

Keywords: science and religion, climate change, science skepticism, communication

Editors' Comments

Matthew Groves (2019-2021 Fellow) *is a self-described devout Christian from Southern Appalachia and a physics teacher. He has spent many years communicating the science of climate change with skeptical audiences in schools, churches, media, and professional conferences. His insights into effective communication with climate change deniers are critically important to science teaching in the age of the Anthropocene, especially in light of the current war on science and the politicization of scientific issues so prevalent in the U.S. We hope this manuscript will prove helpful to our readers who teach critical science content such as climate change.*

Introduction

In the many years since James Hansen - then the Director of NASA's Goddard Institute for Space Studies - testified to congress in 1988 warning about the dangers of human-caused global warming, the scientific community has made many strides in our knowledge about climate change (Shabecoff, 1988). The UN's Intergovernmental Panel on Climate Change has produced five massive documents compiling the hundreds of thousands of hours spent in climate research, laying the case bare for all to see: the climate is indeed changing, it is indeed due to human activity, and it is a serious problem. However, many in the climate community ask themselves over and over: "*why have we done so little to address this? The data is so clear! The results are overwhelming! How can they not see?*" Despite some positive trends in public opinion and the modest successes of various national governments, it is indeed hard to avoid the impression that humanity is losing the fight for climate action.

Having grown up in a white evangelical community in rural Appalachia, I have personally come across quite a few people who might be called *climate deniers*. In my time as both a youth minister and a science teacher, time and again I have experienced a small-scale version of the problem: *the data is clear, so how can people remain unconvinced?* I came to realize that the in-house methods of science communication that I was taught in university - with an emphasis on data, process, and rigor - routinely failed me in conversations with skeptics. Instead, I leaned into the communication skills I developed as a teacher and a pastor and have found significant successes with audiences of all ages,

denominations, and acceptance levels of climate science. I hope to share my lessons learned about language, emotion, and strategy with the aim of letting you learn from my tedious mistakes and help the American scientific community move towards a more productive and effective approach in the years to come.

Language Matters

Language is an area where educators can grow to more effectively reach out to others. Any type of communication is a subtle, complex endeavor. We have all been misunderstood, or agonized over word choice in a delicate message. Even when disregarding topics that carry political baggage, science education can be fraught with difficulty when communicating technical knowledge to a non-specialist. Within a specialist community, we develop specialized language to refer to incredibly precise topics quickly. By itself, jargon is a good thing! It allows for efficient communication within the community. However, we often come to rely on this specialized vocabulary to such an extent that we forget that others lack knowledge of the words and concepts they describe.

Communicating with non-specialists without using your own terminology is a necessary skill for climate change, but it's also a good activity in general. Perhaps a few words are worth the effort to explain, but overall we should strive to avoid all language used purely in our field. Although there may be some exceptions, the maxim holds true in general: if you truly understand your work, you should be able to explain it to a child. The rise of Plain Language Summaries is a very welcome trend on this topic.

Using esoteric language can be even more ostracizing for non-specialists than we may realize; this is why many activists rightly focus on language and its consequences. However, it is also true that placing a high premium on using correct language will limit your ability to be heard; if the language you rely on is something you learned in graduate school, anyone without a masters degree will be hard-pressed to understand your talking points.

These gaps in technical literacy appear in surprising places. As a current high school science teacher, I can anecdotally confirm studies like this one pointing out that most adult Americans cannot accurately read logarithmic graphs, despite their widespread use in displaying COVID information throughout the pandemic. If my high schoolers struggle to master some of the finer points of graph analysis, how can we expect someone to do better if they haven't closely analyzed a graph in decades? Our audience members may even be specialists in a type of language that is directly tied to climate action (financial policy, or agriculture, etc), but not in another. Especially when we add in other layers of technical language tangentially related to climate - like justice and ethics, risk, economics, policy, or health impacts - we risk using multiple sets of jargon simultaneously, and we lose audiences.

Words also mean different things in different contexts, which is especially tricky if there is a cultural gap between the communicator and the audience. Knowing more about your specific audience (see part 3 below) will certainly help, but I also have learned to choose my words very carefully. One solution for this is to avoid tripwire words. How we say things really matters, even if the underlying concept is the same. This lesson is used often in politics, as speechwriters often try to avoid words with negative connotations, but we can certainly apply the lessons to climate change as well. Some people I talk to are still very hung up on the distinction between global warming and climate change, believing that the shift in vocabulary reflects the shakiness of the underlying science. To get around this problem, oftentimes I completely avoid using these terms. I often finish a full hour Sunday School class without using either, but end up in a place that's much closer to where I want our conversation to culminate. We spend time talking about humanity's relationship with God, each other, and nature, and therein I've been able to spark much more interesting conversations, which are fundamentally tied to climate change, than if I had started with throwing in those words initially and triggered someone's sensitivities. If we can arrive at the conversations we want without tripping people up, all

the better! This isn't being dishonest, it's just smarter communication. In my own work, if I walk into a church and trigger every audience member by leading with the climate-related issues that are sticking points for this community, no one will listen to me. This is true regardless of how central those tangential topics really are to solving the climate crisis - like its intersections with race, economics, gender, etc. When I plan my lessons, I think to myself: *"Here are the 8 words that will stop half of the audience from listening to me. How can I cover these concepts without saying those words?"*

In summary, language matters and we should try to avoid language that has bad connotations - as jargon, or because of its political/theological baggage - for our audiences. This not only helps us communicate towards better climate action, but also contributes to a better public understanding of science more broadly, which in turn benefits public health, scientific funding, and recruitment for the sciences.

Feelings and Facts

Science is deeply concerned with the pursuit of objective, statistically-sound, data-driven conclusions. Unfortunately, people are not. As scientists, we have been trained to think a certain way, with certain assumptions about things like peer-reviewed literature, certain ways of communicating, and a certain etiquette. The realization that others are not only indifferent, but perhaps even hostile to the foundations of your life work can be demoralizing.

History has made clear that the answer for building support for climate action is ***not*** providing the public with more graphs. The people who were going to be convinced by data have already been convinced by data years ago. What we sometimes call the *fact deficit model* - in which we simply need to shout facts to people ever more loudly - does not seem promising. Over three decades have passed since Director Hansen's testimony before Congress announced to the public that humans are responsible for global warming; although our scientific understanding has certainly become more robust since then, the basic scientific story has not changed in 30 years. If this was purely a scientific issue, we would have solved it years ago. But the lay public does not respond to scientific data in the way that scientists do, so we need a different approach.

This is why it is not effective to arrive at a class for non-specialists (like the Sunday School classes I teach, or meetings for politicians, or non-major students, or the public) with a slide deck with dozens of graphs from recent literature, because *they won't care.* This can be incredibly disheartening, but is true. But what is our alternative?

The Climate Reality Project, founded by former Vice President Al Gore and one of the largest climate non-profit organizations in America, provides a good example of fruitful next steps. Al Gore frequently presents the most famous slideshow in the world, which is over 90 minutes. There are significant amounts of data in the presentation, which you can view online, but they are almost always paired with pictures of people showing how the data affects their lives. This approach is shared by organizations like the Climate Visuals, who have reached this conclusion from significant research.

If we lead with data and only data, anyone who isn't a specialist will quickly lose interest. Before we have even properly begun we have already lost our most important target audience members. Perhaps they feel embarrassed because they cannot read the chart, or don't remember how the axes work, and are not brave or invested enough to ask a question. These may be people with high school or even college educations who simply never analyze data - data analysis is a skillset that can be lost, just like a language.

As an example, this visualization from the Wall Street Journal shows the overwhelming effectiveness of the measles vaccine in preventing infections (DeBold & Friedman, 2015). It elegantly conveys a significant amount of data - 26 states over nearly a century - organized into a central argument: the vaccine worked. However, it's also a disorienting graph for people without practice in analysis. The x-axis is time, which is a common enough choice. But what is the y-axis? Nothing. To

condense so many states into one visual, the editor abandoned the simple choice - a linear y-axis referring to the number of cases per year in each state and producing one graph per state - in favor of a colormap for the dependent variable. Is this a bad graph? Of course not. I'm actually rather fond of it. But it does require more effort from lay people than we might expect, and more often than not those laypeople will not provide the effort. Instead of leading with data like this, I have had much more success by leading with connections to other sectors of human life. For my audiences, this often means the Bible. I walk into Sunday School carrying my thick, red, well-worn New Oxford Annotated Bible - the default Bible for academics - and make sure to mention that I went to seminary. I open with a prayer and stay for the coffee hour or worship service afterwards. In short, I show them that I care about what they care about. This can be anything! If they have any kind of humanitarian interest, or fascination with nature, or like to ski or fish. Or perhaps they farm, or vacation at the beach, or have allergies. Because climate change affects so many parts of our world, it allows almost infinite possible approaches. Find one that applies to your audience and use it.

The problem seems to be that people don't care enough about the facts they do have, not that they lack facts. We need to find more ways to reach people that don't rely on graphs and Excel tables. This is disheartening for scientists, because that data is our lifework, but we must adapt. Learning from Al Gore's presentation, before using the Wall Street Journal visual during my vaccination talks, I first share a picture of a Danish tombstone, which includes the names of five siblings, ranging in age from 2 to 15 years old, who all died during a diphtheria outbreak in 1903 (McCloskey, 2018). The human suffering conveyed in the photo garners much more audience attention, which makes them much more likely to try and understand the more complex graphs like the WJS visual.

