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Center for Theology, Science, and Human Flourishing

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ACKNOWLEDGMENTS

This collection contains revised versions of selected papers presented at the *Practicing Science: Virtues, Values, and the Good Life* conference at the Notre Dame London Global Gateway in August 2018. Keynote speakers at the conference included Kristján Kristjánsson (Jubilee Centre for Character and Virtues) with response by Darcia Narvaez (University of Notre Dame), Andrew Pinsent (Ian Ramsey Centre for Science and Religion) with response by Antje Jackelén (Church of Sweden), Michael Spezio (Scripps College), and Matthew Stanley (New York University Gallatin School of Individualized Study) with response by Don Howard (University of Notre Dame). We are grateful for the insightful reflections offered by Fern Elsdon-Baker (University of Birmingham), Gerald McKenny (University of Notre Dame), and Michael Welker (University of Heidelberg), which concluded the conference.

The conference was the culmination of the transdisciplinary *Developing Virtues in the Practice of Science* research project, supported by a grant from the Templeton Religion Trust and led by Celia Deane-Drummond, Darcia Narvaez, and Thomas A. Stapleford at the University of Notre Dame. Transdisciplinary work of this kind requires humility, curiosity, and a certain measure of risk, and we were fortunate to be able to work with a dedicated and adventurous team of scholars, including Dori Beeler, Louise Bezuidenhout, Emily Dumler-Winckler, Emanuele Ratti, Timothy S. Reilly, Fionagh Thomson, and Nathaniel A. Warne. The team's work was augmented by the analysis of Mark Graves and enhanced by work with graduate students Char Brecevic, Michelle A. Marvin, Nicholas Ogle, and Michael Yankoski.

This project benefited from external advisors' engagement; they also served as session chairs at the conference: Markus Christen (University of Zurich), Jeanne Nakamura (Claremont Graduate University), Yulia Egorova (Durham University), Rayna Rapp (New York University), and Michael Spezio (Scripps College). We especially thank Markus and Michael for contributing to the conference as speakers.

We thank all of the short paper contributors who elevated the discussion with their fresh perspectives which now appear in this collection: Jennifer Baker (College of Charleston), Jordan Droira (University of Oklahoma), Eranda Jayawickreme (Wake Forest University), Daniel Kuebler (Franciscan University of Steubenville), Braden Molhoek (Center for Theology and the Natural Sciences), and Gregory R. Peterson (South Dakota State University). Musharraf Hussain (Karimia Institute), Matias Petersen (University of the Andes), Irena Schneider (King's College London), and Mara-Daria Cojocaru (Munich School of Philosophy) also delivered short papers.

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EDITORIAL INTRODUCTION

CELIA DEANE-DRUMMOND, THOMAS A. STAPLEFORD, AND DARCIA NARVAEZ

This book represents the proceedings for the conference held at the end of a three year project of intensive dialogue on science and virtue between scholars trained in philosophy, sociology, theology, history, psychology, and anthropology and those engaged in the philosophy and sociology of science, theology, history of science, psychology and ethnography of science. Since 2016, a multi-disciplinary research team at the University of Notre Dame, funded by the Templeton Religion Trust, has been exploring the relationship between virtue and scientific practice with a particular focus on laboratory research in biology. We called the project "Developing Virtues and the Practice of Science" (DVPS) to highlight our focus on how what scientists actually do both reflects and shapes their cognitive and behavioral dispositions.

Over the last several decades, virtue has attracted increased attention from philosophers, theologians, and psychologists. However, little of the research on virtue has attended to the development and function of virtue within scientific research and practice. The questions that drove DVPS, and still remain to some extent unresolved even after three years of research, relate to understanding and interpreting the dispositions of scientists as they go about their laboratory work. The specific questions that we sought to address in this work were the following:

- How can the language of virtue enrich, change, or challenge our understanding of science?
- Does the contemporary practice of scientific research require or bolster certain virtues (or vices)?
- How can ideas drawn from virtue ethics or virtue epistemology illuminate (and perhaps improve) the training and mentoring of scientists?

This e-book is an open-access work designed to allow students, researchers, and educators to have ready and easy access to the proceedings of the final DVPS conference. It is divided into five main sections which, while they overlap to some degree, can guide the reader interested in some areas more than others. The sections take the reader through historical analyses, ethnography, educational psychology, philosophy and theology. The book concludes with a section that opens a way forward, suggesting how multidisciplinary approaches to virtues in the practice of science can innovatively edge us towards thinking about future scientific research.

The first section, *Scientific Virtues Through Time*, has four chapters by theologians, historians, and philosophers of science. Philosopher Jennifer Baker opens the volume with "Aristotle and Ainslie: An Empirical Basis for Virtue Ethics." Many critics of the field of virtue ethics believe that it is insufficiently rooted in empirical work. Nevertheless, most traditional versions of virtue ethics are naturalistic, so they are able to include updated scientific discoveries about human behavior. Virtue ethicists often hesitate to make connections to ancient accounts of moral psychology associated with virtue ethics. This may be because of a perception that ancient moral psychology depends on an ancient and somewhat anachronistic metaphysics. In this chapter, Baker relates virtue ethics to the most recent research in behavioral science, focusing particularly on the framework of George Ainslie. She argues that contrary to common suppositions, it is possible to make ancient assumptions about virtue fit with modern social scientific accounts of human motivation. Once the ancient and contemporary approaches are joined, it is possible to arrive at a more convincing explanation of what could justify virtue ethics theory.

Historian Matthew Stanley contributes a chapter entitled "The Virtue of Productive Uncertainty, or, What to Do When You Don't Know Something." He suggests that one mark of "good" scientists is their ability to address issues of the unknown in a way that allows for further research and deeper engagement—what he calls "productive uncertainty." He argues that such an outlook is rarely explicitly discussed within science. Yet a detailed analysis of practice allows certain values and virtues that are usually submerged to surface. Stanley discusses how three important scientists—James Clerk Maxwell (1831–79), Arthur Stanley Eddington (1882–1944), and Carl Sagan (1934–96)—grappled with questions of productive uncertainty. He explores how they justified their values of productive uncertainty, and what resources they drew on for those justifications. All three drew on religious values to help articulate and support their scientific practices. Maxwell, Eddington, and Sagan came from different religious contexts (conservative, liberal, and secular, respectively) so considering them alongside each other demonstrates the variety of ways that scientific virtues can interact with and depend on wider categories.

Chapter 3, entitled "On Making the World Habitable," by theologian Emily Dumler-Winckler, considers the significance of the work of Ralph Waldo Emerson for establishing the framework of scientific practice. Emerson declared that it is by "the religious sentiment," and "not by science or power," that "the universe is made safe and habitable." He and his fellow transcendentalists embraced the insights of the second scientific revolution of the nineteenth century. At the same time, they were aware of the limitations and dangers that attend certain modern scientific practices and views of nature. Dumler-Winckler presents the argument that disenchanted views of modern science tend to alienate us from nature, God, one another, and ultimately from our own agency. They do so by celebrating our power to dominate creation and its creatures or to become impervious to nature's perils through stoic detachment. The modern temptation is to think that it is by these forms of knowledge or power that the world is made safe and habitable. Ironically, both views—namely, that human beings are meant to conquer or to withdraw from nature—have long been attributed to Emerson. Dumler-Winckler argues that, on the contrary, Emerson was devoted, beginning to end, to expounding the virtues that modern agents would need to overcome both forms of alienation and make a home within the world. He thereby illuminates the virtues needed to perfect practitioners of religion and science in a way that remains highly relevant to contemporary concerns.

The fourth chapter, Nathaniel A. Warne's "Have We Forgotten about Happiness? Scientific Practice and the Contemplative and Active Life," considers both the theological and philosophical implications of the kind of virtues sought in the practice of science. Warne recognizes that within our DVPS project, the emphasis has been on observing the development of virtues within the context of vocation, specifically regarding laboratory scientists and musicians. The arguably more important question, however, especially philosophically and theologically, is: what are the ends and goods of the virtues that we seek to know more about and understand in the practice of science? Further, what relationship do the vocations of particular scientists have with the achievement of those ends? The research team of the Developing Virtues project has been concerned, as much as possible, with thinking about the virtues within a particular historical, theological, and philosophical framework that understands virtues not as ends in themselves but as means to something greater, namely happiness. Like Barker, Warne considers in particular the work of Aristotle and his scholastic interpreters, though he is not shy about illuminating their different approach to metaphysics as compared with contemporary social scientists. Instead, he seeks to bring the discussion back into the teleological frame of thinkers like Aristotle and Thomas Aquinas, who thought of happiness not as an activity or practice but as contemplation (*theoria*, *contemplatio*). He also considers further how virtues, happiness, and contemplation are viewed in the work of twentieth-century philosopher Josef Pieper. Pieper drew extensively on ancient and medieval figures, along with the psychology of his day, to address philosophical and theological questions. He is also partly credited with the twentieth-century retrieval of "virtue ethics." In a nutshell, this chapter asks: what is the relationship between vocational practices and the classical eudaimonistic conception of happiness and the good life?

The second section, *Science in the Everyday*, covers ethnographic, psychological and philosophical engagement with the topic of the daily practice of science in a laboratory setting. Ethnographer Fionagh Thomson begins this section with "Telescopes, Microscopes & Simulations: The Everyday Scientific Practice of Deciding 'What is Real'?" Contemporary science, across a wide range of different disciplines, often presents knowledge as necessarily contingent rather than absolute and, increasingly, as contextually and historically specified. As such, the sciences in general promote the practice of continually critiquing, debating, and scrutinizing current knowledge through valuations and assessments that (can) lead to modification, alteration and, at times, radical change in light of new evidence. The method(ology) of deciding what is "real," "true," authentic," and/or "accurate" in scientific practice therefore remains contested, even while the nature and reliability of human senses in scientific observations has been questioned throughout much of scientific history. Consequently, while scientific practice is embraced as a human endeavor, it is simultaneously framed as one that inevitably leads to personal prejudices, misapprehensions, and biases. The latter are presented as inherent weaknesses, even vices, in rigorous scientific practice—weaknesses and vices that must be overcome or mediated through repeated reproduction and verification of experimental results and, more recently, the implementation of machine learning and automated systems—all in an effort to remove human error. Drawing on ethnographic fieldwork with astrophysicists (including instrument scientists, astronomers, and cosmologists) and microscopists in a UK university, Thomson explores the everyday scientific practice of deciding "what is real." She highlights the key role of practical wisdom in that practice (an inherently human endeavor) through Hans Georg Gadamer's concept of "dialogue as play" extending beyond individual human bodies. She focuses on everyday interactions through and with technologies in an open shared dialogue, as well as the importance of "being human," "getting it

wrong," and embracing prejudice, and she asks the question: do the sciences place too much faith in mediated visual images and/or computer simulations in deciding "what is real"?

Chapter 6, psychologist Eranda Jayawickreme's "How Easy Is It to be Intellectually Humble in Our Daily Lives?," considers how good thinking involves the cultivation of intellectual virtues that promote unbiased, rational thought. Recently, contemporary scientists have increasingly understood wisdom as unbiased thought, and have specifically argued that such thinking can be facilitated through the enactment of intellectual humility (IH). IH has been defined as a disposition to be alert to, admit to, and take responsibility for cognitive limitations and mistakes or, alternatively, as lacking the vices associated with pride. In this chapter, Jayawickreme discusses newly published data on the validation of a measure of IH developed by an interdisciplinary team. This measure conceptualizes IH as a disposition to be alert to, admit to, and take responsibility for cognitive limitations and mistakes. He also discusses data on situational predictors of IH in daily life, where the manifestation of intellectual humility was predicted by measures that tracked perception of interpersonal situations as disagreeable and interlocutors as moral. He also outlines preliminary results of a psychological intervention that was designed to promote IH, using a novel educational video highlighting the role of IH and intellectual virtues through real-life examples from the history of science. He concludes by discussing how these results can help us understand how IH can be fostered as part of the training of scientists.

The seventh chapter, by philosopher Char Brecevic, is entitled "Ethical Virtues in Scientific Representation." Consideration of virtues in the generation of scientific representations is generally delimited to theoretical desiderata including empirical adequacy, simplicity, elegance, robustness, and predictive power. The virtues found in the domain of ethics are rarely, if ever, entertained in the philosophical context of assessing the stylistic and functional aspects of scientific representations, given that philosophers of science are often concerned with theory choice rather than moral questions. When the focus is on more popular representations of science found outside laboratory settings, often purposefully designed to capture the attention of nonexpert audiences, these ethical virtues become relevant to the discussion of what scientists ought to consider when constructing their representations. Given that many nonexperts readily grant epistemic authority to scientists and given that popular scientific representations are often the primary means by which the imaginability of scientific matters is extended or restricted, Brecevic argues that scientists have a profound impact on the ways nonexperts posit possible futures. These, in turn, influence how individuals orient themselves towards others and to the world. To demonstrate this influence, Brecevic evaluates a variety of rhetorical statements from Jennifer Doudna's *A Crack in Creation* that exemplify the themes of power, control, and promise associated with CRISPR-Cas9 technology. Brecevic suggests that the consideration of ethical virtues in the construction of popular scientific representations is needed to ensure that the epistemic authority granted to scientists is used responsibly.

The third section of four chapters, *Virtue Ethics and Science Education*, explores aspects of education using different social science methodologies. Chapter 8, "The Role of Ethnographies in Developing Virtue Ethics for the Life Sciences," by Louise Bezuidenhout and Dori Beeler, draws on their joint ethnographic research conducted as DVPS postdoctoral fellows at the University of Notre Dame. As the two point out, there has been a lot of recent interest in virtue ethics as an alternative to deontological framings of responsible conduct of research for the life sciences. Proponents of a virtue ethics framing contend that it offers a more holistic interpretation of responsibility, focusing on charac-

ter development rather than on rule following. Moreover, virtue ethics offers a way to talk about science that does not impose unnatural boundaries between individual-as-self and individual-as-scientist. Further, by focusing on situational conduct, virtue ethics offers an important approach for discussing responsible actions within daily laboratory life. Despite the benefits to be accrued through the use of virtue ethics, opponents criticize this approach for being difficult to teach and discuss. Such objections arise from the situatedness of virtue ethics, which argues that individuals learn through *doing* and that actions can be understood only in context. In order to counter these objections, many proponents of virtue ethics for the life sciences are turning to textual accounts of "exemplary scientists" as a means of demonstrating virtuous behavior in context.

Bezuidenhout and Beeler take issue with the current selection of exemplars for virtue ethics discussions for two key reasons. First, the discussions tend to use the research achievements of successful scientists as a proxy for exemplarism, thereby marginalizing exemplary individuals who embody other key components of virtuous science, such as mentorship, teaching, and community building. Second, the narratives currently used tend to be auto/biographies of scientists that do not systematically present the socio-historical context in detail. Nor do the narratives explicitly foreground the position of the author in the text. As an alternative to these problematic texts, Bezuidenhout and Beeler suggest that the rising number of ethnographic accounts of laboratory practices should be recognized as important tools for virtue ethics teaching and discussion. These texts differ from auto/biographies and popular texts as they are methodologically rigorous and present detailed descriptions of daily laboratory life. The authors demonstrate these differences using two texts focusing on the invention of polymerase chain reaction (PCR): the ethnography *Making PCR* and the autobiography *Dancing Naked in the Mind Field*. They demonstrate how students and teachers can use a secondary data analysis of these texts in order to unpack aspects of virtue ethics in relation to daily conduct as well as more broadly in relation to misconduct. They conclude by suggesting types of ethnographic studies that could be very beneficial for developing a robust virtue ethics account of scientific practice.

In Chapter 9, "Maintaining Virtue in Modern Scientific Practice: Providing a Foundation to Move Forward," biologist Daniel Kuebler delves further into the examination and practice of virtue in science. The communal practice of science has long been associated with a specific set of scientific virtues. However, the modern landscape of scientific research, with its increasing competition for government funds and growing ties between industry and academia, has made the maintenance of these virtues more challenging. Two troubling examples of the problem include the increasing number of academic fraud cases as well as the documented difficulties of reproducing published results. The scientific community has attempted to address these issues, but the remedies tend to focus on legalistic and policing solutions rather than on examining how best to cultivate virtuous habits. While training that stresses normative rules and accountability can influence behavior, it has its limits. If survey results of scientists are correct, the vast majority of fraud and data manipulation cases go undetected. As a result, the risks associated with unethical behavior appear low relative to the perceived benefits that individual scientists can acquire in terms of money and career advancement. In such an environment, explaining how to be ethical in research does not necessarily help develop the requisite internal rationale for *why* one should behave in a virtuous manner. Kuebler argues that without an appreciation of the intrinsic value of virtuous behavior, the temptation to cut corners can prove too alluring in the current environment. It seems that new systems are needed to address these challenges.

In particular, there is a need to develop curriculum that focuses on the intrinsic value of living a virtuous life and implement it long before individuals embark upon a scientific career. In addition, he suggests that there is a need to explore different financial models to alleviate the considerable pressure on practicing scientists to act unethically.

Philosopher Kristján Kristjánsson's chapter suggests a different aspect of what could be called a new approach to scientific education and is entitled "Scientific Practice, Wonder, and Awe." He argues for and elaborates upon two different conclusions: first, that scientific practice can, and ideally should, cultivate moral virtues in its practitioners (in addition to more obvious intellectual virtues such as wonder), specifically the moral virtue of awe; and second, that science education can, and ideally should, inspire in students love of transcendent ideals, such as truth, and introduce them to morally relevant awe experiences. This is true for both budding scientists and budding interested laypeople who will be future friends rather than foes of scientific inquiry. He further examines the importance of the subtle differences between wonder and awe. Although his arguments may seem a rehearsal of the time-honoured view that all good education should help students see the world anew, what is radical and controversial is his claim that such aims cannot be accomplished through the elicitation of mere wonder as an intellectual virtue. Even education in the apparently down-to-earth subject matter of the natural sciences should aim higher than that. He suggests that seeing the world anew is not only about seeing *external* reality anew—this flower, that galaxy—but also about seeing *ourselves* anew in light of, and as part of, that reality, and allowing ourselves to become lost in rapture as we grapple with the existential and moral ramifications of our being in the world.

The eleventh chapter, by developmental psychologist Darcia Narvaez, is a response to Kristján Kristjánsson's chapter and is entitled "Reclaiming Awe for the Right Things." She suggests that, in searching for awe today, we can see the traditional awe of truth, beauty, and goodness, but also some twisted sisters. In Donald Trump's America, awe of untruth and the meaning of "truthiness" comes into the question. She believes that awe of beauty often runs skin deep and awe of goodness often presents as egoistic or ethnocentric self-aggrandizement. The awe of technology and the awe of power over others also seem widely present today. Thus, in discussing awe, we need to attend to better and worse kinds of awe. She argues that the best kinds of awe rely on connections or relationships that raise communal sensibility. Such capacities require cultivation, especially in childhood when related brain areas are rapidly establishing themselves through experience. Western science too often emphasizes awe of power, detachment, and control rather than a holistic relational awe fostered in alternative world views, such as Indigenous science, and the natural world may be the worse for it because of such attitudes of domination. She argues that an Indigenous approach to science restores rightful relationships with the other-than-human and lubricates the path to sustainable lifeways.

The fourth section, with five chapters, engages philosophical, theological, computer science, and psychological perspectives and looks into the different possible *Frameworks for Practicing Scientific Virtues*. Philosopher Jordan Droira opens this section with "Caring to Ask: A New Picture of Inquisitiveness." Droira argues that scientists ought to cultivate the intellectual character virtue of care—characterized primarily as a virtue of inquisitiveness. He borrows from Vrinda Dalmiya's 2002 work "Caring to Know" and Lani Watson's "What is Inquisitiveness," reaching his conclusion in four parts. He outlines how epistemologies of ignorance distort scientific inquiry, primarily employing the ideas of Linda Martin Alcoff. He then offers a brief picture of Dalmiya's intellectual virtue of care and Watson's intel-

lectual virtue of inquisitiveness. He then proposes a hybridization of Dalmiya and Watson's proposals, characterizing how agents should be held accountable in the context of epistemologies of ignorance. This synthesis can be summarized as: we hold them accountable for the character virtue of "caring inquisitiveness." Finally, he concludes that this new paradigm of caring to ask enriches the way we look at research generally, since it includes the benefits that accompany virtue ethical theories more generally.

Chapter 13, entitled "Mapping the Language of Hope within Empirical Research onto Virtue Theory," by theologian Michelle A. Marvin, explores the question of whether or not hope is a moral virtue—an issue of recent debate in the field of moral philosophy. Scholars such as Luc Bovens and Adam Kadlac argue that hope is valuable for leading a good life, whereas others, such as Christopher Bobier and Barbro Fröding, assert that hope is not an intrinsically good disposition of character. Research in this area frequently associates hope with situations of medical illness, particularly for individuals close to death. However, current virtue ethics scholarship does not account for the multiplicity of contemporary meanings given to hope within empirical research, such as optimism and expectation. Marvin's chapter addresses the issue of the polysemous language of hope by mapping various uses of hope language within empirical research onto virtue theory. Specifically, she considers the equivocal uses of hope throughout psychiatrist Elisabeth Kübler-Ross's seminal 1969 work *On Death and Dying*, and how these discrete meanings of hope contribute to a conclusion that all terminally ill patients "…[maintain] some form of hope until the last moment." To assist with mapping these different meanings of hope onto virtue theory, she discusses how medical ethics and virtue theory underwent corresponding transformations during the twentieth century, and brings contemporary research on optimism and expectations to bear on the medical hope language of the late twentieth century. By examining the language of hope in Kübler-Ross, this chapter provides insight into a dimension of hope underlying current debates over hope's status as a moral virtue.

Psychologists Timothy S. Reilly and Darcia Narvaez contribute Chapter 14, "Virtue Ideals and the Scientific Researcher: Morality, Wisdom and Climate," based on field research from the DVPS project. Although interest in virtue has increased sharply in psychology since the turn of the twenty-first century, virtue as contextualized by practices and traditions remains understudied. Reilly and Narvaez consider how features of individuals and their contexts may correspond with virtue in science. The DVPS project team developed a list of virtues with an interdisciplinary group from psychology, ethics, philosophy of science, history of science, and anthropology. The list was presented to scientists (n=259) who rated their importance in two ways (facets): personal ideals (PI) and ideals for the domain of science (DI). Prior work with Darcia Narvaez established that each rating method fit a three-factor structure: (1) relational, (2) role, and (3) intellectual virtue. They examine and report on regression models for each virtue facet and factor, using scores on moral reasoning, wisdom, and moral imagination as predictors. They then examine regression models to predict moral behavior, specifically counterproductive work behavior (CWB) and organizational citizenship behavior (OCB), using as predictors virtue rating methods (PI and DI), while considering workplace ethical climate and social support. Their data shows that measures of wisdom—especially insight (for intellectual and role virtue); tolerance (for intellectual and relational virtue); and moral imagination (for relational virtue)—predicted ratings of virtue as PI and DI, while PI virtue ratings predicted moral behavior. Further, PI virtue was most related to workplace behavior. They consider both the research implications and future directions that these results imply.

Computer scientist Mark Graves's chapter is entitled "Semantic Analysis of Moral Values in Semi-Structured Interviews" and uses Latent Semantic Analysis (LSA) to study interview results from DVPS. LSA uses computational tools to extract implicit meaning from text and makes it possible to quantify the level that a moral value occurs implicitly within interview text by comparing it with meaning representations of theory-derived value descriptors. Statistical methods are then used to compare participant groups on their interviews' quantified semantic similarity to moral value descriptors, which yields a characterization of the groups' differences in implicit moral values. Graves describes a semantic analysis investigation that uses DVPS data (27 laboratory scientists and 44 ensemble musicians) who each completed a one-hour, semi-structured interview. The scientists ranged in experience from undergraduate research assistants to tenured professors, and the musicians ranged from music directors to amateur instrumentalists. Graves found that the text of interviews with scientists showed higher latent value for honesty and integrity, while interviews with musicians showed higher latent value for religious value. Comparing transcript latent values across location found higher latent values for religious value in the US when compared with the UK.

Chapter 16, "Value in Virtuous Community: Insights about Valuing the Self and Other from Computational Cognitive and Brain Sciences," by psychologist Michael Spezio, presents work in progress. The moral philosopher Robert C. Roberts suggests that the study of virtue needs the support of a virtuous community. In other words, to understand what virtue is and how it flows in practice, it helps to be in that flow oneself. How can one hope to recognize virtuous formation without entering it oneself, in hope and in the company of others? Spezio suggests that those seeking a deeper understanding of virtue more broadly, and virtue in the sciences in particular, would benefit from scientific inquiry into the cognitive affections and the affective cognitions of those committed to virtuous community, and of actions modeled after their practices. He considers a series of different questions, including the following:

- How do people with long-lived commitments in such communities value one another and themselves?
- How do they remember and describe their formation and transformation? How do they remember their past selves?
- How do they describe their hope for the future?
- How important are empathy, theory of mind, and humility in managing the daily challenges of life in community?
- Can computational models of cognitive and neural systems shed light on the transformations of mind and brain that happen?

Drawing on work with several communities of L'Arche in the US and in France, and with the community of Homeboy Industries in Los Angeles, he relates computational models of mind and brain to narrative accounts of how the self and other are valued within communities dedicated to virtuous formation.

The final section consists of five chapters, again drawing on a multidisciplinary approach to the focal topic, but concerned more broadly with where to go next, and is entitled *The Future of Scientific Virtues.* Psychologist Markus Christen's Chapter 17 asks: "Does the Digitalization of Science Affect Scientific

Virtues?" Information and communication technology has penetrated almost all spheres of life and influences our way of thinking, our interactions with others and our roles as citizens, workers and consumers. Science is affected by this development as well. Whereas the use of computers has been commonplace for many years, big data analytics and artificial intelligence applications will increasingly be applied in many scientific disciplines. Such technologies will not only provide novel tools for gaining insights in complex data, but are also likely to become "digital assistants" for researchers, suggesting to scientists what to read, which hypotheses to pursue, and how to navigate through an increasingly complex landscape of ethical and legal obligations. They even generate genuine scientific knowledge.

Christen's chapter aims to explore the consequences of such a development for scientific virtue. He asks: What does it mean for the virtue of curiosity when "smart software agents" suggest research questions? How does accountability change in networked science, where humans and machines interact? Can AI that accompanies a researcher through his or her studies and "learns" his or her work patterns affect collegiality among researchers? How will the skill of reasoning be affected when it is partially outsourced to algorithms? Will big data analytics allow for a new level of objectivity? By addressing such questions, Christen aims to outline the possible impact of digitalized science on six scientific virtues: curiosity, intellectual honesty, skepticism, objectivity, perseverance, and meticulousness. He provides further practical suggestions of how to ensure that those virtues are not undermined when using digital tools.