No Silver Bullets

We often sort people into two simple categories: *science believer / acceptor* or a science *denier*. Reality is rarely so simple, and most people don't fall neatly into either category. In my experience, people are much more likely to fall onto a spectrum for many scientific issues in addition to climate change (evolution or COVID are good examples). Yale's Program on Climate Change Communication conveys this excellently in a program they call Global Warming's Six Americas," which has empirically sorted Americans into six sub-groups: *alarmed*, *concerned*, *cautious*, *disengaged*, *doubtful*, and *dismissive*.

By splitting the country into more than two groups, Yale gets at an important truth: there are many types of denial and each requires its own special type of communication. If we cannot differentiate between groups, we won't be able to reach them well. To borrow a metaphor from my Appalachian roots, there is no single *silver bullet* of climate communication, but rather *silver buckshot*, which is a cluster of BBs cased together that spread out after firing. Instead of one message for all people, we need to recognize the subtleties of specific audiences and tailor our messages to them.
I encourage you to look through the description for each group and ponder where you would fit in (there is also a brief survey that will categorize you automatically). But just as importantly, try to think of someone in your life who fits into each category, and how you would try to reach them in different ways. My communication strategies are very different for each group. When approaching a crowd of mostly those in the *concerned* group, I know they will be mostly receptive and perhaps be looking for local opportunities to become more involved. However, for *doubtfuls* and *dismissives* I have to prep extremely well and must be very cognizant of any verbal tripwires that might alienate my audience.

In activism circles there's a common saying, *everyone brings one*, meaning each member should bring one other member to an event, doubling the attendance. I have adopted a twist on the expression: *everyone moves one*, meaning we should focus on moving someone one rung along the Six Americas at a time. Persuading a *dismissive* person to attend a climate rally in one conversation is never going to happen. If that is our expectation, we will always be disappointed. However, we can perhaps

shift someone from *dismissive* to *doubtful* over the course of a few respectful conversations. In my own work, that is a common goal: moving someone from *dismissive* to *doubtful* or perhaps even *cautious* over the course of a Sunday School series.

And if nothing else, I can aim to preserve the relationship and their respect for me. In certain environments, all I can do is leave my audience of *dismissives* thinking, "*Well, he was wrong about everything, but he did seem like a nice young man who loved the Lord, so he can't be all bad.*" That may have only moved them a few decimal points along the ladder, but it has kept open the relationship and made them much more likely to come to me with questions later; I may be their only climate-focused contact, and I can't afford to throw away that possible connection. Over the course of a longer study perhaps I can move them a little and perhaps I can't, but if I don't have my expectations re-oriented, I will always be disappointed. In climate activism, the Six Americas are represented by various organizations. Groups like the Sunrise Movement have shifted many young people from *concerned* into *alarmed*, while organizations like Citizens Climate Lobby have tried to move *dismissives* or *doubtfuls* into *cautious*.

Tailoring our message to specific groups requires us to better understand their moral foundations. Psychologist Jonathan Haidt has written a book (Haight, 2012) and given a TED Talk about the different moral frameworks of conservatives and liberals, and studies confirm that communicators experience success when framing their environmental arguments in terms of traditionally conservative values like loyalty, patriotism, sanctity, and purity.

Some scientists and science educators say, "*I don't care what religion/politics/etc my audience has, science should be objective.*" And of course science seeks objectivity and is true regardless of where you are or your cultural background. But if we are trying to reach someone, they will never receive our scientific knowledge if we cannot reach them personally.

Conclusion

As a concluding thought, I encourage you to reflect on a time when you changed your mind about something important to you. In our line of work, perhaps you did revise a scientific opinion when presented with new data. Bravo! But especially in our personal lives, we are often spurred along by respectful conversations with people we trusted. In my experience, this is also the most effective path for science communication. Prolonged respectful dialogue is certainly the road less traveled in today's culture and much more demanding than other options, but I believe it may be our most promising option for science communication today.

The author received no financial support for the research, authorship, and/or publication of this manuscript.

Matthew Groves (matthew@matthewdgroves.com) is a science and faith educator from rural Appalachia. He has worked in youth ministry and is currently a high school science teacher in Nashville, TN. He serves on the steering committee for Young Evangelicals for Climate Action and the Tennessee chapter of Interfaith Power and Light and has been featured on NPR. You can learn more about his work and invite him to speak at your church or gathering at matthewdgroves.com.

References

DeBold, T. & Friedman, D. (2015, February 11). Battling infectious diseases in the 20th Century: the impact of vaccines. *Wall Street Journal.*

Haight, J. (2012). *The righteous mind: Why good people are divided by politics and religion.* Random House, Inc.

McCloskey, J. (2018, January 22). Haunting photo shows why vaccinations are a good thing. *Metro.*

Romano, A., Dominion, G., & Guidi, S. (2020, May 19). The public do not understand logarithmic graphs used to portray COVID-19. *LSE School of Public Policy*.
Shabecoff, P. (1988, June 24). Global warming has begun, expert tells senate. *New York Times*.

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 83-88

Called to Care, Trusted to Teach: The Role of Hospital Chaplain in Educating Patients, Families, and Medical Staff during a Pandemic

Rev. Casey Bien-Aimé
Lankenau Medical Center

Rev. Kristel Clayville
University of Illinois at Chicago

ABSTRACT

The theory and practice of spiritual care has transformed over the years. Chaplains have broadened the definitions of their work, formalized spiritual assessments, and gained greater understanding of multi-faith and interfaith support. In 2020, the COVID-19 pandemic forced a new shift in thinking specifically causing many healthcare chaplains to add technology and phone support to their practice. Spiritual care was offered by telephone, video application, recorded religious services, and many other creative/socially distanced interventions. Chaplains are trained to adapt. They quickly formed support networks, shared their ideas and plans, and built a new foundation to withstand new issues that arose in 2020. In this article, we describe how chaplains were able to pivot quickly into new aspects of their role, teaching and learning from other spiritual care communities across the country, and how they have been called upon to educate their healthcare communities in a new landscape created by the pandemic.

Keywords: science and religion, chaplaincy, COVID, pandemic, spiritual care,

Editors' Comment

Rev. Casey Bien-Aimé (2019-2021 Fellow) *is the Spiritual Care Coordinator and Endowed Chair of Pastoral Care at Lankenau Medical Center where she brings awareness to the importance of incorporating spirituality in healthcare.* ***Rev. Kristel Clayville, Ph.D., (2019-2021 Fellow)*** *holds a doctorate in Religious Ethics from the University of Chicago's Divinity School and is ordained in the Christian Church, Disciples of Christ. Throughout the COVID-19 pandemic, she served as a chaplain and ethicist at the University of Chicago Medical Center with a focus on the existential and spiritual issues facing organ transplant patients. In this contribution, they share how their challenges in bridging the communication gap between doctors, patients, families, hospital staff, and other healthcare advocates and how their methods of care and communication had to change due to the COVID-19 pandemic. While hospital chaplaincy looks quite different from traditional K-16 science education, we think the ways they adapted to the difficult times of the pandemic can resonate with reflects and may inform the changes required of science educators as well.*

Introduction

The theory and practice of spiritual care has transformed over the years, especially as hospital chaplains integrated into interdisciplinary medical teams. Chaplains have broadened the definitions of their work, formalized spiritual assessments, and gained greater understanding of multi-faith and interfaith support. In 2020, the COVID-19 pandemic forced yet another shift in thinking about how

to support patients in isolation and how to connect families to their loved ones. Many healthcare chaplains added technology and phone support to their practice. Spiritual care was offered via telephone, video application, recorded religious services, and many other creative socially distanced interventions. Chaplains are trained to adapt. They quickly formed support networks, shared their ideas and plans, and built a new foundation to withstand the new challenges that arose in 2020. While many still associate the term *chaplain* and even *spiritual care* with Christianity; professional chaplains serve in an interfaith/multifaith capacity. We serve all members of our community, those who identify with a formal faith tradition and those who do not. We help patients, families, and staff connect to what gives them strength and hope and help them make meaning from uncertainty. As chaplains we visualize ourselves as standing in the gap between patients and their medical team, between family members in disagreement, and between our hospitals and the communities we serve. Many of us helped with communication when patients and doctors seemed to be speaking two different languages. This kind of communication work is foundational to the role of the chaplain and to the functioning of hospitals. The pandemic brought about changes in clinical practice that created opportunities to educate and to further be the bridges that connected different value systems. In this article, we outline how chaplains pivoted quickly into new aspects of their role and how they have been called upon to educate their healthcare communities in a new landscape created by the pandemic. We will focus on the chaplain's communication with four different groups: patients and families, medical teams, hospital operations, and the broader community.

Initial Impacts of the Pandemic on Spiritual Care

On March 13, 2020, hospitals all over the country learned that the virus we had heard about and feared, had officially caused a global pandemic. Hospital teams had been hearing murmurings of the novel virus and its impact in other countries, and even how it was affecting our Pacific coast colleagues, but with the CDC officially declaring this a pandemic, many of our hospitals changed their practices and shifted to new methods of giving care.

The chaplains at hospitals caring for COVID positive patients, in the early days of the pandemic, were navigating many changes, both in how we would practice and the rules the hospitals would follow. Due to limited PPE and overall uncertainty about how this novel virus spread, at first many chaplains were not permitted in the rooms of our COVID patients. We found new ways to support families over the phone, and to offer meaningful rituals from doorways and windows. Chaplains educated the medical teams on the go. There was limited time for didactics and presentations at nursing huddles. We explained our practices as we did them. We charted clearly. We updated policies posted online and in the nursing units. The question everyone in the hospital was asking was, "Am I considered essential staff?" For chaplains, the answer was not straightforward.

While a chaplain is not providing support for physical/medical needs of our patients, our role has remained crucial during the pandemic. A chaplain's work is often in person and physically close. We sit in rooms, offering listening, conversation, ritual, and prayer. Our practices can have extended periods of silence, and our rituals and prayers often involve touch and closeness. The way chaplains practice was completely upended with the guidelines we would need to follow during the pandemic. Touch was off the table. Long encounters increased risk of contracting or spreading the virus. When staff received communications about possible exposure, we were asked if we had worn our PPE, stood six feet away, and if we were in the room longer than 15 minutes. Chaplains and spiritual care professionals at the beginning of the pandemic had to continually update our roles and responsibilities to adapt their practice for the health and safety of the communities we served. Our first major change in our practice centered around communication, particularly communicating to patients and their families.

Communication with Patients and Families: Tele-Chaplaincy

The chaplain stands in a room, gowned, gloved, masked, and shielded. He is holding an iPad. He sometimes props the iPad on the tray table to give his arm a rest, as the family sings hymns, reads scripture, and prays for their mother lying in the bed. On the days that she is more alert, he holds the iPad for her, so she can mouth her responses to her family. He brings the iPad close to her so they can hear her better over the beeping machines and general noises in the hallway. Occasionally they ask the chaplain to pray, or help read her lips, when her voice is too weak. But mostly, they forget that someone else is in the room. In these precious moments it is just mother and children, looking into each other's eyes, listening to each other's voices, longing to be in the same room again.

Traditionally, chaplains provide support to families of hospitalized patients. Many hospitals stopped visitation altogether, and those who did not, severely restricted it to short visits, and often only at end of life. With many of our patients intubated or on breathing treatments, out of breath, tired, or even prone in bed, our time spent at bedside was now split with time calling families who longed to be present with their loved ones.

In a profession where eye contact, silence, and body language are major parts of our tool kit, offering presence and support over the phone became a challenge for many. Chaplains had to translate their usual skillset to phone and video calls with family. One of the first areas to adjust was our opening lines and scripting. Families receiving calls from hospital extensions were answering with fear and anxiety. In our typical conversations we would have time to explain our work and communicate our role – with phone calls, we were battling with the loved one's fear that a call was coming to report bad news. We began our calls with words like, *non-urgent* and *routine*. We centered ourselves before calls, making sure we were calling from a quiet place, where we were not out of breath, rushed, and where we could communicate calmly through the phone lines. We learned how to narrate the silence. Where we could usually communicate our comfort with silence through our bodies, we had to explain the silence with words, saying things like, "*I hear the silence in our conversation. I'm giving space in our pauses so you have time to process and think. I am not in any rush. But if the silence is uncomfortable or you are silent because you don't want to talk about this over the phone, we don't have to continue this conversation here.*" Our closings also had to be clearer and more deliberate. Where we would normally say, "*Have your nurse page us*." We now had to encourage them to write down our contact information (and to have other departments' contact information available as they often asked us for assistance in navigating communication with so many departments serving remotely). While this has not been the way we like to practice our calling, chaplains have added these and many other tools to our presence tool kid, allowing us to better serve those who need to use the phone or video applications to connect to us.

For those chaplains who were given permission to get N95s and use additional PPE, our role as tech support increased greatly during pandemic. Many of us walked around with phones and tablets that used applications like Facetime, Zoom, and Doximity. We helped families celebrate birthdays, view or plan funerals and memorial services, and facilitated family meetings and interdisciplinary calls. Spiritual care departments partnered heavily with information technology and audio-visual departments. We trained on different operating systems so we could support the nurses and other staff who were also using the technology more than ever before. Even chaplains who identified as technology natives were stretched thin, trying to educate patients, families, and staff on the new technology that was not an everyday part of their lives.

Communication with Medical Teams: Notes as a Form of Education

A palliative care team is beginning their day by discussing their list of patients. The list is three times its normal length – small print on multiple pages. Symbols and highlighter marks on each page help organize their day, with bold letters noting which patients are COVID positive. The chaplain peaks her head in the door and apologizes that she

can't sit in on the team meeting, that she is running to the Emergency Department for a trauma. They lament together as they think about how devastating it is to watch so many die and be debilitated by the virus on top of the regular trauma, illness, and loss seen in the hospital. The chaplain reminds them to check her notes as she runs out the door. As the team runs the list and meets with family (in meetings or by phone) they check the chaplain's notes to assure them of the chaplain's presence. "Yes, ma'am, I see the chaplain's note. The priest gave your mother Last Rites last night." "I'll put in a request with the chaplain to read that poem to your husband." "I see a note here that the chaplain posted pictures of you and your son in the room, with quotes from his favorite movie to inspire him. Is there anything else you'd like from their team?"

With the use of the electronic medical record (EMR), reading interdisciplinary notes has never been easier. For Spiritual Care departments who use these charting systems, our notes have become more visible and a great way to educate staff about our role. At the height of the pandemic, the days often felt like a blur. With multiple deaths a day, countless family meetings, and a long list of phone calls to make, chaplains were not able to do the in-person conversations with our nursing teams. Where we would once round with the medical team, or chat after nursing huddles, many chaplains found ourselves having to trust that the note was being read and our work was being seen in black and white on the screen.

We have used Spiritual Assessments to clarify how we are supporting patients and families. Dr. Gowri Anandarajah (2005) defines Spiritual Assessment as "methods to identify a patient's spiritual suffering and spiritual needs related to medical care" (p. 372). It takes many forms, with a variety of acronyms used to delineate the questions and conversations between spiritual care professionals and the patient/family we are serving. We assess faith tradition, connection to community, rituals and practices that bring healing, and how the team can support those healing practices. These succinct, yet detailed notes were ways of educating the team on what spiritual care does in general and in light of the virus.

Communication with Hospital Operations: Collaboration with Infection Prevention about Rituals in the Hospital

On March 6, 2019, a chaplain is seen standing outside the hospital's prayer/meditation room. She is wearing a clerical collar and holding a small container of ashes. It is Ash Wednesday, a holiday on the Christian calendar that begins the season of Lent when many will attend services, start a form of fasting, and have an ash cross on their forehead. For hospital chaplains that serve large Christian populations, it can be one of their busiest days of the year. Wearing a glove on her right hand, she dips her thumb in the ash, marks the head of the person in front of her, and offers a prayer. Some of the staff and families make special prayer requests, some cry and hug the chaplain, many thank her, citing that their 12-hour shift always prevents them from attending their religious services.

Fast forward to February 26, 2020 – that same chaplain now looks very different. She now wears scrubs and sneakers. She has a bottle of hand sanitizer in her pocket and a bag of pre-ashed cotton swabs in a canvas bag. Cards with special Ash Wednesday prayers are laminated and placed in plastic baggies. Staff are not permitted to line up at the hospital's prayer room. Instead, the chaplain schedules times to visit each unit. Directs staff not to congregate at the nursing station and to keep distance. Those who want the chaplain to administer the ashes stay distanced for the prayer, they move together as the chaplain sanitizes her hands, removes a cotton swab from one of her many bags, dips it in the ash, marks the staff person's forehead, and discards the used swab in a bag marked for incineration. Some staff ask for the pre-bagged ash swabs to self-administer, others ask for the baggies in order to bring this blessing to isolated family members at home. Honoring this ritual always made for a long day, but now, the process needed to keep her community safe, makes her day even longer and more complicated. With months of preparation, countless emails with administration and leadership, meetings and discussions about emotional needs and physical risks, and finally a week of late-night bagging and preparing the materials. The chaplain completes this one-day ritual exhausted but honored to give some semblance of normalcy to an emotionally and physically exhausted community.

Hospitals are known for their celebration weeks: nurses week, spiritual care week, hospital week, and many more. These are opportunities to educate the hospital community about the services provided by these professionals, but also a time to thank and support the professionals in those fields. Nurses week 2020 was celebrated May 6th through the 12th. Hospitals were at a loss for how to acknowledge the week. The awards and dinners could not be in person. The meals and treats couldn't be eaten together. And for the chaplain collaboration, the blessing of the hands, had to be completely re-thought. In the past, chaplains would round the hospital with oil or holy water, sometimes with a ritual including small wooden hearts, ribbons or colored paper. Chaplains would greet the medical teams, hold their hands, and bless them. The ritual was always moving, and sacred. But how do you offer this intimate blessing from six feet apart?

Chaplains had to collaborate with Infection Prevention (IP) at our hospitals to ensure any practice they offered was safe. To facilitate these conversations, chaplains would provide a range of options to the IP team. Often having to explain the history and background of the rituals. Each spiritual care department has their own philosophy of spiritual care. For departments that utilize a multi-faith approach, many holidays are honored - often depending upon the patient population served by the hospital. Chaplains find creative ways to help patient's honor their holiday while being mindful of the restrictions and limitations of being in the hospital. For Ash Wednesday, a holiday honored by many Christian denominations, chaplains will often collaborate with the community to distribute ashes to staff and patients who are unable to make it to their respective faith community. For Passover, the chaplains have assembled and distributed bags of *Kosher for Passover* treats, and a *Kosher for Passover* menu for the Jewish patients. During the month of Ramadan, some chaplains would deliver date bars and blessings for Muslim staff and patients to break their fast at the end of the day. These are just the tip of the iceberg when it comes to honoring local faith traditions, especially in hospitals that serve diverse communities. For chaplains who practiced this multi-faith approach, each holiday practice had to be re-evaluated by the department and approved by the IP team and the command center. With each holiday and ritual, the administrators making the decision needed to be educated about the significance and importance for patients. Often decisions were changed, edited, and debated many times before approval.