Philosopher Emanuele Ratti's chapter "Machine Learning, Automated Science, and Virtues" also deals with the automation of science and in some respects follows up on Christen's contribution. This chapter is presented as a long abstract with a link to a published work that will become live on publication. He suggests that the applications of machine learning (ML) and deep learning to biology have fostered the idea that the automated nature of algorithmic analysis will gradually dispense human beings from scientific work. In his contribution, he shows that this view is not necessarily problematic, at least when ML is applied to biology. In particular, he claims that ML is not independent of human beings and cannot form the basis of automated science.

Braden Molhoek contributes Chapter 19, "Student Mental Health, Job Concerns, and Issues in Academic Publishing: The Perpetuation of Injustice in the Pursuit of Science," and explores the practical aspects of mental health and other issues in the course of science practice. Molhoek examines how the academic pursuit of science is inhibiting the acquisition of virtue among undergraduates, graduate students, postdocs, and contingent faculty. His argument starts by examining the mental health of students, and the underlying causes of mental distress. He then turns to issues of employment for graduate students, postdocs, and contingent faculty. He argues that employment concerns continue to create mental distress and interfere with the conditions necessary for the acquisition of virtue. The final part of the chapter explores what Molhoek considers as the unjust practices of academic journal publishers. He concludes with some preliminary suggestions on the steps necessary to address these concerns.

Theologian and peace studies scholar Michael Yankoski's chapter, "Justice on the Blockchain? What Might 'Smart Contracts' Mean for Virtuous Action?," also raises the issue of justice, but from the perspective of the application of new technologies. Advocates of distributed ledger technologies ("blockchains") argue that this new category of technological innovation will prove as positively dis-

ruptive to human societies as the Internet. The argument is that blockchains render centralized guarantors of trust—banks, courts, and governments—obsolete (or at least much less necessary) for monetary exchange, contractual justice, and historical record keeping. As such, blockchains are believed to provide the rails for frictionless international monetary exchange, "smart contracts" promise to execute themselves with incorruptible precision, and every transaction conducted will be immutably recorded on publicly visible ledgers. Put simply, blockchains are purported to be nothing short of a revolution in trust between humans. This chapter seeks to place the claims of blockchain proponents in conversation with the virtue of justice as traditionally construed in the work of medieval theologian Thomas Aquinas. In particular, Yankoski asks whether blockchain technologies and "smart contracts" should be considered a help or a hindrance to the practice of justice. He suggests that while aspects of blockchain technologies may well aid the practice of certain limited forms of contractual justice, we should be wary of anything that purports to make "rendering to each their due" automatic and effortless.

Philosopher Gregory R. Peterson presents the final chapter in this volume, "Scientific Practice and Democratic Virtues." Peterson takes the discussion of scientific futures to the broadest sociological scale by considering it in terms of political relationships. His chapter proposes a model for thinking about how scientific practice may contribute to the formation of democratic virtues. Democratic virtues are those virtues necessarily present in a polity (in whole or part) for the proper functioning of liberal (as opposed to illiberal) democratic regimes. Democratic virtues overlap with but are distinct from traditional civic virtues, which are not always democratically oriented. A longstanding argument supports the claim that scientific practice supports or even requires the possession or development of moral character. Less direct attention has been given to the relation of scientific practice and democratic virtues. Peterson argues that scientific and democratic virtues are intersecting sets and that virtues formed in the context of scientific practice contribute to the formation of democratic virtues, especially intellectual virtues, that support democratic governance and contribute to the wisdom of the crowd.

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PART I.

SCIENTIFIC VIRTUES THROUGH TIME

CHAPTER 1.

ARISTOTLE AND AINSLIE: AN EMPIRICAL BASIS FOR VIRTUE ETHICS

JENNIFER BAKER

> "Is it not clear that there are several concepts that need investigating simply as part of the philosophy of psychology and, as I should recommend—banishing ethics totally from our minds? Namely—to begin with: 'action,' 'intention,' 'pleasure,' 'wanting.' More will probably turn up if we start with these. Eventually it might be possible to advance to considering the concept 'virtue;' with which, I suppose, we should be beginning some sort of a study of ethics." Elizabeth Anscombe, "Modern Moral Philosophy," 1958

When the question under consideration is which virtues accompany science, it might seem to be coming at things from the wrong way round to ponder the extent to which science has come to support an account of virtue.[1] But failing to ask science to check on our understanding of virtue, while it has been invited over and is on hand, is a bit like keeping the car hood shut while the mechanic is over. This is not the same as a request for a re-design, however. There are already ample examples of virtue ethics (and ethical proposals more generally)[2] being redone with a focus on information gleaned from, for example, social psychology[3] or personality psychology.[4]

But I don't want a new car. Not yet. Like others, I do not even recognize classical virtue ethics in the descriptions of those offering upsells.[5] Imagine instead that I am only looking for the visiting mechanic to inventory parts of the engine in order to confirm that the classic car in the driveway should run. This is all that I hope to do in this paper: emphasize (show off) the psychological capacities that "motor" classical virtue ethics, those crucial to its various and modern forms.[6] I want to suggest that these components can be recognized by contemporary science, and are actually described in

1. Thanks to the students in Chris Surprenant's class at the University of New Orleans for letting me try out these ideas with them. Thanks also to the Society for Philosophy and Psychology for letting me get feedback on this as a poster. And thank you to my interlocutors at the Notre Dame London conference.

2. John Doris, *Talking to Our Selves: Reflection, Ignorance, and Agency* (Oxford: Oxford University Press, 2015).

3. Christian Miller, *Moral Character: An Empirical Theory* (Oxford: Oxford University Press, 2013).

4. Nancy Snow, *Virtue as Social Intelligence: An Empirically Grounded Theory* (New York: Routledge, 2010).

5. See Mark Alfano, *Character as Moral Fiction* (Cambridge: Cambridge University Press, 2013) or Jesse Prinz, "The Normativity Challenge: Cultural Psychology Provides the Real Threat to Virtue *Ethics*," *Journal of Ethics* 13 (2009): 2–3.

6. Contemporary eudaimonist accounts of virtue include: Julia Annas, *Intelligent Virtue* (Oxford: Oxford University Press, 2011); Rosalind Hursthouse, *On Virtue Ethics* (Oxford: Oxford University Press, 2001); Mark LeBar, *The Value in Living Well* (Oxford: Oxford University Press, 2013); Daniel Russell, *Practical Intelligence and the Virtues* (Oxford: Oxford University Press, 2009). There are Stoic accounts as well, for example, Lawrence Becker, *A New Stoicism* (Princeton, NJ: Princeton University Press, 2011).

behavioral science to the extent that we virtue ethicists could simply adopt these newest of formulations. I think this could be a useful way to ward off skepticism (warranted enough, no doubt) about how plausible ancient accounts of our moral psychology could still be. It is also a way to move forward, as the ongoing research could sync up with the continued development of modern approaches to virtue. I conclude with an example of this.

There are all sorts of virtue ethics, of course. Some may be non-naturalistic so that overlaps with science are of limited use. But as Julia Annas explains, the original, eudaimonist, accounts of virtue are naturalistic.[7] I mean to discuss this type of virtue ethic. Contemporary accounts following this model should not be derived from science, nor reduced to it, and yet are "weakened if the best contemporary science conflicts with its claims or makes it hard to see how they could be true."[8] Contemporary eudaimonistic approaches take happiness to be a final end and practical rationality to be necessary to virtue.[9] An eudaimonistic virtue ethic will also include, in some version, accounts of the following: (1) self-generated reward (SGR) and (2) self-imposed behavioral norms (SIBN). (We will soon see that the behavioral scientists represent these as "personal rules," or verbal commitments that we generate ourselves. I give an example of their equivalence to SIBN.)[10] If we look for support for these features, we will single out virtue ethics, as other accounts of ethics do not depend on SGR or emphasize SIBN at all. And we will also be running a rather efficient test, as classical and neo-classical virtue ethics take SGR and SIBN to result in the better-known features of the view (resultant automaticity, *akrasia*, *enkrasia*, changes in what is pleasurable, acting ethical "for its own sake," improved agential efficacy). If there is no scientific basis for SGR and SIBN, virtue ethics would not be able to work as promised. The mechanic could walk away from the engine before checking anything else. There would seem to be no point in taking a neutral stand between ethical theories, comparing (or compiling!) features of virtue with other discovered propensities towards acting ethically. Not if it turns out virtue ethics won't run.

If I have not sustained the car-in-the-driveway metaphor for too long: cars might have bodies that withstand wind pressure, drivers might tend to obey stop signs, theorists have lots of ideas about what counts as ethical. Science can track such things. But we want to know about *this* model of car. And so I propose we turn to behavioral science to do this check, rather than to the scientific fields that have already generated accounts of moral behavior or moral judgment, even if the accounts seem somewhat friendly to the idea of virtue.[11] This involves ignoring some extant support for SGR and SIBN, but there are several benefits to taking up one specific explanatory framework and applying

7. Julia Annas, *The Morality of Happiness* (Oxford: Oxford University Press, 1993).

8. Julia Annas, "Virtue Ethics," in *The Oxford Handbook of Ethical Theory*, edited by David Copp (Oxford: Oxford University Press, 2005), 526.

9. Lorraine Besser-Jones. *Eudaimonic Ethics: The Philosophy and Psychology of Living Well* (London: Routledge, 2014).

10. Annas, *The Morality of Happiness*.

11. There are many examples of studies about discrete phenomenon that could be used to inform or support virtue ethics. See, for example, M. H. Bazerman,"In Favor of Clear Thinking: Incorporating Moral Rules into Wise Cost-Benefit Analysis," *Perspectives on Psychological Sc*ience 5.2 (2010): 209–12, and J. M. Paxton, "Patterns of Neural Activity Associated with Honest and Dishonest Moral Decisions," *Proceedings of the National Academy of Sciences USA* 106.30 (2009): 12506–11. Even studies that do not purport to support virtue ethics might be accommodated fairly easily, as soon as the ethical assumptions at odds with virtue ethics are set aside. See Joshua Green and Amatai Shenhav, "Moral Judgments Recruit Domain-general Valuation Mechanisms to Integrate Representations of Probability and Magnitude," *Neuron* 67 (2010): 667–77.

it to eudaimonistic virtue ethics as described.[12] George Ainslie's approach has been demonstrated to mesh well with counter-proposals from other behavioral scientists as well as with related fields such as neuroscience.[13]

Ainslie's proposals are mature and well-known, and have been vetted by those working in other fields.[14] He developed his approach on the basis of animal studies, experiments with human subjects (including controlled experiments), neuroanatomical data, and clinical observations. He is best known for his account of hyperbolic discounting, which overturned the idea that our preference curves were exponential, a matter of consistent preference over some specified time. Instead, animals and humans alike prefer smaller rewards sooner, and these behavioral choices can be best represented on a hyperbolic curve. Ainslie's was a seminal contribution, impacting his own field but also the fields of economics, animal science, and neuroeconomics. He has also applied his theory in a very broad manner, making it much easier for non-scientists to apprehend. He has used it in explanation of common phenomena like procrastination and addiction, for example.[15]

Invoking one specific, robustly developed and articulated scientific framework is a way to limit the freedom philosophers have to interpret data for themselves. This is to heed warnings philosophers have developed through recent trial and error. As John Doris puts it, philosophers should no longer lean "too heavily on any one study, or one series of studies, in theory construction."[16] Ainslie's framework *is* the constructed theory with which philosophers would need to contend. Assessing theory is what philosophers are trained in, and it seems more appropriate for philosophical ethicists to do this rather than generate interpretations of data that are *ad hoc*. Finally, since Ainslie limits his investigations to general motivation, we virtue ethicists are assured that his own toolbox was not designed to test assumptions about ethics with which a virtue ethicist would disagree. Ainslie is not assuming, for example, that ethics can be gauged through observation, or that any moral judgment must be rational or somehow maximizing. (He is not testing this car by whether it travels on some particular route.) Since he has not operationalized ethics for his work, it begs fewer questions. And often, from the perspective of a virtue ethicist, surprising basic claims about "what a good person would be expected to do" can still be at odds with the account.[17]

12. I want to point out a different approach with similar aims. Rosalind Hursthouse has provided a list of empirical claims necessary to the viability of a eudaimonistic virtue ethic. Her focus, however, is on how there is no evidence yet (not in evolutionary biology or even in armchair speculations) to show that our human nature is incompatible with virtue. See "Human Nature and Aristotelian Virtue Ethics," in *Human Nature*, edited by Constantine Sandis and M. J. Cain (Cambridge: Cambridge University Press, 2012), 169–88.

13. George Ainslie, "De Gustibus Disputare: Hyperbolic Delay Discounting Integrates Five Approaches to Impulsive Choice," *Journal of Economic Methodology* 24.2 (2017): 166–89. See also George Ainslie, "Palpating the Elephant: Current Theories of Addiction in Light of Hyperbolic Delay Discounting," in *Addiction and Choice: Rethinking the Relationship,* edited by Heather Nick and Gabriel Segal (Oxford: Oxford University Press 2016), 227–44.

14. His influential book *Break-Down of Will* (Cambridge: Cambridge University Press) was published in 2001. As just one example of his use in a field like philosophy, see Mathieu Doucet and Rachel MacKinnon, "This Paper Took Too Long to Write: A Puzzle About Overcoming Weakness of Will," *Philosophical Psychology* 28.1 (2013): 49–69.

15. George Ainslie, "Procrastination: The Basic Impulse," in *The Thief of Time: Philosophical Essays on Procrastination*, edited by Chrisoula Andreou and Mark White (Oxford: Oxford University Press, 2010), 11–27.

16. Doris, *Talking to Our Selves*, 49.

17. It seems pedantic to insist upon, but the ancient virtue ethicists were so loath to specify what counted as examples of good behavior because the theory always had to be consulted. Perhaps more vividly, Aristotle was only willing to give a few examples of behavior that is reliably wrong (murder, theft, adultery). See Christian Miller, "The Real Challenge to Virtue Ethics," in *The Philosophy and Psychology of Character and Happiness*, edited by Nancy E. Snow and Franco V. Trivigno (London: Routledge, 2014), 19.

Right off the bat, Ainslie's approach lends support to one of the most basic assumptions in ancient virtue ethics. Plato tells us our soul has three parts that vie for control over our behavior. Annas describes these aspects of our moral psychology as focused on immediate, midrange, and longer-term goals.[18] Ainslie gives us an empirical basis for agreeing that agency is divided, a matter of coordinating various parts and perspectives. Animal and human experiments alike, he writes, demonstrate "that we have successive motivational states that regularly conflict, and in a way that prevents durable resolution."[19] Ainslie describes the "internal bargaining" between these constituent "states" as being what prevents us from acting like children given free rein in a candy store. We develop methods to "avoid or forestall" decisions that would reflect only our shortest-term interests. Addiction is particularly revealing of these types of internal conflicts. Addicts, for example, may report an interest in exercising restraint at the same time as they are seeking or actually taking drugs.[20]

We see this possibility in Aristotle's descriptions of *akrasia*, or the inability to do what we think is best. Some approaches that have been used to supplement ethics—such as rational choice theory—fail to problematize motivation enough to acknowledge how often we are akratic. Ainslie, in contrast, sees this as the question we ought to set out to answer: "what motivates someone to repeatedly choose what she herself often sees as a poorer option, even if she is trying to stop choosing it?"[21] What akratic behavior reveals about us is simply missed if we treat it as merely irrational, glossing it: "when someone is seduced by a fudge sundae or cocaine high, she chooses immediate consumption in one modality despite larger, later losses in others—health, wealth, safety."[22] Ainslie instead accounts for *akrasia* by identifying the appeal of the "lesser" immediate reward and the ubiquity of "inconsistent propositions." We simply do want to have cake and eat it too. This observation about human nature is what ancient philosophers are notorious for telling us. (Recall Plato's description of us as leaky jars in the *Gorgias*.) Ainslie's investigations into how we avoid short-term diversions is the same work Plato did without the benefits of modern science.[23]

And like Aristotle, Ainslie also emphasizes that we should never think of choice in terms of a single moment in time. Choice, in order to be explained, must be regarded diachronically, rather than synchronically. This is to understand that our agency, our values and self-understandings, are involved in the *creation of reward*. Martha Nussbaum sees this insight from classical virtue ethics as having been roundly ignored: "most philosophers who have written about the appetites have treated hunger, thirst, and sexual desire as human universals, stemming from our shared animal nature. Aristotle himself was already more sophisticated, since he insisted that the object of appetite is 'the apparent good' and that appetite is therefore something interpretative and selective, a kind of intentional awareness."[24]

If we unduly isolate "choice" from this context, we'd mistakenly assume that an agent might choose in the same way over time, unless she got some new information. But neither animals nor humans

18. Annas, *Intelligent Virtue*, 122.

19. George Ainslie, "Money and MacGuffin: A Factor in Gambling and Other Process Addictions," in *The Mechanisms of Self-Control: Lessons from Addiction*, edited by Neil Levy (Oxford: Oxford University Press, 2013), 20.

20. Ibid.

21. Ibid., 17.

22. Ibid.

23. George Ainslie, "Selfish Goals Must Compete for the Common Currency of Reward," *Behavioral and Brain Sciences* 37.2 (2014): 135–36.

24. Martha Nussbaum, "Non-Relative Virtues: An Aristotelian Approach," *Midwest Studies in Philosophy* 13.1 (1987): 32–53.

do this. And we are often receiving new information at a rapid pace. What if we changed our choices accordingly? We would behave like distracted children in that candy store. To make it even more obvious that our preferences are not static and cannot be modeled as such: even chosen rewards are perishable. We are, Ainslie explains, designed to tire of them.

The complexities of this motivational system emerged, Ainslie argues, to encourage us to "explore our environment, both when we are young and inept and when we have become master problem solvers."[25] He explains that if our reward mechanisms operated in strict proportionality to how much of some external stimulus we could get, then a reward rate sufficient to shape our behavior when we were beginners would lead us to rest on our laurels once we had become adept. But instead, as we learn an activity, the reward it generates increases only at first. It then decreases again because our appetite does not build as much before it is satisfied.

Ainslie proposes that we have developed a few methods for coping with this phenomenon. For one, we consider choices in terms of the way one choice will affect later choices. The pleasures of an addict aren't shared by most of us, because most of us can effectively imagine how things might go as a result. We also test out how we might feel after taking an option. There has come to be a lot of agreement on the basic neural mechanics of choice, and it suggests that "we try out scenes before entering them."[26] Multiple studies of monkeys entertaining choices in their intraparietal cortex indicate they are engaging in "vicarious trial and error."[27] When we, too, do this, we are not just considering the route to greater rewards, we "bring up a memory so as to relive a scene, or a plan so as to anticipate one, or another person's experience so as to model one, and may stay engaged with any of them for a considerable time without necessarily being moved to any actual behavior."[28]

So this isn't simple math we are doing. Ainslie explains that "a scenario competes for our engagement against alternatives such as preparing coffee, taking a nap, or imagining something else." We entertain *prospective* rewards: dessert before or feeling self-controlled later. This places a very heavy emphasis on the role of our imagination, a rejection of accounts that describe us in terms of first- and second-order desires. Aristotle similarly saw imagination as key to explaining our behavior, as Jessica Moss's recent interpretative work carefully points out. She argues that not only "non-rational character virtue" but also practical rationality depends, for Aristotle, on past pleasurable perception.[29]

But this may not yet explain why we do not always respond in predictable ways to external and somehow pre-set rewards. It is also due to what Ainslie has come to recognize as the nature of reward. He has identified a type that cannot be traced back to what is on offer in some external way. It's a type of reward "which does not strictly depend on events outside of the mind, or on the promise of such events." He has termed this type of reward "endogenous" in his article "Grasping the Impalpable: The Role of Endogenous Reward in Choices, Including Process Addictions," where he explains that such rewards are "a class of incentives that do not depend on the prediction of physically privi-

25. Ainslie, "Money and MacGuffin," 22.

26. Jessica Moss argues for the Aristotelian emphasis on the role "phantasia" or imagination plays in our practical rationality. I mention her work again a bit later. See Ainslie, "Money as MacGuffin," 26.

27. Ibid., 16-37.

28. Ibid., 26.

29. Jessica Moss, *Aristotle on the Apparent Good: Perception, Phantasia, Thought and Desire* (Oxford: Oxford University Press, 2012), 235.

leged environmental events."[30] Though we may begin with instrumental motives, we learn to cultivate endogenous rewards, "coining" them for ourselves, engaging in a kind of "hedonic management." A student put it well when she offered that it feels much better to do well on a test than to not study. Her satisfaction at her self-image would be its own "endogenous" reward. Virtue ethicists surely find this story familiar. The notion of endogenous rewards lends support to the idea that we can begin to pursue being nice without finding it particularly easy, or for instrumental reasons, but later find ourselves regarding even our unsuccessful efforts to be nice pleasurable. "Endogenous" reward is key to explaining behavior when it in no way matches outside, assumed standards. It is in play when we follow our own prescriptions, confounding those noting only what we are missing out on. Ainslie thinks this category of rewards is of great explanatory significance. It is a "hypothesis about an area of human economy that has eluded systemic study, and perhaps for that reason has not been recognized by conventional utility theory, even to the extent of being a blank terra incognita."[31]

Virtue ethicists can use "endogenous reward" to explain how agents can come to take pleasure in doing the right thing, making them less tempted to stray from good behavior than other agents. This has been considered an implausible feature of virtue ethics. We know this for certain as updaters sometimes remove it to better fit with assumptions about moral activity being a matter of sacrifice or duty. But even for virtue ethicists, it can be difficult to explain the pleasure of right action in comparison to plain, simple pleasure. And, of course, if behavioral science can explain that reward is something we determine and so does not "come at us" at various levels, perhaps the pleasure of right action can be connected to reductions in the temptation to stray from behavior we consider good. Ainslie does not take up the topic of "right action," of course, but let us consider if his framework nevertheless allows us to recognize how we might personally commit to a goal like being nice. This has us turn to the role self-conscious commitments have been discovered to play in our choices, as behavioral scientists study them.

Ainslie's third suggestion, when it comes to tactics we use to delay our response to immediate rewards, is the use of what he calls either "verbalized commitments," "principles," or "self-rules." I want to suggest that these are included under the category contemporary virtue ethicists refer to (and translate) as "rules" or "norms." (I prefer specifying that they are "endorsed norms," leaving unendorsed norms to be things we follow without much awareness.) But let me acknowledge that we are not always accustomed to associating virtue ethics with rules, self-generated or not. As Dan Russell explains, "it is a mistake to think that good ethical reasoning can be codified and broken into rules which one can grasp and apply correctly, regardless of one's particular character and if only one is a quick enough study."[32] So the self-generated rules (or principles or commitments or norms or standards) that we do discover through practical rationality are not the sort that can be handed to us, ready for use. Rosalind Hursthouse uses the term "v-rules" (virtue rules) to distinguish between these understandings of rules.[33] Nor can they explain ethics on their own. But virtue ethics does take advantage of what contemporary virtue ethicist Lawrence Becker describes as our proclivity for thinking and

30. George Ainslie, "Grasping the Impalpable: The Role of Endogenous Reward in Choices, Including Process Addictions," *Inquiry* 56.5 (2013): 446–69.

31. Ainslie, "Money as MacGuffin."

32. Daniel Russell. *Practical Intelligence and the Virtues* (Oxford: Oxford University Press, 2009), 23.

33. Rosalind Hursthouse, "What Does the Aristotelian *Phronimos* Know?," in *Perfecting Virtue: New Essays on Kantian Ethics and Virtue Ethics*, edited by Lawrence Jost and Julian Wuerth (Cambridge: Cambridge University Press, 2011), 47.

acting "consistently," in, as he puts it, an "informal," "unsystematic," and "serviceable" sort of way.[34] We identify and support "normative propositions" in these efforts. Ainslie describes, it seems to me, a subcategory of these norms, as he is always talking about them being self-authored. Eudaimonistic virtue ethicists seem to invoke a broader category, leaving room for "orphan" or "unendorsed norms" that still have effects on us, even when we have not identified them.[35]

On the other hand, Ainslie's terminology can seem a little loose. Ethicists are not very accustomed to thinking of a diet as itself a principle, but in *Break-Down of Will* Ainslie describes efforts to stop eating "ad lib" as a matter of making a resolution to "decide according to principle." A consciously-endorsed diet would serve as a "criteria for deciding which choices constitute lapses," and so we see that it would work as a personal rule or a principle or a standard, and that neither Ainslie nor the virtue ethicists are dependent on any over-formalizing of the nature of a rule.[36] The terms (verbalized commitment, principle, norm, rule) are currently interchangeable, as there are no proposals concerning how these might function differently in practical reasoning. We represent these "self-rules" to ourselves in intractable ways. And like the virtue ethicists, Ainslie recognizes no *a priori* or even unusual motivational force in the personalized rules we develop. They work instead by giving us a way to put our own credibility up as a stake when contracting with ourselves. For example, when we consider dessert, we can also consider being the kind of person who now eats dessert before dinner. This is so even if we weren't particularly committed to any rule about dessert or even being a person of one sort or another. As the research on norms has shown, it can be enough that you see that others have these commitments.[37] For Ainslie, such matters factor into how we'd feel about a choice after the fact by providing a practical-motivational basis for self-blame. This self-prediction process is recursive, as each estimate of future self-control is fed back into the estimating process, thus forming part of the incentive for each choice.

So, though it may be already clear, if you catch yourself "violating your diet," the cost can't be thought of only in terms of extra calories. The cost is psychic. As Ainslie puts it: "there are no external sanctions for this contract you've violated with yourself" and yet "you have lost credibility with yourself, making you fearful of future risks, and it is natural that you begin to look for reasons to keep the diet violation from actually counting as one."[38] Add to this some evidence that our personalized rules will likely concern general topics and behaviors, rather than very small concerns: our recursive self-prediction functions not just with respect to some singular choice but to also "bundles" of choices that present themselves to us. Given that these bundles involve rewards that will accrue at various times,

34. Becker, *A New Stoicism*, 64, 111.

35. Lawrence Becker slowly walks us through the way norms internal to one's endeavors can (or not) be made compatible with other norms we self-consciously endorse. See Aristotle, n s commitments ewards is the use of what he calls ces, as behavioral scientists study them. ght play i of reward thBiIbidIibid., 84, and 128–31 for the argument for virtue made with reference to the role of norms.