Communication with the Broader Community: Educating Community Clergy

On March 10, 2021, a hospital system honored the one-year mark of their first COVID + patient and the hundreds of patients who had died that year. On that same day a local church was offering second doses of the Pfizer vaccine to their community. As socially distanced patients sat in folding chairs in their parish hall, the local hospital chaplain dropped off prayers for the vaccine and knitted hearts for the medical professionals. The pastor of that church offered a prayer, as the vaccine distribution team played a streamed service over their laptops. With tears in their eyes, and hope in their hearts, the congregation and community were able to hold both their hopes and fears at the same time. With pastors, chaplains, and medical professionals working together, the community was given space to process the complexity of emotions that came with a year of quarantine and immense grief.

The education provided by chaplains was multi-directional. While chaplains often are used to train medical professionals and hospital administrators about religious and cultural needs, they also help connect with the community, particularly local faith communities, to educate local clergy and faith leaders. Chaplains serve on interfaith councils, ministeriums, and town councils. Many religious leaders have routines of reaching out to sick and hospitalized congregants and community members. With the pandemic, many hospitals limited or even completely restricted these visitations. Such restrictions forced chaplains to be even more mindful of the broad approach and understanding of diverse religious practices and rituals. While some clergy were able to use zoom and facetime to connect with their congregants, many relied on chaplains to offer the rituals expected by their parishioners.

As vaccines began to roll out, chaplains served on vaccine confidence committees and helped support community vaccination sites. They offered written and extemporaneous prayers for those receiving the vaccine. They bridged the gap between the medical/scientific community and the religious/spiritual. As healthcare chaplains look ahead, we hope to continue to care for our local communities to offer grace and guidance to navigate the complexity of spiritual and physical health.

Conclusion

One of the foundations of spiritual care education is communication; specifically, our ability to understand what is going on with ourselves, and to help share those understandings with and between others. Because of this internal work, spiritual care professionals have anticipated and weathered change well. Whether supporting the changes in a patient's life or bearing witness to the changes in the healthcare landscape, a chaplain acknowledges the many transformative moments faced in the hospital. Because of the training and skills of chaplains, this profession created new ways to support their sites, in a time of uncertainty. They created and re-created in the face of changing rules and roles.

Communication is key to the practice of spiritual care. We communicate about difficult topics; one's deep feelings, existential thoughts, conversations around death and dying, and much more. When the pandemic hit, chaplains used that foundation of communication to build, grow, and reform their own practices to better serve their communities. There was no one way to be a chaplain in a pandemic, but what united spiritual care professionals across the world in 2020, was the ability to adapt and educate as we went. We hope to never face a pandemic or disaster of this magnitude ever again, but if we do, the chaplains are ready to tend, transform, and teach through whatever comes our way.

The authors received no financial support for the research, authorship, and/or publication of this manuscript.

Rev. Casey Bien-Aimé (Bien-AimeC@mlhs.org) is ordained in the American Baptist denomination, endorsed and commissioned as a chaplain from her ordaining body. She received her undergraduate degree in Religious Studies/Biology at Drew University, her seminary training at Palmer Theological seminary, and Clinical Pastoral Education at Thomas Jefferson University Hospital. She has served as the Spiritual Care Coordinator at Lankenau Medical Center since 2015, where she has helped build the Spiritual Care Department. Rev. Bien-Aimé has a passion for interfaith work and interprofessional dialogue that has fueled many collaborative efforts within her health system and community.

Rev. Kristel Clayville, Ph.D., (kclayvil@uic.edu) is ordained in the Disciples of Christ denomination, and served as a hospital chaplain during much of the pandemic. She received her masters, doctoral, and fellowship training at the University of Chicago, and completed Clinical Pastoral Education at Northwestern University Memorial Hospital. Currently, she spends most of her time teaching technology ethics in the College of Engineering at the University of Illinois at Chicago, where she also teaches religion and medicine in the medical school.

References

Anandarajah, G. (2005). Doing a culturally sensitive spiritual assessment: Recognizing spiritual themes and using the HOPE questions. *AMA Journal of Ethics, 7*(5), 371-374. doi:10.1001/virtualmentor.2005.7.5.cprl1-0505

ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 3, 89-103

Communicating Religiously and Culturally Sensitive Science Content

Mark A. Bloom
Dallas Baptist University

Ian C. Binns
University of North Carolina at Charlotte

Lee Meadows
Alabama STEM Council

ABSTRACT

In this manuscript, three science educators describe strategies used to effectively communicate about religiously and culturally sensitive science content and share lessons learned from their experiences. Mark A. Bloom (2019-2021 Fellow) describes the challenges he overcame in teaching climate change science at an evangelical university by creating an environment of trust and "speaking the language" of his audience. Ian C. Binns (2017-2019 Fellow) shares his experience, as a white person, learning to look at an issue from alternative perspectives when discussing environmental racism on the Down the Wormhole podcast with people of color. Lee Meadows describes his efforts to teach human evolution in the American South. His success derives from his emphasis on students acquiring understanding of evolution, rather than convincing them of its truth, created a safe and respectful environment for learning.

Keywords: climate change, evangelicals, environmental racism, human evolution, religiously sensitive, culturally sensitive

Editors' Comment

***Mark A. Bloom, Ph.D., (2019-2021 Fellow)**, is a Professor of biology and science education at Dallas Baptist Univeristy. **Ian C. Binns, Ph.D., (2017-2019 Fellow)**, is an Associate Professor of elementary science education in the Department of Reading and Elementary Education in the Cato College of Education at the University of North Carolina at Charlotte. **Lee Meadows** is an Associate Professor of secondary education at the University of Alabama and is the Executive Director of the Alabama STEM Council. While Lee has not participated in a Sinai and Synapses Fellowship (yet?), we wanted to bring his expertise in human evolution education in the American South to this article about teaching religiously and culturally sensitive science content.*

Introduction

Education is all about change – if one's understanding of the world is not growing, it is deteriorating (Wheatley, 2006). However, change is oftentimes difficult and human nature finds comfort in the familiar and is, therefore, often resistant to such change. Further, individuals' cultural values and accepted behaviors within a group are deeply important to how they operate (Kotter, 1996) – these too can impede their willingness to change. Haight (2012) metaphorically describes two

motivations that guide human behavior as an elephant with a human rider on its back. While the rider might appear to be guiding the direction in which the pair is moving, it is the elephant who truly has control - if you frighten the elephant, it really doesn't matter what the rider tries to do, the elephant goes where it wants. With regards to our motivating factors, the elephant represents our deep-seated, evolutionary-based, primal guiding mechanism that exhibits itself through gut-instincts and reflex responses. The rider, by contrast, is a much more recently derived motivating mechanism that operates from our rational brain and employs logic and critical thinking skills to justify our behaviors and beliefs. Haight (2012) asserts that too often, when attempting to influence others, especially when it relates to rethinking deeply-held convictions or social norms within a group, leaders are talking to the rider, who's very purpose is to justify the current behavior – in other words, to maintain status quo. In a world where '*we've always done it this way*' is comfortable and '*let's try something new*' can induce anxiety, talking to the rider is often the wrong strategy to influence change. Instead, Haight says we need to speak to the elephant and change the underlying powerful impulse.

When teaching religiously and culturally sensitive science content to religious communities, it is important to communicate in such a way that one can avoid *frightening their impulsive elephant* while, at the same time, helping the learner consider new perspectives with their *rational and logical rider*. For example, if a science teacher began her unit on evolution by saying something like *"Students, whatever you learned in Sunday school about Adam and Eve and all the animals really doesn't matter. It's time to learn the real origin of species."* you can be sure that a subset of her students are already shutting down and learning will not occur. Instead, if the teacher uses a more religiously-sensitive approach and says something like *"Students, while some may not agree with the biological theory of evolution, I think we should all at least understand what it is and what evidence scientists have by which it is supported."* then even religiously-conservative students who may have strong misgivings about evolution may be more willing to listen and learn the science behind the theory. From my personal experience, I have seen many students who are surprised to learn exactly what the theory of evolution is (and is not) - it often does not match what they have learned outside the science classroom. Once they learn the accurate science of evolutionary theory, they can then make their own determination of whether or not it can reconcile with their religious beliefs. In *Epistemology: The Justification of Belief*, Wolfe (1982) describes this process – once a person realizes that their present concept is insufficient (e.g. science is anti-Christian or scientists are atheists), the only honest thing to do is to discard the old idea completely or to make some big adjustments to it that incorporate the newfound understanding. Piaget (1980) describes this process as recognizing a contradiction and then, through assimilation or accommodation, creating a more authentic cognitive schema. This process is the existential challenge facing a science educator when teaching religiously sensitive content. In the present paper, we will describe our strategies for teaching religiously and culturally sensitive science content in three distinct settings. Mark will share his experiences teaching climate change science to conservative evangelicals at a Christian university. Next, Ian will talk about his experience addressing environmental racism on the *Down the Wormhole* Podcast. Finally, Lee will share his efforts teaching human evolution in the American South.

Teaching Religiously-Sensitive Content in Christian Higher Education [Mark Bloom]

My favorite class to teach is biology for non-science majors. In this class, I have students from all colleges on campus and I know that this is likely the last science class they will ever sit through. In this survey course we cover topics including human body systems, genetic medicine, ecology, evolution, and anthropogenic climate change and I consider this a last chance opportunity to clear up some misconceptions about science. My students are predominantly conservative, evangelical, Christians (from various denominations) and many have skeptical views of science - especially regarding topics such as physical and biological origins, biomedical advances, and climate change. To address this skepticism, I integrate nature of science (NOS) into my teaching throughout the course

and pay particular attention to students' religious backgrounds and the concerns I know they bring with them to the classroom (Bloom, 2021).

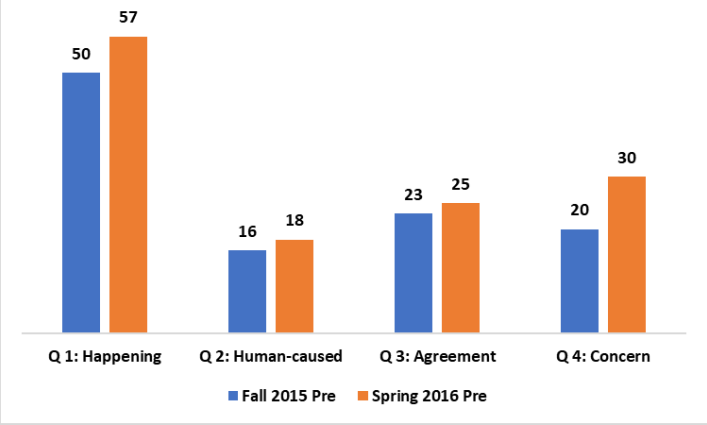
While many may not consider climate change a religiously-sensitive topic, evangelical Christians overwhelmingly reject the notion that human behavior is the driving force behind global warming (Branch et al. 2016, Arbuckle & Konisky, 2015). Renowned author and New Testament scholar, N.T. Wright asserted that many evangelicals deny scientific claims like climate change, "not because the evidence is wanting or because Christian theology requires it, but because they don't like its political implications" (Wright, 2015, p. 2). An example of this is seen with Richard Cizik, former vice president of the National Association of Evangelicals who, after publicly acknowledging human-induced climate change, was forced to step down from the position (Dudley, 2011). In addition to this prevalent negative view of climate change science among evangelicals, many of my students are from Texas, a state that produces much of the oil and gas in our country - indeed, climate change science can be a tough sell.

To address the climate change skepticism among my students, I first frame the discussion with a Christian-focus. Each weekly session begins with a devotion to integrate a Christian worldview with the science content. During the session on climate change, the devotion calls on Genesis 2:15 in which Adam is told that he is to tend and watch over the Garden of Eden. The devotion then goes on to explain that this creation mandate describes our relationship to the planet and justifies the need to care for the environment as extension of our Christian faith.

In the fall of 2015 and the spring of 2016, I tried out a new approach to teaching my students about climate change. Before teaching the lesson, I used a short questionnaire populated with questions taken from Global Warming's Six Americas (Leiserowitz et al., 2011) to pre-assess the students. Immediately after the lesson, I used the same questionnaire to post-assess their beliefs to look for growth. A subset of the survey questions assessed four areas of students' understanding of climate change: 1) confidence that climate change is occurring, 2) confidence that climate change is caused by human activity, 3) confidence that scientists agree about climate change, and 4) how concerned is student about climate change. Figure 1 shows the skepticism among my students regarding these three aspects of climate change. Only approximately half of the students were in agreement that climate change was even occurring. Less than 20% agreed that climate change was human-caused. A maximum of 25% of the students believed that scientists were in agreement about climate change. Finally, only 20% (fall 2015) and 30% (spring 2016) were personally concerned about climate change.

Figure 1

Students Initial Climate Change Skepticism

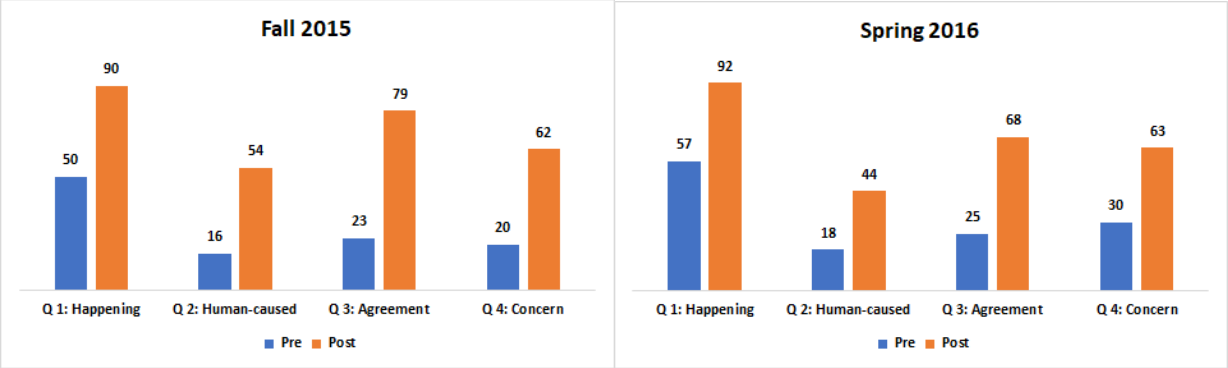


To address my students' skepticism towards climate change, I sought the expertise of Dr. Katharine Hayhoe, a climate scientist from Texas Tech University. I felt Dr. Hayhoe could have a positive influence on my students as she is, herself, an evangelical Christian and the wife of a church pastor. She and her husband co-authored *A Climate for Change: Global Warming Facts for Faith-based Decisions* (Hayhoe & Farley, 2009). Dr. Hayhoe provided a recorded lecture entitled *Climate Change: Facts, Fiction, and Faith*, which I showed my students in place of my traditional classroom lecture. In the video, Dr. Hayhoe grounds her concern over climate change in scriptural truths and encourages climate change action as an outgrowth of Christian stewardship to the Earth and as an act of loving our neighbors, particularly disadvantaged populations around the world who will be most impacted by climate change.

Figure 2 shows the change in students' beliefs after viewing the video lecture. A Wilcoxon signed rank t-test of significance showed all changes to be significant at the $p < 0.05$.

Figure 2

Belief Change After Video Lecture



While students reported how much they liked the Christian framework from which Dr. Hayhoe taught, a follow-up study was designed to measure its impact on the changing viewpoints. The video was edited to remove the portions that referenced bible verses and christian values and the name was changed to *Climate Change: Facts and Fiction*. One class was shown the original Christian-framed lecture and the other was shown the secularized version. The results surprisingly showed no significant difference between the two groups except with regards to how concerned the students were for others (higher concern post-assessment for those who watched the Christian-framed lecture)[1]. Perhaps this surprising discovery could be explained by the students' motivated cognition that Morgan (2021) shares in his manuscript also contained in this special issue. It is likely that the students believed the science presented in the lecture, with or without the Christian frame, to be trustworthy because of the setting in which it was delivered. Where I teach, all material, regardless of subject, is taught from a Christian worldview and all full time faculty are members of Baptist churches (aligned with the university). As such, students can trust that values and beliefs misaligned with Christian values and beliefs will not be taught. In other words, the students had greater trust in the university and their professor than they did on the guest evangelical scientist herself.

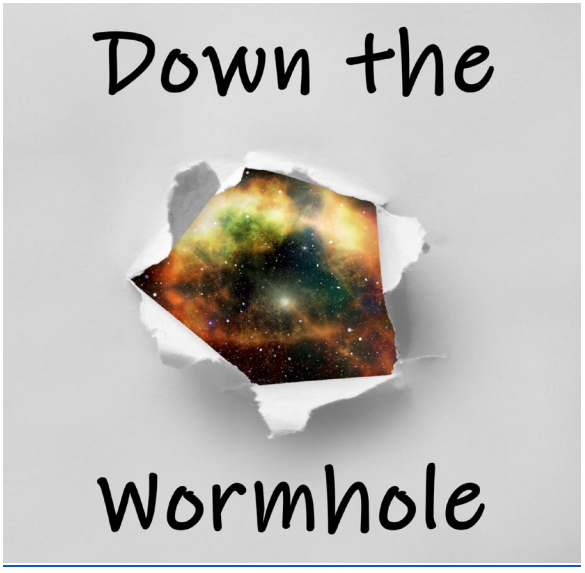
[1] For more information on both studies, see Hayhoe et al., 2019.

Communicating About Environmental Racism in the Public Space [Ian Binns]

The popularity of podcasts continues to grow each year. In their annual report, Edison Research (2021) found that 80 million Americans are weekly podcast listeners, a 4% increase from the previous year. This report also indicates that the podcasting audience is highly diverse in terms of listener backgrounds. Additionally, podcasts as an educational tool continue to be an important area of research. Sprague and Pixley (2008) argued for the use of podcasts in education as podcasting began to take hold. Research indicates that podcasts may play a valuable role in reaching students beyond school walls and have the potential to enhance children's literacy skills (e.g., vocabulary knowledge, storytelling techniques), engagement, and collaboration (Besser et al., 2021; Morgan, 2015; Putman & Kingsley, 2009; Smythe & Neufeld, 2010). Creating podcasts in the classroom also has the potential to provide opportunities to level the playing field and amplify the voices of children who are diverse with respect to academic achievement (O'Bannon et al., 2011). Furthermore, some even explore the role of podcasting for social justice in social work programs (Ferrer et al., 2020).

Podcasting is something that I began to explore a few years ago after participating in the Sinai and Synapses fellowship from 2017-2019. One of the goals of the second year of the fellowship was to focus on content creation. Podcasts were part of this effort. Near the end of the fellowship, Rev. Zack Jackson, the pastor of Community United Church of Christ in Reading PA as well as an adjunct professor of theology at Palmer Theological Seminary, and I approached each other about creating a podcast because we didn't want this to end. Three other fellows joined us: Rabbi Rachael Jackson, who was an analytical chemist before rabbinical school, Kendra Holt Moore, a Ph.D. candidate in Religious Studies at Boston College and Assistant Professor of Religion at Bethany College, and Dr. Adam Pryor, Associate Professor of Religion and Vice President for Academic and Student Affairs also at Bethany College. This led to the creation of our podcast in 2019, *Down the Wormhole*[2], where we explore the relationship between science and religion (Figure 3).