36. Ainslie, *Break-Down of Will*, 88. At 1164b30-1165a5 of the *Nicomachean Ethics*, Aristotle seems to describe decision-making with the use of some personalized rules, and if we think of the eudaimonistic tradition as including the Stoics, they make us even more comfortable with the notion that practical rationality incorporates rules. See Becker, *A New Stoicism,* 56–59, and Annas, *The Morality of Happiness*, 107.

37. Cristina Bicchieri, "Norms, Conventions, and the Power of Expectations," in *Philosophy of Social Science: A New Introduction*, edited by Nancy Cartwright and Eleonora Montuschi (New York: Oxford University Press, 2012), 208–31.

38. Ainslie, "Money as MacGuffin."

any personal rules are going to be designed to apply at some level of generality, to bundle A versus bundle B. And they will also encompass the span of time in which the rewards come from these.[39]

This might be enough to suggest that we generate behavioral norms for ourselves, but what makes them stick? How do they come to have any force at all, when they do?

Ainslie argues that the way we commit to certain behaviors is by putting up "pledges" to ourselves to get us to follow personal rules of this sort. The type of self-credibility that works as a pledge in every situation is a lot like the commitments to ethical norms that virtue ethics takes to be so consequential. Ainslie writes: "the more you believe that you will keep (the pledge) the more you can keep it and the more you will subsequently believe; the less you believe you will keep it the less you will keep it, and so on."[40] As the stakes get higher, you have to "throw in more collateral," such as the credibility of your intentions generally. Ainslie's explanation seems to capture the conscious commitment that virtue ethics recommends. But how would this type of self-commitment result in the increased automaticity and fluidity of behavior that classical virtue ethics describes as the result of being successfully committed?

Ainslie explains that "mental processes are learned to the extent that they are rewarded. Hyperbolic discount curves predict that mental processes based on incompatible rewards available at different delays do not simply win or lose acceptance, but interact over time. Processes that are congenial to each other cohere into the same process. Contradictory processes treat each other as strategic enemies. Ineffective ones cease to compete at all."[41] If we engage in the match between a highlighted, endorsed norm and our motivation, the result could be that our efforts cohere. For example, we intend to be nice and all the efforts to do so become coordinated in our minds. We will not only associate this commitment with ourselves, but with any pleasure for any success we've had with it. (More on this pleasure in a moment.) We will begin to think we are successfully nice. This then should make it even easier to continue being nice.

These possibilities are promising to virtue ethics. If personal rules can begin as instrumental, then become pleasurable to follow for their "own sake," we see, potentially, how virtue becomes its own reward. This, even more than the idea that we can come to take pleasure in good behavior, is the claim that distinguishes classical virtue ethics from all manner of alternative takes on ethics.[42] Once again, even friends of the ancient approach can find the "for its own sake" standard implausible and seem to wave it aside in a bit of second-hand embarrassment. And yet Ainslie's research provides support to this major component of the "engine" of classical virtue ethics.

Finally, eudaimonistic ethics does not merely expect that we can recognize, internalize, and personalize standards for ourselves, becoming motivated by these standards rather than some further reward, but that we also experience negative psychological feedback when we violate these. Eudaimonistic

39. These claims about bundling are being tested currently. Also see Don Ross, "The Relationship Between Addiction and Reward Bundling: An Experiment Comparing Smokers and Non-smokers," *Addiction* 106.2 (2010): 402–9.

40. George Ainslie, "Emotion: The Gaping Hole in Economic Theory," in *Economics and the Mind*, edited by B. Montero and Mark White (London: Routledge, 2006), 26.

41. George Ainslie, "Free Will as Recursive Self-Prediction: Does a Deterministic Mechanism Reduce Responsibility?," in *Addiction and Responsibility*, edited by George Graham and Jeffrey Poland (Cambridge: MIT Press, 2011), 64.

42. Jennifer Baker, "*Virtue and Behavior*," *Review of Social Economy* 67.1 (2009): 3–24.

virtue ethics needs us to be able to recognize when we are acting improperly by our own lights. It should be stressful when we fail to keep our commitments, and traditional virtue ethics anticipates a psychological "kick" if we do. As Aristotle made clear in the *Rhetoric*, agents are themselves the best test of our norms, standards, and claims, because we experience tensions in these as a form of felt "distress."[43]

To this account, Ainslie adds some familiar observations: not all people wield responsibility well and some of us too readily excuse our own failures. If so, do these people then fail to even notice their failures, removing some of the consequences classical virtue ethics anticipates? Even if so, Ainslie sees them as experiencing negative feedback, a form of willpower failure where we lower our expectations for doing what we intend. The "distortions of planning" we engage in to kid ourselves about the various self-rules we've evaded seems to be, on Ainslie's account, as harmful as classical virtue ethics warned, as it reduces your own trust in yourself.[44]

Though he does not take up ethics explicitly, Ainslie seems to leave room for the idea that merely paying attention to virtue can be usefully incorporated into our agency. He writes that "a given train of imagination" might be "instrumentally useful." A "plan or hypothesis about environmental contingencies, or some other mental process that is not rewarding in its own right"[45] can help us to resist the breaking of personal rules. Suppose you experiment with trying to be nice, and set yourself a personal standard to that effect. Ainslie suggests that having such a rule about your behavior might result in multiple effects. The rule "I will be nice" can curb (if not eliminate) cravings simply because it becomes appealing to keep to it. If you accept this rule, you might begin to see temptations to be cruel or gossip as not just acts isolated from anything else, but instead as capable of setting a precedent. Someone might urge you on by saying an incident of "non-nice" behavior is "harmless," but even if you recognize that the action has no other bad consequences, you know you will see its relevance as an instance of breaking a rule you accept. Thus rules can aid self-control by silencing opportunities to do something harmless and tempting but inconsistent with how we want to think about ourselves.

If I have suggested that contemporary social and behavioral science might inspect the "engine" of classical virtue ethics and nod in recognition at its Greek-named parts, that is good. But we can also see that, from the perspective of behavioral science, some components of classical virtue ethics will still seem untested and without support. Let me end with this challenge, then, noting that this would be a productive focus for those developing theories of classical virtue ethics. Such theories depend on virtue having a certain appeal as a goal, one that differs from other goals in terms of permanence.

Becker has defended this proposal by suggesting that it is the nature of a commitment to the development of one's agency that explains this.[46] Ainslie recognizes no such features, and his recent work has focused on the idea that we quickly tire of the stimulus of a repeated experience (unless we avoid this through addiction). To keep ourselves from boredom with a reward, we must continually stoke our appetites. Ainslie points out that there are several ways to do this. It just isn't clear that any is compatible with virtue, which involves unwavering commitment to doing the right thing.

43. Jessica Moss, *Aristotle on the Apparent Good: Perception, Phantasia, Thought and Desire* (Oxford: Oxford University Press, 2012), 76.

44. Ainslie, "Money as MacGuffin," 27.

45. Ibid., 26.

46. Becker, *A New Stoicism*, 130.

One way to outsmart ourselves, to not tire ourselves out with any chosen goal, is to pace ourselves so that we create an opportunity for a novel or surprising treat. This "incentive to restrict premature consumption" builds appetite "by using adequately rare occasions as cues for consumption."[47] This does not readily map on to our descriptions of virtuous behavior. Situations might be novel, but the norms which we apply have grown familiar from use. Virtue ethics does not recommend novel experiences as some remedy for exhaustion at being good, as an example.

Another method Ainslie describes is stoking our appetites by breaking a rule or creating some loss. The risk of losing money while gambling might reinvigorate one's appetite for the regular rewards of self-control with one's money. Aristotle writes of the mistakes of our youth being crucial, and perhaps the regrets we develop from bad behavior then work in the way Ainslie suggests.[48] But mostly, virtue ethics recommends a steady and regular commitment to doing the right thing. It does not suggest we will grow tired of being good. This may represent the current limits of scientific support for philosophical theories of virtue.

Yet I hope we are leaving classical virtue ethics in a more plausible position than it has often been assumed to be in. This would be good because there are always going to be things that we need ethics, and not just science, for. For example: the justification of good behavior. Without begging questions about what ethics amounts to, will science be able to distinguish between the successful clever smoker (constantly refreshing his appetite and motivating himself thereby) and the successful other-directed and very good friend? At least, I cannot yet foresee how science will pick up norms we follow and analyze them apart from our particular psychologies, testing them against our own behaviors and any norms we find worthy and in conflict. This also isn't work we do alone, in our minds. This is work we do together, as ethical theorists.

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47. Ibid.

48. A reviewer helpfully points out that there is a substantial support for this claim in the literature on the "sociology of failure."

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CHAPTER 2.

THE VIRTUE OF PRODUCTIVE UNCERTAINTY, OR, WHAT TO DO WHEN YOU DON'T KNOW SOMETHING

MATTHEW STANLEY

Science textbooks are full of facts—things we know. But scientists spend most of their time thinking about things we *do not* know. It is not always clear how one should deal with the unknown. Should it be avoided, confronted, minimized, ignored? When an experiment fails, or an equation refuses to yield its solution, what should be done? There are many strategies. Some are productive, some are not. Guidelines for these situations are absolutely essential for the practice of science, though they are rarely stated explicitly. Instead, they are governed by usually unspoken virtues and values. Scientists who make their uncertainty productive are celebrated as insightful, dogged, or sometimes just stubborn. The unknown can be frightening and arresting, and one mark of a "good scientist" is the ability to continue forward despite those obstacles. Where do these virtues come from? Out of the many possible approaches to uncertainty, why did certain scientists or groups of scientists choose one particular approach? Can we understand the kinds of justifications used for specific kinds of scientific practices?

I here trace one kind of justification for scientific virtues: a religious type. Religion has historically provided rich resources for scientists grappling with categories like uncertainty. This paper presents three case studies where religious ideas were used as justification for the epistemic virtue I call "productive uncertainty"—embracing the unknown as a proper source for scientific investigation, even in the absence of firm technical foundations. Essentially, this is the claim that one should continue working on a scientific problem despite gaps and incompleteness. My case studies examine the work of James Clerk Maxwell (1831–79), Arthur Stanley Eddington (1882–1944), and Carl Sagan (1934–96). These physical scientists, from three different generations, thought carefully about issues of productive uncertainty and relied on quite different connections to religious thought.

Maxwell: Explicit Theological Justification

Maxwell's story is perhaps the most straightforward of the three. His thinking about science, religion, and uncertainty was highly scriptural and connected directly to familiar themes of creation and design. Maxwell is best known today through the equations named after him. These were the first interrelated mathematical descriptions of the behavior of electricity, magnetism, and light (though he

never wrote down the quartet that modern physics students memorize).[1] His extraordinary achievement was showing that electricity, magnetism, and light were all unified: what looked to be different phenomena and forces were actually just manifestations of a deeper unity.

Maxwell was also an evangelical Christian. He was raised in both the Anglican and Presbyterian traditions, and as a young man in Cambridge came to evangelicalism through a powerful conversion experience. In the Victorian age, evangelicalism was not a separate sect, but rather an ecumenical outlook that cut across denominations. That outlook was typically associated with a deep respect for scripture and an emphasis on a personal relationship with Jesus Christ, rather than institutional authority. Like most evangelicals, Maxwell thought of humanity as deeply sinful and in need of redemption from a wholly-other divine power. His God was the creator and lawgiver of Genesis who carefully crafted a universe for human beings.[2]

This framework was important for how Maxwell dealt with questions of uncertainty in his work on electromagnetism. By the time he finished college, there were already indications that magnetism was related to electricity, but it was not clear exactly how or why.[3] Neither the laboratory nor theoretical evidence suggested any fruitful routes of study. Maxwell, however, persevered. He developed a mechanical model of ether in which it could support transverse waves of electromagnetic effects, which he realized would travel at the speed of light.[4] This suggested a profound conclusion: "that the luminiferous and the electromagnetic medium are one"—the unification of light and electromagnetism.[5] Maxwell embraced the unification of natural laws suggested by his mechanical model, even though some of his colleagues (such as Lord Kelvin) objected. He was convinced that there was a true connection between optics and electromagnetism, a fundamental unified principle hidden in the chaos of observable phenomena. What reason did he have for taking unity seriously as a guideline?

It was not that he had a naïve belief in the unity of nature. Maxwell seriously considered the possibility that the unification of natural laws was only a feature of the mind and not the physical world. As a young man he wondered: "[A]re we to conclude that these various departments of nature in which analogous laws exist, have a real interdependence; or that their relation is only apparent and owing to the necessary conditions of human thought?"[6]

Maxwell knew it was entirely possible that the concept of an orderly, unified universe was simply a

1. The most useful biography of Maxwell (despite some Victorian hagiography) remains Lewis Campbell and William Garnett, *Life of James Clerk Maxwell* (London: Macmillan, 1882).
2. Maxwell's religious views are discussed in Matthew Stanley, *Huxley's Church and Maxwell's Demon* (Chicago: University of Chicago Press, 2015) and Paul Theerman, "James Clerk Maxwell and Religion," *American Journal of Physics* 54 (1986): 312–17.
3. On the development of Maxwell's theory overall see P.M. Harman, *The Natural Philosophy of James Clerk Maxwell* (Cambridge: University of Cambridge Press, 1998), 98–124; Daniel Siegel, *Innovation on Maxwell's Electromagnetic Theory* (Cambridge: University of Cambridge Press, 1991); Crosbie Smith, *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain* (Chicago: University of Chicago Press, 1998), 218–38; M. Norton Wise, "The Mutual Embrace of Electricity and Magnetism," *Science* 4387 (1979): 1310–18; M. Norton Wise, "The Maxwell Literature and British Dynamical Theory," *Historical Studies in the Physical Sciences* 13 (1982): 175–205.
4. See Harman, *Natural Philosophy*, 64–67, 102–8, and Smith, *Science of Energy,* 226–27.
5. James Clerk Maxwell to Michael Faraday, 19 Oct 1861, in P.M. Harman, ed., *Scientific Letters and Papers of James Clerk Maxwell*, Vol. 1 (Cambridge: Cambridge University Press, 1990), 685–86. (Hereafter, *SLP*.)
6. James Clerk Maxwell, "Essay for the Apostles on 'Analogies in Nature,' February 1856," in *SLP* 1, 376–77.

human psychological construction projected onto the world. To illustrate this danger, he presented two possible metaphors for the laws of nature:

> Perhaps the 'book,' as it has been called, of nature is regularly paged; if so, no doubt the introductory parts will explain those that follow, and the methods taught in the first chapters will be taken for granted and used as illustrations in the more advanced parts of the course; but if it is not a 'book' at all, but a *magazine*, nothing is more foolish to suppose that one part can throw light on another.[7]

If nature was like a book, then there was a single unified argument. There was a common thread holding together the text that could be used to interpret and understand the whole even if you were only able to read one chapter. If so, then in physics, electricity could help you understand magnetism because they were both part of a single "document." In that case unity was a reasonable goal.

But if nature were like a magazine, where the separate articles had nothing to do with one another or were written by different authors, there was no such assurance. A magazine has no single argument. There would be no guarantee that any one article could help the reader understand any other. There would be no justification to persist in looking for unity. If this were the case, there would be no reason to think that electricity could help us understand magnetism. It was not obvious why scientists should choose one metaphor over the other. Whether nature was like a book or a magazine was of the highest importance. But how was one to decide? For Maxwell, the key was that he knew the book of nature's author—God—and he knew how that author wrote.

Maxwell thought of natural laws as being "parts of one universal system."[8] The interrelationship of natural laws was a way that God communicated His existence, and it was the unity of laws that revealed this communication. An arbitrary distribution of individual laws (like the articles of a magazine) would not suggest anything about a divine plan, but unification (like the chapters of a book) would be highly improbable and therefore was a kind of divine communication. Maxwell thought God had a plan for the world, and part of that plan was designing natural laws to fit together like the pieces of a puzzle.

Maxwell often described the importance of unity in his God's plans. He thought this could be helpful for men of science:

> I think that each individual man should do all he can to impress his own mind with the extent, the order, and the unity of the universe, and should carry these ideas with him as he reads such passages as the 1st Chap. of the Ep. to Colossians…, just as enlarged conceptions of the extent and unity of the world of life may be of service to us in reading Psalm viii.; Heb. ii. 6, etc.[9]

For Maxwell, a divinely unified universe was something that could be found in the Bible, not just the laboratory. Persisting in the scientific goal of a unity of nature was therefore encouraged by theology. The scriptural passages Maxwell referred to in this letter emphasized God's role as creator of the natural world and awe that God had designed his creation for man. Thus Maxwell linked the unity and order of nature not just with divine creation itself, but also with the role of humanity in that creation. He also argued that we can see "wisdom and power" in the uniformity of natural laws: "uniformity,

7. James Clerk Maxwell, "Analogies," in *SLP* 1, 381–82.

8. James Clerk Maxwell, "Inaugural lecture at King's College, London," October 1860, in *SLP* 1, 670.

9. James Clerk Maxwell to Charles John Ellicott, Bishop of Gloucester and Bristol, 22 November 1876, in *SLP* 3, 418.

accuracy, symmetry, consistency, and continuity of plan are as important attributes as the contrivance of the special utility of each individual thing."[10] A properly evangelical reading of scripture could, he thought, justify his searching for unity in the unknown.

This was because Maxwell thought God had designed the laws of nature with the special feature that they were meant to be discovered: "[Once we understand some science] we are prepared to see in Nature not a mere assemblage of wonders to excite our curiosity but a systematic museum designed to introduce us step by step into the fundamental principles which are displayed in the works of Creation."[11]

In particular, the unity of laws was intended for discovery. The connections of natural laws were systematic, in that they were designed to attract the attention of humans and lead them to deeper principles. Laws were laid out like a trail to guide the attentive person from diverse phenomena to unification via strategic connections. Maxwell's God wanted him to push through the puzzles. His theology gave him a powerful set of tools for understanding the natural world and for guiding his investigations in physics:

> Is it not wonderful that man's reason should be made a judge over God's works, and should measure, and weigh, and calculate, and say at last 'I understand I have discovered—It is right and true'…. We see before us distinct physical truths to be discovered, and we are confident that these mysteries are an inheritance of knowledge, not revealed at once, lest we should become proud in knowledge, and despise patient inquiry, but so arranged that, as each new truth is unraveled it becomes a clear, well-established addition to science, quite free from the mystery which must still remain, to show that every atom of creation is *unfathomable* in its perfection.[12]

Discovering the design of these laws was not meant to be an easy victory, however. Their revelation was balanced against the deeper truths which humans could never know. God's intent was to encourage us to always be investigating further, not to be satisfied with what we already had:

> While we look down with awe into these unsearchable depths and treasure up with care what with our little line and plummet we can reach, we ought to admire the wisdom of Him who has arranged these mysteries that we find first that which we can *understand* at first and the rest in order so that it is possible for us to have an ever increasing stock of *known* truth concerning things whose nature is absolutely incomprehensible.[13]

Note the evangelical warnings against human pride and the evocative image of man's limited powers represented by "our little line and plummet." The deepest truths of nature were simply beyond our understanding, except where God allowed us to explore. As with the evangelical position on sin and redemption, our ability to know anything about the universe was the result of God's grace in making those things knowable. Comprehension of nature came from God's free choice to set up the laws of nature such that they could be understood, not only a result of human efforts.

Maxwell's explanations for the importance of unity show that it was not solely a scientific goal. It also had profound religious significance. It was a religious virtue to know that God had intention-

10. Ibid., 417.

11. James Clerk Maxwell, "Inaugural Lecture at Aberdeen," in R.V. Jones, "James Clerk Maxwell at Aberdeen, 1856–1860," *Notes and Records of the Royal Society of London* 28 (June 1973), 71.

12. Ibid., 77. Punctuation is Maxwell's.

13. Ibid., 77.

ally created a mysterious but comprehensible universe. A virtuous person pushed into that uncertainty assured that there were answers and that they were findable. This gave Maxwell confidence that uncertainty could be productive: even if the world looks messy, you should persist in looking for unity. His approach to this problem was typical of conservative religious thought of the time, postulating a close relationship between the physical world and its creator and resting on the idea that the Book of Nature could provide insight into God's thoughts.

Eddington: Implicit Theological Justification

For my next case, the religious context is significantly different. Now we will examine how *liberal* theology can contribute to questions of productive uncertainty. For this we look at the Cambridge astrophysicist A.S. Eddington, now best known as the man who provided the first observational evidence for Einstein's theory of relativity. That was extremely important, but his scientific legacy is more significant in astronomy. He was one of the first theorists to understand the inner workings of stars and laid the foundation for stellar astrophysics.[14] But he is of interest here due to his religious belief. He was a lifelong member of the Religious Society of Friends, better known as the Quakers. The Quakers are a Protestant sect that emphasizes the presence of God within everyone and, relatedly, an embrace of mysticism, pacifism, and social activism. As was typical of liberal religion, they contended that personal religious experience was primary, with scripture and institutions secondary.

As with Maxwell, we examine how a particular religious idea intersected with questions of uncertainty: what the Quakers call "seeking." This refers to the Quaker virtue of constantly exploring, searching, and looking for new things in both the spiritual and temporal worlds. This is an anti-dogmatic stance: one should not try to find complete certainty because this leads to stagnation and a refusal to accept new ideas. Quakers associate this idea with a mystical outlook. Mysticism requires an ability to accept new knowledge at any time, unlike fundamentalism, which rejects in principle that true knowledge is revisable. A seeker is a pragmatist, using whatever knowledge and tools are useful, instead of worrying about whether they are absolutely true.

Eddington tried to follow the ideal of seeking, and this played an important role in his work in astrophysics. It allowed him to make progress on a difficult area of theoretical astronomy. In 1916 he began investigating a problem that had proven intractable for astronomers: what, exactly, *are* stars? And, how do they shine? Previous attempts to solve these problems involved creating theoretical models of stars based on physical principles that were well-understood, such as Newtonian gravity and thermodynamics.[15] These attempts failed, and the resulting models behaved nothing like stars. It was clear by the twentieth century that gravitation was not enough to explain why stars were hot. It seemed that some critical element was missing from physics. This was a deductive critique: without total certainty in one's foundations, one has nothing.

Eddington took a different approach to the question of stellar energy. He maintained that the most obvious feature about stars is that they shine, and therefore models must account somehow for this output of energy. Astronomers knew nothing about the detailed behavior of the energy source, so

14. The only major biography of Eddington is A.V. Douglas, *Life of Arthur Stanley Eddington* (London: Thomas Nelson, 1956), though it has significant gaps. Matthew Stanley, *Practical Mystic* (Chicago: University of Chicago Press, 2007) examines the religious and scientific aspects of his life. On Quakers and science more broadly see Geoffrey Cantor, *Quaker, Jews, and Science* (Oxford: Oxford University Press, 2005).

15. Karl Hufbauer, *Exploring the Sun: Solar Science Since Galileo* (Baltimore: Johns Hopkins Press, 1991).

Eddington made a pragmatic, simplifying assumption. Assume that the energy is generated throughout the star in the simplest way possible:

> It is clear that we cannot arrive at much certainty with regard to the conditions in a star's interior…the weak link in the present investigation is that I have assumed without much justification that [energy production] is constant throughout a star. I have given some evidence that if it is variable the general character of the results would not be greatly altered; and, as a step toward the elucidation of the problem of stellar temperatures, I plead to be allowed provisionally one rather artificial assumption.[16]

He justified his uncertain foundations by appealing to the possibility of progress on a difficult problem. And he was able to make progress: with slight adjustments of his provisional assumption, Eddington was able to reproduce many of the observable characteristics of stars without knowing any of the details of where the energy comes from.

This curve turned out to be an excellent fit to the data and was essentially the first success in theorizing about the interiors of stars. Not everyone was impressed, though. His colleague James Jeans argued that the fit between calculation and observation was meaningless because it was not based on firm deductions. Whether forward progress or firm foundations was more important was not obvious, and their disagreements became the basis of their famously vigorous debates at the Royal Astronomical Society.[17] Eddington continued on despite his colleagues' criticism. He manipulated his new mathematical models and compared them to observations, and the differences allowed him to infer some of the basic behaviors of the source of stellar energy.

In 1917 there were still multiple possibilities for the physical mechanism, with the most likely candidates being either the annihilation of oppositely-charged particles or "transmutation" (what we today call fusion). Eddington argued that the competing theories should be judged on how well they allowed further scientific investigation:

> The theory of annihilation of matter is more fertile in astronomical consequences than the other forms of the subatomic theory, and for this reason alone it seems worthwhile to follow it up in detail. We shall not be greatly concerned with *how* the annihilation is accomplished; but it may perhaps be well to have a scheme in mind.[18]

Even after his success, he was not content to let it stand as a finished product. He presented it as something that needed to be challenged, pushed, and most of all *used*. Manipulating a theory at the edge of its applicability helped to not just solve the problems at hand, but also indicate where further investigation would be useful: "In this calculation we have pressed the theory to an extreme degree. Our object is not so much to assert the truth of the conclusions, as to use every opportunity of discovering by comparison with observation the directions in which our approximate treatment may be improved."[19] Intriguingly, he said that a theory should not be like a building (a permanent structure to be admired) but rather like an engine (something to move one forward).[20]

16. A.S. Eddington, "The Radiative Equilibrium of the Sun and Stars," *Monthly Notices of the Royal Astronomical Society* 77 (1917): 17.
17. Matthew Stanley, "So Simple a Thing as a Star," *British Journal for the History of Science* 40 (2007): 53–82.
18. A.S. Eddington, *Internal Constitution of the Stars* (Cambridge: Cambridge University Press, 1926), 306.
19. A.S. Eddington, *Stars and Atoms* (London: Oxford University Press, 1927), 40–41.
20. A.S. Eddington, "The Internal Constitution of the Stars," *The Observatory* 43.557 (October 1920): 357. This was Eddington's Presidential Address to Section A of the British Association.

Eddington justified his methodology by pointing out that he had made great steps forward in understanding stars. Seeking new, if tentative, knowledge, rather than restricting himself to what was certain, had allowed him to bypass some of the problems of stellar astrophysics. He also said that this pragmatic, exploratory approach to science explained how progress can be made at all when results are constantly being overturned. This discarding of knowledge is not the tragedy it seems; rather, the tragedy occurs when people think they know everything necessary about a subject. Instead, they need to accept that any result is temporary, and true only so far as it allows further exploration. This makes the danger of disproof into a benefit, forcing a scientist to continually improve. This is how uncertainty becomes productive—if the puzzle piece does not fit, look for another place to use it.