Figure 3
Down the Wormhole Podcast



Over the first two years we addressed a variety of topics related to science and religion. In several episodes we had discussions about challenging topics. They were always done in a respectful

[2] https://www.downthewormhole.com

manner. Our intent is to continue to have fruitful conversations. It's easy to argue that because we are all friends, respectful conversations about challenging topics are easy. That's a valid point and one I considered when coming up with an example of how we addressed challenging topics on a podcast. This is why I chose an episode from our series on race and racism.

In the summer of 2020, during the height of Black Lives Matters protests, we decided to record a series on race and racism in science and religion. We knew it was too important of a topic for us to ignore. This ended up being a four episode miniseries. The first episode focused on who we are as podcast hosts. We wanted to explicitly discuss who we are as individuals and our individual journeys focused on anti-racism. The second episode focused on the Bible. Our third episode focused on environmental racism. The last episode focused on racism and education. I want to focus on the third episode.

The third episode was a "crossover" episode with the *Color Correction podcast*, based in Philadelphia. *Color Correction* focuses on race and faith "from the perspective of a Black girl, an Asian guy, and a white guy too.[3]" Zack is friends with one of the hosts and we all agreed that a conversation on environmental racism was a good time to record with them.

Before we address the episode, it is important to first understand the phrase 'environmental racism.' The Climate Reality Project (2021) says the following about environmental racism:

> When we talk about environmental racism, we're talking about the disproportionate burden of environmental hazards placed on people of color. This oppression is often achieved systemically, through policies and practices that effectively place low-income and communities of color in close proximity to polluting facilities like power stations, plastics plants, and methane gas pipelines or to infrastructure like major highways (para. 3-4).

Environmental racism is not a new term. Over the last several decades studies have shown that communities of color are disproportionately affected by a multitude of environmental hazards compared to other communities (Climate Reality Project, 2021; Newkirk, 2018; Skelton & Miller, 2016). As recently as 2018, EPA researchers found that when it comes to air pollution from particulate matter, "results at national, state, and county scales all indicate that non-Whites tend to be burdened disproportionately to Whites" (Mikati et al., 2018, p. 484).

The recording date was the first time I met the hosts of *Color Correction*, Bethany, Andrew, and Kris. As mentioned, Zack and Kris have known each other since college. This was going to be a raw conversation on a very challenging topic and I did not know what to expect. Instead of going into detail on the full episode, I want to focus on a few exchanges that occurred throughout this conversation. You will see from these quotes that in some situations we did not hold back. Yet, we were honest and respectful to each other. The following themes emerged from our conversation: *United Church of Christ and environmental racism*, *economics and power*, *dehumanization of black and brown people*, and *appealing to white people*. It's important to note that while I present these themes as separate, each of them overlap throughout the episode. I encourage you to listen to the full episode.

United Church of Christ and Environmental Racism

After introductions Zack started us off with a brief history of how the United Church of Christ (UCC), in which he is a pastor, in essence started the environmental justice movement. I encourage you to look at Shaver (2021) for a more thorough explanation of this topic. Zack introduced us to a landmark 1987 study titled *Toxic Wastes and Race in the United States* that was conducted by the Commission for Racial Justice of the UCC (Commission for Racial Justice, 1987). Zack informed us

[3] https://www.colorcorrectionpodcast.com

that "of all the different factors that would predict where a toxic waste dump would be located, race was the overwhelmingly largest factor" (Binns et al., 2020, 4:30). In a report released 20 years later that was also commissioned by the UCC (Bullard et al., 2007), Zack pointed out that "not only had very little changed, but the things that had actually changed had gotten worse" (Binns et al., 2020, 5:15). Bullard et al. (2007) found that for the most part, policymakers were unwilling to address the issue of race when it comes to environmental disasters. Or as Zack put it,

> One of the reasons very little changed is on us, and by us, I mean *white climate activists* [emphasis added], who after realizing how important race was in this conversation, also realized that we're not going to get a broad coalition of Congress if we make that a central issue. ... We discounted the people that were affected by the environmental crisis, we told them their issues were secondary, that we need to fix the carbon problem now, and then we'll take care of your injustice issues later. I [Zack] have told people before that we need to fix climate change and that if we don't stop it, humanity will not exist and it won't matter if we have systemic racism or not. (Binns et al., 2020, 5:30)

This was honest of Zack. He followed this up with some important questions that we should all consider. "What am I preserving? What ideal society am I trying to save by ignoring the cries of the majority of people?" (Binns et al., 2020, 8:30). Of note, a recent study released after the recording of our podcast found these environmental racism disparities still persist (Mascarenhas et al., 2021).

Economics and Power

Throughout our podcast we addressed the role of economics and power with respect to environmental racism. We include many examples of the role of economics and politics. For example, early in the episode, Kris addressed the messaging around economics, saying "the intersection always seems to be about economics and what is good for the bottom line. That's the way it gets sold to people who are poor. 'We're going to put this in your neighborhood, but we're going to give you a good job. Even if that job slowly kills you'" (Binns et al., 2020, 13:18). In another example, Andrew talked about the lack of power that exists in communities of color, saying "there's a reason that you didn't build a gas plant in the middle of a suburb. That's because those communities have resources and are empowered. There's a reason why you go to places where people can't fight back" (Binns et al., 2020, 20:46). Finally, a third example brought it home to Philly when talking about economics and power. Kris talked about something that the city of Philadelphia decided to do to help with green space (Philadelphia Parks & Recreation, 2021). He told us "you can get a free tree in Philly if you own your home, but that is the catch. You have to own. That's where the wealth gap is" (Binns et al., 2020, 24:44).

It was during the conversation on the trees in Philadelphia program when I recognized that my perspective needed to shift. I initially thought that this program was a good thing. The city giving homeowners trees is a positive step in trying to increase green space. That was how I saw it and how I still see it, but with a caveat now. After this conversation I understood how even with a program like this, economic disparities still exist and need to be addressed.

The Dehumanization of Black and Brown People

Early in the conversation Bethany provided an important perspective for us to consider, namely, the dehumanization of black and brown people in our country:

> What I feel like we keep talking about is the inherent dehumanization of people and workers, when you have a system of capitalism. Does that mean racism cannot exist? Or capitalism cannot exist outside of a space where systemic racism is not at the right. So everything that we keep coming back to in this discussion really sounds like a lack of recognizing people's full humanity. So it's easy for environmental activists to distance themselves from the effects of industries that are causing harm to communities that they may not necessarily live in. Or it's easy for companies to say, 'well, we can't take our money or we can't invest more money in doing this better, cleaner. Our employees really need these jobs. You're willing to risk the lives of other people in order to make that happen. I feel like what we're saying over and over again really reinforces the dehumanization of black and brown bodies in this country under capitalism. (Binns et al., 2020, 19:01)

Later in the episode during an exchange on the water crisis in Flint, MI, Zack brought up the fact that the amount of money raised in the first day after the fire at Notre Dame Cathedral in 2019 could have easily fixed the water crisis, Bethany returned to the theme of dehumanization and why the Flint water crisis still exists. She said "That's your European icon, right? The value of it is inherently higher than a predominantly Black city. It's unspoken and I think even people listening to me will say 'it's Notre Dame!' But again, if you really break it down why Notre Dame feels more important than this city where currently people and children are suffering...the difference is black people" (Binns et al., 2020, 32:23).

As someone who was devastated when Notre Dame Cathedral burned down, I can understand how some may be offended by Bethany's statement. However, Bethany is right. The dehumanization of black and brown people continue to play a role in environmental crises like the Flint water crisis. This needs to be recognized and addressed if we hope to prevent crises like this in the future.

Appealing to White People

A final theme that emerged from our conversation was appealing to white people, how this has been used to address environmental problems, and if this is a good strategy. This came up in several parts of our conversation, including when we talked about the Flint water crisis and Notre Dame. After Bethany's comment about why people don't care about the Flint water crisis, Andrew returned to an earlier part of our conversation on the increased amounts of people with asthma in a part of Philadelphia that is made up of mainly black communities with the zip code of 19125. He speculated that "maybe that's why I sense a certain amount of tension with environmental activists, because appealing to white people, even though the brunt of the problem is in underprivileged communities, but appealing to white people as a way to get money in support...do people care if 19125 has asthma? I don't know. But people care if whales are dying" (Binns et al., 2020, 32:59).

We returned to this topic of appealing to white people several other times throughout our conversation. Near the end of the episode, I suggested that the reason why white people seem to not care about issues like the Flint water crisis is the mindset of "since it's not really impacting me, what's the point" (Binns et al., 2020, 46:11). In order to help us understand the problem with this mindset, Bethany pointed to a movie theme that is familiar to many of us: a dystopian future. She said "every dystopian story isn't about a dystopian future. It's about the moment in which it would affect white people" (Binns et al., 2020, 47:37). Using the film *The Day After Tomorrow* (Emmerich, 2004) as an example, Bethany said,

> That movie is about this white guy reckoning with years and years of environmental injustice and how it comes to totally destroy the world. But urban communities, urban black and brown communities, are already being destroyed in these ways...I think maybe that's been my issue

> with environmental justice folks is that they distance themselves from the black and brown community so often that are presently affected by it to talk about the distant future, that really that future is now for black and brown folks. (Binns et al., 2020, 48:46)

Later in our conversation I returned to this mindset of "not in our backyard." I said "people don't want to try to help distant island nations because it's not impacting them. But eventually it will impact all of us if we don't do anything about it" (Binns et al., 2020, 52:13). Bethany pushed back, saying

> but I also have trouble with white people framing things as 'okay, eventually this will affect me.' Instead you have to make yourself care about black people. When I was in a DEI training this white woman worked really hard to explain to white people that they should care about racism because it really does affect them eventually. I had to stop her and said 'you should actually just care about other people even if it doesn't affect you at all.' (Binns et al., 2020, 52:27)

This provided a powerful framework for all of us to consider. This helped all of us understand a better way to approach these types of conversations and can help others.

In each of the above examples there are painful realities that can be challenging to accept. Namely that those of us with privilege need to have our perspectives challenged in order to help make lasting change. With respect to environmental racism, we need to acknowledge the role of systemic racism in the development of environmental policies. As Zack pointed out, just targeting the scientific problem is not enough. We also need to focus on the underlying problem, i.e. systemic racism, that led to the construction of toxic industries in communities of color in the first place.

Evolution Education in the American South [Lee Meadows]

The teaching of evolution in American public schools is a perennially tough issue. I work in the American South and have worked across my career as a science educator to help teachers find traction on this issue. The approach I use (Meadows, 2009) is a focus on understanding evolution, but not believing it. In a nutshell, teachers using this approach ask their students to understand evolution and the evidence for it, but not necessarily accept either.

Religious affiliation is dropping across the U.S. (Pew Research Center, 2019), a trend I also see around me in the South, but many science teachers I talk to are still concerned about teaching evolution. Some are deeply concerned or even find evolution impossible to address, and the key factor seems to be the kinds of communities in which they teach. In Alabama where I live and work, teachers in diverse suburban communities have described to me the most freedom to teach evolution. Teachers in rural areas or small towns with high percentages of white Evangelicals have described the most concern about teaching evolution. So even though my work focuses broadly on public schools, the target of my work is helping biology teachers with the religiously sensitive science content of evolution who work in public schools serving religious communities.

Coupling this approach to teaching evolution with the elephant and rider metaphor helps us see why many traditional approaches to teaching evolution simply don't work. Messages like the following are speaking to the rider:

- *"This is a science classroom. We will not discuss religion."*
- *"I can't help you with your questions about religion. You need to go talk to your pastor."*
- *"Evolution is a fact. The scientific evidence is indisputable."*

Each of these messages has an essence of truth. Religion shouldn't be the focus of a science classroom, science teachers often don't have the background to address their students' religious concerns, and evolution is the theory that unifies biology. But these are rational messages that do very little to engage students with religious objections in learning about evolution. They miss the elephant in the room!

Public school teachers can use a different set of messages that speak to the elephant, and honor their religious students' deep beliefs and values:

- *"I know many of you are worried as we get started learning about evolution."*
- *"Your religious beliefs are important. One of my big goals as we learn about evolution is to support your faith."*
- *"If anything you hear during the evolution units sounds like an attack on your faith, please tell me. I might have said something wrong, or you might have misheard me. I want to clear that up quickly."*
- *"My goal is for you to understand what the theory of evolution says and the large amount of evidence for evolution. My goal is not for you to change what you believe about evolution."*
- *"If anything you encounter as we study evolution raises questions about what you were taught at church, feel free to ask me. But please make sure to talk to your parents, your pastor, or your priest about anything that concerns you."*

These kinds of messages speak to students' motivations and internal beliefs. For deeply religious students, they clearly communicate that their teachers value students' faith and work to uphold it. They communicate learning evolution can raise uncomfortable questions, and that teachers want students to find support with those. Most importantly, they communicate to students the focus is on them understanding evolution better without having to accept the evidence presented or the theory itself. They address the elephant in the room by ensuring students their teacher is not trying to steal their faith.

I know personally how difficult this territory is for many science teachers. I grew up in a fundamentalist Christianity as a young earth creationist. I knew then evolution was wrong because it went against the Bible. My views about science and my faith have changed significantly since then, but my faith is still central to who I am as a person. Also, I am sensitive to how difficult learning about evolution is for many Evangelical and fundamentalist Christians, and I believe the public school classroom should never be a place where teachers try to change their students' religious beliefs.

Recently, my religious beliefs and scientific understandings have been stretched in a new phase of growth about human evolution. Growing up in the South, I never had the opportunity to learn human evolution. Evolution was rarely taught or discussed because of its controversial nature, and human evolution certainly wasn't mentioned! This began to change for me when I was honored to join the Broader Social Impacts Committee, which advises the Human Origins Project at the Smithsonian's National Museum of Natural History. For the first time, I had the opportunity to gain an in-depth understanding of the evidence for human evolution, which launched yet another scramble in my religious understanding as I tried to make sense of all that I was learning in light of a Christian view of human origins. It's been another good journey with a pretty amazing set of surprises for my work on the teaching of evolution in Alabama.

Imagine for a moment teaching human evolution in Alabama public schools. You may be like I was, thinking something along the lines of, *"That's a really bad idea."* Teaching evolution is already controversial in the South. Teaching human evolution would be even worse, right? That's what I thought, and it's even what I said publicly. But then I began to see the results of the Human Origin Program's efforts to introduce human evolution into the high school curriculum.

With support from the National Science Foundation (NSF), they had already developed, field tested, and released a curriculum for Advanced Placement Biology (Pobiner et. al., 2018). A key component of this curriculum is the *Cultural and Religious Sensitivity* (CRS, Bertka, 2015) teaching

strategies resource, the purpose of which is to "both encourage and help equip high school teachers to promote positive dialogue around the topic of evolution in their classrooms" (p. 4). Data from the curriculum implementation indicated the AP curriculum was successful, but none of the field testing was done in the deep South. Also, since it was an AP curriculum, we don't have data for how this approach works with students in general biology. Could human evolution work in a regular biology in the South if it was taught with an emphasis on understanding, not belief change? Amazingly, we are currently finding out answers to that question! With NSF support, the Human Origins Program is leading Learning Unity and Diversity in Alabama (LUDA), a project comparing the effect in general biology of teaching evolution with human examples versus non-human examples.

Even more amazingly, human evolution looks to be working well in Alabama classrooms! The project has completed two years of curriculum pilot testing, collecting data on student learning and attitudes. Briana Pobiner, the project principal investigator (and 2019-2021 Sinai and Synapses Fellow), outlined the following as key findings (personal communication, August 5, 2021):

- Student understanding of evolution increases from pretest to posttest. Students of 9 of 12 teachers showed a significant increase.
- Student acceptance of evolution increases from pretest to posttest. Students of 6 of 11 teachers showed a significant increase.
- Students with creationist worldviews showed significant gains in understanding of evolutionary content.

These are pilot data from 12 teachers' classrooms, and the project was moving toward a full implementation in 40 classrooms across Alabama in spring 2020 when COVID-19 struck. Implementation is back on track now for spring 2022, with half the teachers implementing curriculum using human examples and half using non-human examples.

Two key factors appear to explain the success in the pilot classrooms. The first is teachers' use of culturally sensitive strategies in teaching evolution. Teachers were trained and supported in implementation of strategies very similar to the CRS strategies used in the AP curriculum with the game changing result of students realizing no one was out to attack their faith. The version of the CRS used in LUDA helped teachers understand and implement the following values in teaching evolution:

- Acknowledge how diverse religious and cultural viewpoints about the origin, diversity, and evolution of life have existed and continue to exist among human cultures and communities
- Respect students' and teachers' worldviews
- Encourage a supportive classroom environment focused on the goal of understanding the science of evolution, including human evolution, but without promoting any type of belief change

Interestingly, even pilot teachers who were initially hesitant to use the CRS strategies reported good success once they implemented them with their students.

The second factor seems to be simply that kids like learning about themselves! The pilot teachers reported a good level of engagement around the human examples because students saw themselves in what they were studying. A good example of this engagement was in the skin color lesson, which guides students, based on scientific evidence, to explain how allele frequency maps for alleles associated with skin color provide evidence for selection and adaptation in humans, and to construct an argument for natural selection on skin color in humans. Teachers reported this lesson as one of the most popular in the LUDA unit, with many students fascinated by the scientific explanations for variation in skin color based on the interplay of sun intensity, folate, and Vitamin D.

As readers familiar with the American South would suspect, the elephant in the room when teaching evolution is the religious sensitivity of the topic. Appeals to the rider, such as "*Just teach the science*," simply haven't worked. But acknowledgement of the elephant, that is students' deep motivations, religious belief, and even fears, give teachers a clear pathway toward success with this troublesome topic in many Southern communities. Furthermore, the LUDA project gives us good data that this approach actually works in real-world classrooms, even with the contentious topic of human evolution.

Lessons Learned in Communicating Religiously and Culturally Sensitive Science Content

There has been a lot of talk about metaphorical elephants in this manuscript, particularly how not to trigger their emotional reactions that can impede learning about science content that might be viewed as controversial due to religious or cultural implications. In *Virtues as Integral to Science Education* (Melville & Kerr), Ian and Mark both advocate for the inclusion of Aristotelian virtues such as honesty, courage, care, and honesty into science education (Bloom, 2021; Binns, 2021). We also emphasize the importance of establishing an *ethic of belief* (Socket, 1993) in science classrooms, so it is expected that content will be supported by evidence, and to create an environment of trust and respect. The examples presented in the current paper exemplify these needs quite well.