The crux of the matter was that Eddington was arguing for an open-ended scientific process. Proof was not to be valued; it was the ability to know *more* that was important. *Stars and Atoms*, a popular book explaining his technical theory, took pains to explain exactly what this meant:

> It would be an exaggeration to claim that this limited success is a proof that we have reached the truth about the stellar interior. It is not a proof, but it is an encouragement to work farther along the line of thought we have been pursuing. The tangle is beginning to loosen. The more optimistic may assume it is now straightened out; the more cautious will make ready for the next knot…. We have taken present day theories of physics and pressed them to their remotest conclusions. There is no dogmatic intention in this; it is the best means we have of testing them and revealing their weaknesses if any.[21]

In his inimitable style, Eddington illustrated the value of seeking over dogmatism with a reevaluation of one of the Greek classics. The story of Daedalus and Icarus was usually told to admonish those who push too far, but Eddington provided a novel perspective:

> In weighing their achievements, there is something to be said for Icarus. The classical authorities tell us that he was only 'doing a stunt,' but I prefer to think of him as the man who brought to light a serious constructional defect in the flying machines of his day. So, too, in Science. Cautious Daedalus will apply his theories where he feels confident they will safely go; but by his excess of caution their hidden weaknesses remain undiscovered. Icarus will strain his theories to the breaking-point till the weak points gape. For the mere adventure? Perhaps partly; that is human nature. But if he is destined not yet to reach the sun and solve finally the riddle of its constitution, we may at least hope to learn from his journey some hints to build a better machine.[22]

Uncertainty in a scientific investigation was not to be feared, it was to be welcomed as a route to further understanding.

Eddington's tolerance of uncertainty in his theories was very similar to the Quaker virtues of seeking that he embraced in his religious practice. He considered fundamental certainty to be far less important than maintaining a living, transforming faith and a direct experience of God. Eddington felt that mystical Quakerism required an open attitude toward the world. He liked to cite one of the Queries (short questions meant to stimulate prayer and thought at Quaker meetings): "Are you loyal to the truth and do you keep your mind open to new light, from whatever quarter it may arise?" Eddington felt that religious truth should not be admired on a pedestal, but should instead inspire, and ultimately change one's life. Certainty was not to be sought after in either science or religion:

> We seek the truth; but if some voice told us that a few years more would see the end of our journey, that the

21. Eddington, *Stars and Atoms*, 40–41.

22. Ibid, 41.

> clouds of uncertainty would be dispersed, and that we should perceive the whole truth about the physical universe, the tidings would be by no means joyful. In science as in religion the truth shines ahead as a beacon showing us the path; we do not ask to attain it; it is better far that we be permitted to seek…. You will understand neither science nor religion unless seeking is placed in the forefront.[23]

So for *this* Quaker, science shared a virtue with religion: persist in searching for knowledge, even if there will be no end. A complicated puzzle is just one more step on an unending quest. Eddington's approach to linking scientific and religious values was typical of early twentieth century liberal religion: avoiding talk about God as creator or direct divine interaction with the natural world, and instead emphasizing personal religious experience and how a religious outlook can work well with science. The practice of science was encouraged by the spiritual virtue of seeking for truth and a pragmatic approach to all experience.

Sagan: Structural Theological Justification

Our third historical actor, the astronomer Carl Sagan, was quite different, in that he was not conventionally religious in any sense. He was an icon of the public understanding of science, from *The Tonight Show* to his own series *Cosmos*, and the face of planetary exploration. He was also a dedicated secular humanist, meaning he carried both skepticism toward and respect for religious belief. Wary of dogma, he did not hesitate to denounce creationism or fundamentalism. But he appreciated spiritual perspectives, particularly a kind of Spinozistic Romanticism ("We are a way for the cosmos to know itself"), and admired the power of religion to enact change and shape society.

Religion, then, in so far as it shaped Sagan's scientific virtues, was not a matter of religious belief or practice as it was with Maxwell or Eddington. Rather, Sagan adopted a kind of religious *structure*, a religious mode of speech and argument—apocalypticism. The structures of apocalyptic prophecy were widely available and effective in his time and place, the late twentieth century United States, and he adapted them for his own purposes. They were resources that he used for thinking about how scientists should engage with uncertainty.

Sagan began grappling with these issues in the early 1980s when he and his colleagues developed their theories of "nuclear winter." Inspired by the increase of Cold War tensions in the Reagan administration, they studied the large-scale planetary effects of a nuclear war. Their simulations suggested that even a moderate exchange of nuclear weapons would loft enough soot into the atmosphere to block sunlight and cause temperature drops across the globe.[24] This would shatter the terrestrial ecosystem and destroy humanity. Thus Reagan's vision of a winnable nuclear war was fantasy; the whole of the human species was now at risk.

Sagan put his public stature to good use publicizing the dangers of nuclear winter, emphasizing predictions of global apocalypse in the event of such a war. He used shocking, emotional imagery to describe a nuclear winter, deploying all the skills that he had developed to excite the public about science and turning them to a more menacing task. His soaring imagery, wonder about the unknown, and insightful connections to ordinary life now became tools for evoking horror. He emphasized the possibility of extinction, the literal end of humanity. He liked to estimate that the total deaths from nuclear war would be be 500 trillion—all the humans who would ever have lived in the future.

23. A.S. Eddington, *Science and the Unseen World* (New York: Macmillan Company, 1929), 88.

24. See Lawrence Badash, *A Nuclear Winter's Tale* (Cambridge, MA: MIT Press, 2009).

Both politicians and scientists were unsettled by Sagan's doomsaying. It was not so much the prediction itself; it was the *way* he spoke. He sounded like an Old Testament prophet, not a calm, rational astronomer. Critics complained that Sagan was unfairly emphasizing the worst possible interpretation of the results. Sagan had been warned about this by Hans Bethe, who saw early versions of his nuclear winter paper. Bethe cautioned that the paper should be built around the most likely result, not the most dramatic case.[25] But Sagan's writings seemed to omit any caveats and focus on the worst-case scenario. They began to appear less like honest efforts to educate the public and more like propaganda.[26] Many scientists voiced concerns that this exaggeration was an inherently un-scientific thing.[27] One wrote that scientists "prefer to understate their results than to be blamed for overrating them" and that "apocalyptic views are not serving us well in the long run. At worst, they give science a bad name."[28]

But Sagan defended discussing science in apocalyptic terms. He acknowledged that our knowledge of nuclear winter was necessarily theoretical and unverifiable. He then contended that the immediate effects of even one nuclear weapon were so devastating that it was our obligation to assume that there would be even further "unpredictable and catastrophic consequences."[29] Whatever we thought we knew, the reality must be even worse. He justified this by noting that throughout the atomic age humans had continually discovered that nuclear war would be more awful than previously thought.[30] His favorite example was the Bravo H-bomb test, where the explosive yield and fallout spread were vastly greater than predicted.[31] This became a standard move: warning that "we may have severely *under*estimated how long the cold and the dark would last."[32] As bad as the known effects were, there "may be others about which we are still ignorant."[33]

Sagan was more than willing to admit that his predictions were uncertain. His characteristic twist was to assert that that uncertainty should be interpreted as implying an ever-worse reality:

> We do not claim that a given sort of nuclear war will inevitably produce a given severity of nuclear winter; the irreducible uncertainties are too large for that. What we do claim is that the most likely consequences of many kinds of nuclear war constitute climatic and environmental catastrophes much worse than the worst our species has ever encountered—and that prudent national policy should treat nuclear winter as a probable outcome of nuclear war.[34]

Apocalypticism, then, was the "prudent" move. Sagan extended this argument to make the case that

25. Paul Rubinson, "Containing Science" (Ph.D. diss, University of Texas at Austin, 2008), 296–97.
26. Naomi Oreskes and Erik Conway, *Merchants of Doubt* (London: Bloomsbury, 2010), 52. For example, MIT professor Kerry Emanuel criticized the TTAPS team for not being clearer about the uncertainties in "Nuclear Winter: Towards a Scientific Exercise," *Nature* 319.6051 (January 23, 1986): 259.
27. Ibid., 53.
28. Florin Diacu, *Megadisasters: Predicting the Next Catastrophe* (Princeton, NJ: Princeton University Press, 2009), 29, 106.
29. Ibid., 257–58.
30. Carl Sagan, "The Atmospheric and Climatic Consequences of Nuclear War," in *The Cold and the Dark: The World After Nuclear War*, edited by Paul R. Ehrlich et al. (New York: W.W. Norton, 1984), 24.
31. Carl Sagan, "The Nuclear Winter," *Parade*, October 30, 1983, 4.
32. Ibid., 5.
33. Carl Sagan, "Nuclear War and Climactic Catastrophe: Some Policy Implications," *Foreign Affairs* 62.2 (Winter 1983–84): 264.
34. Carl Sagan and R.P. Turco, *A Path Where No Man Thought: Nuclear Winter and the End of the Arms Race* (New York: Random House, 1990), 41.

he, not his critics, was being appropriately conservative. He contended that there were two kinds of conservative thinking: playing down the possibility that something might happen, or assuming that it will happen and taking all the necessary precautions.[35] The first was more typically associated with scientific dialogue, but was no longer appropriate in the world of potential nuclear winter. This was a "tradition of conservatism which generally works well in science but which is of more dubious applicability when the lives of billions of people are at stake."[36] Conservatism, then, should shift from assuming that results would be better, to assuming that they would be worse.[37] He did not deny that the probability of the extinction of humanity was small. But one was obligated to take that small chance seriously when the stakes were so high.

Sagan repeatedly criticized the reluctance of policymakers to accept this. Unless the chances of the more severe instances of nuclear winter were

> not just small, but vanishingly small, risk analysis demands that we give it special attention in making decisions on policy and doctrine; i.e., the value we attach to our civilization and species is so high that even small probabilities that we are placing them in jeopardy must be taken very seriously.[38]

This emphasis on low-probability events had clear implications for policy. Even a 99% effective missile defense could lead to planetary disaster.[39] He hoped that, by this reasoning, the extraordinary consequences of nuclear winter might "help in bringing our species to its senses."[40]

These moves were productive in the sense this essay has been discussing: other scientists took up the issue, and nuclear winter became the subject of many detailed analyses, even if Sagan did not agree with all of their conclusions. Further, the atmospheric models used in the nuclear winter calculations became a crucial part of modern climate science. Sagan's science ignited a chain of research just as Maxwell's and Eddington's did. But it is important to acknowledge that Sagan's discussions of nuclear winter had notable characteristics that were unusual for scientific conversation: warnings of imminent, universal disaster; emphasis on worst-case scenarios; policy critiques; remonstrations against political leaders; promises of the possibility of avoiding disaster; calling for a fundamental restructuring of global politics; and requesting specific policy changes. Some felt this discourse inappropriate for a scientist, and it likely played into his humiliating rejection by the National Academy of Sciences. However, if it is unusual in science, there is a kind of discourse that matches these characteristics: prophecy. If we reconsider Sagan as someone speaking in a prophetic register, his otherwise strange rhetorical choices begin to make sense.

A scientific prophet is not as strange a concept as it might seem. The late twentieth century United States was steeped in prophecy talk. Paul Boyer has shown that "prophecy belief" was widely filtered throughout American culture in this period, even into typically secular contexts.[41] He argues for con-

35. Ibid., 87–88.

36. Sagan, "The Nuclear Winter," 4.

37. Ibid., 7.

38. Sagan and Turco, *A Path Where No Man Thought*, 197.

39. Ibid., 83–5.

40. Ibid., 22.

41. Paul S. Boyer, *When Time Shall Be No More: Prophecy Belief in Modern American Culture* (Cambridge, MA: Belknap Press of Harvard University Press, 1992).

centric circles of prophecy belief: a core group who study the Bible intensely, a further group who live by the Bible but do not typically read it, and an outer circle of "superficially secular individuals who exhibit little overt prophecy interest, but whose worldview is nevertheless shaped to some degree by residual or latent concepts of eschatology."[42] The profusion of apocalyptic literature produced by fundamentalist and evangelical communities during the Cold War effectively flowed into mainstream culture; for example, Hal Lindsey's *The Late Great Planet Earth* became the best-selling non-fiction book of the 1970s. By the 1980s, prophecy belief was a kind of collective discourse found throughout the country. It was a mode of conversation that was both accessible to, and recognizable by, almost everyone, regardless of religious belief.

I am not, of course, arguing that Carl Sagan had a hidden fundamentalist agenda. No one should doubt Sagan's commitment to secular humanism. Rather, by the 1980s prophetic language had become "axiomatic in American life" even among "avowedly secular citizens."[43] The ubiquity of prophecy belief in America has given rise to a particular mode of speech in which a public figure criticizes political leaders through warning of imminent disaster that can only be avoided through profound, genuine acknowledgement of some deeper truths.[44] Sagan's adoption of this way of talking helps us make sense of his noted tendency to draw from "the top of the error bars." Prophets were supposed to be audacious, not conciliatory. They were supposed to arouse strong emotions, not calm their audience. Sagan's peculiar mix of pessimism and optimism was standard for prophets. It was necessary to alarm everyone *and* show the proper route for redemption. And as was traditional, his prophetic speech both moved the citizenry to demand change and invited ad hominem attacks on the speaker as a false prophet. The arguments of both Sagan and his critics were significantly shaped by Cold War America's embrace of prophecy talk.