In Mark's example, teaching about climate change to evangelical students, he stayed true to the science of climate change (*honesty*) but found experts who would be viewed as trustworthy to conservative Christian students (*trust*, *respect*, and *care*). As Ian participated in communicating with people of color about environmental racism, he did so with honesty - even recognizing his own blind spots at times (*courage* and *respect*). When Lee taught human evolution to students in the American South, he did not try to convince them of the truth of evolution. Instead, he showed them the evidence for evolution (*honesty*, *courage*, and *ethic of belief*) and expected the students to understand the science - he left their beliefs up to them (*respect*, *trust*, *care*).

Many science and mathematics educators may have religious backgrounds that are quite different from their students or lack religious background altogether. Students come from diverse socioeconomic, racial, and cultural backgrounds and, as such, will hold diverse perspectives regarding religiously and culturally sensitive science content. We hope that the present paper will help educators reflect upon the importance of understanding our students' backgrounds to better perceive how they can carefully present their content to best achieve their goal of science literacy for all of their students. Now, this goal is more important than ever.

The authors received no financial support for the research, authorship, and/or publication of this manuscript.

Mark A. Bloom, Ph.D., (markb@dbu.edu) is a professor of biology and science education at Dallas Baptist University in Dallas, Texas. He is also co-executive director of the International Consortium for Research in Science & Mathematics Education and co-editor of the Electronic Journal for Research in Science & Mathematics Education. His research focuses on the philosophy of science, the intersection of science and religion, and citizens' understanding of religiously sensitive socio-scientific issues. His best friend is Ian C. Binns.

Ian C. Binns, Ph.D., (ian.binns@uncc.edu) is an associate professor of elementary science education in the Department of Reading and Elementary Education at the Cato College of Education at the University of North Carolina at Charlotte. His research focuses on the interaction between science and religion with the goal of helping people understand what makes science and religion unique and how they both benefit society. Specifically, his research looks at how preservice elementary teachers' scientific literacy and faith-based beliefs influence their perceptions of how

evolution, creationism, and intelligent design should be addressed in the classroom. Ian is also a host of the podcast Down the Wormhole, which explores the "strange and fascinating relationship between science and religion."

Lee Meadows, Ph.D., (pleemeadows@gmail.com) is a science educator and the Executive Director for the Alabama STEM Council. A teacher at heart, he has taught high school chemistry, physics, and physical science; college chemistry; and many teacher education courses, especially science teaching methods. He's the author of *The Missing Link: An Inquiry Based Approach for Teaching Evolution to All Students* and co-author of *Making Sense of Science and Religion: Strategies for the Classroom and Beyond.*

References

Arbuckle, M. B. & Konisky, D. M. (2015). The role of religion in environmental attitudes. *Soc. Sci. Q.* 96, 1244-1263.

Bertka, C. (2015). *Cultural and religious sensitivity (CRS) teaching strategies resource.* bit.ly/TeachHumanEvolution

Besser, E. D., Blackwell, L. E., & Saenz, M. (2021). Engaging students through educational podcasting: Three stories of implementation. *Technology, Knowledge and Learning*. doi: https://doi.org/10.1007/s10758-021-09503-8

Binns, I. (2021). Teachers, virtues and professional practice. In W. Melville & D. Kerr (Eds.), *Virtues as integral to science education: Understanding the intellectual, moral and civic value of science and scientific inquiry* (pp. 105-116), Routledge.

Binns, I. C. (Host), Jackson, Z. (Host), Stewart, B. (Host), Yang, A. (Host), & Eden, K. (Host) (2020, August 5). Racism part 3 with the Color Correction podcast (environmental justice) (No. 49) [Audio podcast episode]. In *Down the Wormhole.* https://www.downthewormhole.com/e/racism-part-3-with-the-color-correction-podcast-environmental-justice/

Bloom, M. A. (2021). The links between the virtues, science and science education. In W. Melville & D. Kerr (Eds.), *Virtues as integral to science education: Understanding the intellectual, moral and civic value of science and scientific inquiry* (pp. 15-33), Routledge.

Branch, G., Rosenau, J. & Berbeco, M. (2016). Climate education in the classroom: Cloudy with a chance of confusion. *Bull. At. Sci.* 72, 89-96.

Bullard, R. D., Mohai, P., Saha, R., & Wright, B. (2007). *Toxic wastes and race at twenty 1987—2007: A report prepared for the United Church of Christ Justice & Witness Ministries*. United Church of Christ. https://www.nrdc.org/sites/default/files/toxic-wastes-and-race-at-twenty-1987-2007.pdf

Climate Reality Project. (2021, April 6). *Environmental racism: What it is and how you can fight it.* https://www.climaterealityproject.org/blog/environmental-racism-what-it-and-how-you-can-fight-it

Commission for Racial Justice. (1987). *Toxic wastes and race in the United States: A national report on the racial and socio-economic characteristics of communities with hazardous waste sites.* United Church of Christ. https://www.nrc.gov/docs/ML1310/ML13109A339.pdf

Dudley, J. (2011). *Broken words: The abuse of science and faith in American politics*. New York: Crown Publishers.

Edison Research. (2021). *The infinite dial 2021*. https://www.edisonresearch.com/the-infinite-dial-2021-2/

Emmerich, R. (Director). (2004). *The day after tomorrow* [Film]. 20th Century Fox.

Ferrer, I., Lorenzetti, L., & Shaw, J. (2020). Podcasting for social justice: Exploring the potential of experiential and transformative teaching and learning through social work podcasts. *Social Work Education, 39*(7), 849-865, DOI:10.1080/02615479.2019.1680619

Haight, J. (2012). *The righteous mind: Why good people are divided by politics and religion*. New York, NY: Vintage Books.

Hayhoe, D., Bloom, M. A., & Webb, B. S. (2019). Changing evangelical minds on climate change. *Environmental Research Letters, 14*(2), 024016-024016. https://doi.org/10.1088/1748-9326/aaf0ce

Hayhoe, K. & Farley, A. (2009). *A climate for change: Global warming facts for faith-based decisions*. New York, NY: FaithWords.

Kotter (1996). Leading Change. Boston, MA. Harvard Business Review.

Leiserowitz, A., Maibach, E., Roser-Renouf, C. & Smith, N. (2011). Global Warmings Six Americas. Yale Univeristy and George Mason University. New Haven, Ct.

Mascarenhas, M., Grattet, R., & Mege, K. (2021). Toxic waste and race in twenty-first century America: Neighborhood poverty and racial composition in the siting of hazardous waste facilities. *Environment and Society, 11*(1), 108-126. https://doi.org/10.3167/ares.2021.120107

Meadows, L. (2009). *The missing link: An inquiry approach for teaching all students about evolution*. Portsmouth, NH: Heinemann.

Melville, W. & Kerr, D. (Eds.) (2021). *Virtues and integral to science education: Understanding the intellectual, moral and civic value of science and scientific inquiry*. Routledge.

Mikati, I., Benson, A. F., Luben, T. J., Sacks, J. D., & Richmond-Bryant, J. (2018). Disparities in distribution of particulate matter emission sources by race and poverty status. *American Journal of Public Health, 108*(4), 480-485. https://doi.org/10.2105/AJPH.2017.304297

Morgan, J. (2021). Overlapping magisteria: Motivated cognition and the places where science and religion mingle. Electronic Journal for Research in Science & Mathematics Education, 25(3).

Morgan, H. (2015). Focus on technology: Creating and using podcasts promotes student engagement and learning.*Childhood Education, 91*, 71–73.

Newkirk II, V. R. (2018, February 28). *Trump's EPA concludes environmental racism is real*. The Atlantic. https://www.theatlantic.com/politics/archive/2018/02/the-trump-administration-finds-that-environmental-racism-is-real/554315/

O'Bannon, B. W., Lubke, J. K., Beard, J. L., & Britt, V. G. (2011). Using podcasts to replace lecture: Effects on student achievement. *Computers and Education, 57*, 1885–1892.

Piaget, J. (1980). Experiments in contradiction. Chicago and London: University of Chicago Press.

Pew Research Center. (October, 2019). "In U.S., Decline of Christianity Continues at Rapid Pace." https://www.pewforum.org/2019/10/17/in-u-s-decline-of-christianity-continues-at-rapid-pace/

Philadelphia Parks & Recreation. (2021). *TreePhilly: A program of Philadelphia Parks & Recreation*. https://treephilly.org

Pobiner., B; Beardsley, P; Bertka, C.; & Watson, W. (2018). Using Human case studies to teach evolution in high school biology classrooms. *Evolution Education and Outreach, 11*(3). https://doi.org/10.1186/s12052-018-0077-7

Putman, S.M., & Kingsley, T. (2009). The atoms family: Using podcasts to enhance the development of science vocabulary. *The Reading Teacher, 63*(2), 100–108.

Shaver, R. (2021). Wonder as an invitation to engage in environmental justice. Electronic Journal for Research in Science & Mathematics Education, 25(3).

Skelton, R. & Miller, V. (2016, March 17). *The environmental justice movement*. Natural Resources Defense Council. https://www.nrdc.org/stories/environmental-justice-movement

Smythe, S., & Neufeld, P. (2010). "Podcast time": Negotiating digital literacies and communities of learning in a middle years ELL classroom. *Journal of Adolescent and Adult Literacy, 53*(6), 488–496.

Sprague, D., & Pixley, C. (2008). Podcasts in education: Let their voices be heard. *Computers in the Schools, 25*(3–4), 226–234. https://doi.org/10.1080/07380560802368132

Wheatley, M. J. (2006). *Leadership and the new science: Discovering order in a chaotic world.* Oakland, CA: Berrett-Koehler Publishers, Inc.
Wolfe, D. L. (1982). *Epistemology: The justification of belief*. Intervarsity Press.
Wright, N. T. (2015). *Surprised by scripture: Engaging contemporary issues*. New York, NY: HarperCollins Publishers.