This was the frame for Sagan's approach to productive uncertainty. When uncertainty intersected with possibly apocalyptic outcomes, he argued, scientists should emphasize the worst possibility. He demanded that they call for policy based on the worst possible non-zero probability outcome—nuclear winter and the extinction of humanity. This higher standard was characteristic of prophetic dialogue and was intended to shame leaders and mobilize listeners to demand immediate change to avert disaster. This prophetic precautionary principle seemed very strange to scientists, but makes perfect sense if we understand that Sagan was drawing on the widely available resource of prophetic culture. No one was particularly shocked when Jonathan Schell or Jerry Falwell drew on this resource. But the distinctive character of the prophetic mode of speech was very different from the conventional expectations of scientific communication. To Sagan, doing good science in an apocalyptic age meant assuming the worst. For him, this was the virtuous way to deal with uncertainty.

Conclusion

We have seen three versions of the epistemic virtue I call productive uncertainty. It deals with how scientists should proceed when their knowledge of a situation is unclear, incomplete, or nebulous. We have seen how this virtue was conceived of and articulated in rather different ways over three gen-

42. Ibid., 3.

43. George M. Shulman, *American Prophecy: Race and Redemption in American Political Culture* (Minneapolis: University of Minnesota Press, 2008), ix.

44. James Darsey, *The Prophetic Tradition and Radical Rhetoric in America* (New York: New York University Press, 1997); Shulman, *American Prophecy*.

erations. For Maxwell, the maxim was "have faith." For Eddington, "there is always more." For Sagan, "assume the worst." But in these exemplars' own times and places, not everyone agreed with their approaches. While most scientific investigators would agree that uncertainty could be mediated or made useful, exactly how to do so was (and is) not always clear. Indeed, our three historical actors would likely have some lively conversations even as they agreed that uncertainty can be a starting point and not an end. They would all agree that uncertainty should not discourage scientific investigation, and that one should push forward even when there are doubts or shaky foundations.

All three of these approaches marked off certain scientific practices as good, virtuous, or valuable. All three also drew on religious resources to articulate and justify those scientific practices. Again, they did so in importantly different ways. Maxwell's scientific values were explicitly religious; he literally cited chapter and verse to guide investigations of the natural world. Eddington's were implicitly religious; one can see the links between his Quaker epistemology and his scientific practice, but it takes some careful investigation and could easily be missed. Sagan's scientific values were structurally religious; his own religious beliefs and practices were largely irrelevant, and instead he used efficacious forms of communication that had traditionally belonged to a religion to which he did not adhere. It seems that each case has increasing distance between religious propositions and scientific values.

One could read this diachronic story as a secularization narrative, though that is misleading. It would be perilous to claim that 1980s America was less religious than Edwardian England. Rather, I think this is an indicator of the changing acceptability of professional scientists speaking about religious matters. This was expected in the Victorian period, frowned on in the early twentieth century, and completely shocking by the end of the twentieth century. Conversely, this narrative arc indicates how religion can still affect scientific values even without explicit discussions of God in technical journals. Science is more than facts and equations; religion is more than scripture and rituals. Both are sets of values, and those sets can sometimes overlap productively—say, when asking how to address uncertainty. A good life for a scientist is one that productively links the known and unknown, and one that can find solidity among mystery. This, it turns out, is something with which religion has some experience.

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CHAPTER 3.

ON MAKING THE WORLD HABITABLE

EMILY DUMLER-WINCKLER

LOVE AND THOUGHT

Two well-assorted travelers use
The highway, Eros and the Muse.
From the twins is nothing hidden,
To the pair is nought forbidden;
Hand in hand the comrades go
Every nook of Nature through:
Each for other they were born,
Each can other best adorn;
They know one only mortal grief
Past all balsam or relief;
When, by false companions crossed,
The pilgrims have each other lost.
– Ralph Waldo Emerson[1]

In "An Address Delivered before the Senior Class in Divinity College" at Harvard Divinity School in 1838 (hereafter, "Divinity Address"), Ralph Waldo Emerson declared that it is by "the religious sentiment" and "not by science or power" that "the universe is made safe and habitable" (78).[2] He and his fellow transcendentalists embraced the insights of the so-called second scientific revolution of the nineteenth century. At the same time, they were aware of the limitations and dangers that attend certain modern scientific practices and views of nature. These disenchanted views tend to alienate us from nature, God, one another, and ultimately from our own agency. They do so by celebrating our power to dominate creation and its creatures or to become impervious to nature's perils through stoic detachment. The modern temptation is to think that it is by these forms of knowledge or power that the world is made safe and habitable. Emerson saw then what we know now—the toxic effects of these temptations. Ironically, both views (namely, that human beings are meant to conquer or to withdraw from nature) have long been attributed to Emerson.[3] On the contrary, as I read him, Emer-

1. Ralph Waldo Emerson. Poems, Complete Works, Vol. 9.

2. Unless otherwise noted, all Emerson quotations throughout this essay are from Ralph Waldo Emerson, *Emerson: Essays and Lectures* (New York: Library of America, 1983).

3. For the former, see Cornel West, *The American Evasion of Philosophy: A Geneaology of Pragmatism* (Madison: University of Wisconsin

son is devoted, beginning to end, to expounding the virtues that modern agents would need to overcome both forms of alienation, to make a home of the modern world we inhabit. My aim is as much constructive as it is interpretive. I am interested in getting Emerson right in order to illuminate our understanding of the virtues today.

In this short essay, I would like to say something about these virtues—about their distinctions and unity—and about how these matter for practitioners of modern science, and more broadly for all who would make a home of the world we inhabit. Along the way, we will see that Emerson maintains some version of the classic distinction between the intellectual and moral virtues, as well as the theological virtues—faith, hope, and love—that perfect them. He is interested in the virtues that perfect science, as well as its perfection by the religious sentiment. From his early work *Nature* to the "Divinity Address," and from his 1841 essays on "Intellect" and "Art" to his final lecture series, Emerson helps us to think about the virtues that perfect the modern practices of science and religion.

At the outset, a cautionary note is perhaps in order. Unlike Aquinas and Aristotle before him, Emerson does not set out to provide us with a detailed analytic account of the virtues or good habits.[4] His account, strewn throughout his literary corpus, is nonsystematic and more akin to Augustine's in form and style. Nonetheless, like his ancient and medieval predecessors, Emerson seems to think that distinguishing between the intellect and will, or the intellectual and moral virtues, helps us to understand and describe the various perfections and imperfections of human agents. But crucially, a distinction is not a division or divorce. As we might suspect, this transcendentalist is as much concerned about the unity of intellectual, moral, and theological virtues as he is about clarifying their differences.

Intellectual and Moral Virtues

In the first paragraph of "Intellect," Emerson asks: "How can we speak of the action of the mind under any divisions, as of its knowledge, of its ethics, of its works, and so forth, since it melts will into perception, knowledge into act? Each becomes the other" (407). It may be tempting to read this as a precursor to the views of contemporary virtue epistemologists who deny any distinction between the intellect and will or between the moral and intellectual virtues. But the final line "each becomes the other" is better read as part of the riddle, an elaboration of the previous question: how can we speak

Press, 1989), 17ff. For the latter, see Robert D. Richardson, Emerson: The Mind on Fire (Berkeley: University of California Press, 1996), 233–34.

4. Jean Porter, *The Perfection of Desire: Habit, Reason, and Virtue in Aquinas's Summa Theologiae* (Milwaukee: Marquette University Press, 2018); David Decosimo, *Ethics as a Work of Charity: Thomas Aquinas and Pagan Virtue* (Redwood City, CA: Stanford University Press, 2016); John R. Bowlin, *Tolerance among the Virtues* (Princeton: Princeton University Press, 2016). The term "habit" is somewhat fraught, especially in the field of psychology. For a recent work that acknowledges its troublesome association with behaviorism in psychology and yet its standard use in philosophy (and puts it to good use throughout), see Timothy S. Reilly and Darcia Narvaez, "Character, Virtue, and Science," *Philosophy, Theology and the Sciences* 5.1 (2018): 51–79. Why use the term here? Put simply, it is standard in theology and philosophy, the disciplines from which I engage these interdisciplinary conversations. Thomas Aquinas insists that virtues are habits and revises Augustine's definition of virtue from a "quality" to a "habit" (I-II 55.4). Many prominent moral theologians (for example, Porter, Decosimo, and Bowlin) have used the term, while clarifying that Aquinas means something more nuanced than our common notion of the word. Others may object: why not use the Latin term *habitus*, to avoid confusion? Over the course of the past century several social theorists have given term *habitus* a central place in their theories. The extent to which their notions of *habitus* are akin to premodern notions is highly debatable. All this is to say, the water is equally murky whether one uses "habit" or "*habitus*." Given the multilingual enterprise of interdisciplinary work, the use of either term should pose no problem to interdisciplinary conversations, so long as one is adequately aware of the qualms in other disciplines and clarifies their use of the term. I follow Decosimo's explication of the term; he sees its four primary features as follows: "Habit is a perfection of a capacity. It is necessarily either good or bad *in se*. It is difficult to change. And it enables action at will" (*Ethics as a Work of Charity*, 74).

of any divisions of the mind or soul? Does each part indistinguishably become the other? Or, rather, does each distinctively become (as in, suit and befit) the other?

That it is the latter becomes clear in the essay. But Emerson puts the point most strikingly in the poem I have used as my epigraph, "Love and Thought." Here, he depicts love and thought as "two well-assorted travelers." Distinct, they are nonetheless well-suited: "Each for the other they were born, each can the other best adorn." Their only mortal grief comes "when, by false companions crossed, the pilgrims have each other lost." The comrades are meant to travel hand in hand, and yet the possibility of deception and divorce looms. Thoughtless love and loveless thought would ensue.

In the essay, Emerson seems to follow Aquinas's distinction between the intellect and will, namely aptness and use, and their respective virtues. The virtues that perfect the speculative and practical intellect give us an *aptness* to think and to act in accordance with reason. But they do not move us to *use* that aptness. That is the job of the will. Nor do they move us to use them well or for good ends. That is the role of the moral virtues. The intellectual virtues perfect the intellect to help us to see rightly, but they do not move us to action, much less right action. For Emerson, the intellect names the capacity to contemplate, to theorize, to reflect on abstract truths in a way that does not *necessarily* move us to act. The same can be said of "Art," the title of the essay that immediately follows "Intellect." The moral and theological virtues are needed in order to use an art or craft (any knowledge about how to do or make something) that one possesses and to put art to good use.

The point here is that one may attain excellence in knowledge and in certain scientific practices without attaining excellence in *all* of the moral or theological virtues needed to perfect these with respect to the ends of life as a whole. The only moral and theological virtues that have a *necessary* connection to scientific technique (picture the lab technician), scientific theory (think of the cosmologists), scientific practices (hypothesis formation, observation, testing, collaboration, and so on), and the intellectual virtues (*scientia*, reasoning, insight, and so forth), are those needed for their basic use and exercise. Nonetheless, one can participate in these activities, acquire these habits, be born with these talents, and even produce these products without further ordering them to the ends of love or justice. For that, one needs the moral virtues such as justice, temperance, prudence, and courage, as well as the theological virtues of faith, hope and love, among others.[5] Some scientists seem to possess all of these together. But some do not. Take James Watson and Francis Crick, who, for all their intellectual brilliance, were unjust in their treatment of Rosalind Franklin. Watson and Crick never fully acknowledged that Franklin's theoretical expertise in molecular physics directly contributed to their ongoing work on DNA and saved them from pursuing a dead end.[6] Even today, it is no secret that the #metoo movement is as necessary in science as in Hollywood. Distinguishing between various intellectual, moral, and even theological virtues helps us to make sense of how this could be the case.

Scientists must possess at least *certain* of the intellectual virtues that perfect their reasoning, understanding, creativity, and imagination with respect to the natural world, and their knowledge of how to create hypotheses and perform experiments. They must *also* possess at least *certain* of the moral virtues that perfect their passions and desires, that inspire them to pursue their inquiries and to work with diligence. Because of the interconnectedness of the moral and intellectual virtues—between apt-

5. For an example of a scientist who argues that faith and wisdom are integral to excellence in scientific practice, see Tom McLeish, *Faith and Wisdom in Science* (Oxford: Oxford University Press, 2016).

6. I am grateful to an anonymous reviewer who helped me to more accurately state Franklin's contributions.

ness and use—in all social practices, including modern science, it is likely that excellent scientists will have a host of other virtues as well: a love of knowledge, open-mindedness, patience, humility, honesty, justice, friendship, and even faith, hope, and love in their secular and theological forms. A wide range of moral virtues are crucial for perfecting the scientist *qua* member of the scientific community, whether in the lab, classroom, guild, or public sphere. Most of us will want to say that the unjust scientist—the one who abuses his power over students, for example—is not an excellent scientist. He may be brilliant and successful by other measures, but he is not exemplary in all aspects of the practice. Furthermore, the moral and theological virtues are needed to perfect the scientist with respect to the whole of life, as a son or daughter, mother or father, friend, citizen, coach, etc.

A Journey of Ascent

In his early work *Nature*, the themes of which he would elaborate over the course of his literary career, Emerson takes his reader on a journey of spiritual ascent from blindness to sight, from the half-sight of science to the vision or song of the Orphic poet. The final chapter of the work, "Prospects," lives up to its name, offering hopeful revelations, visions of a new heaven and earth. But initially the prospects do not look so good. Entering the "kingdom of man," in which God will "go forth anew into the creation," is a matter of good sight and virtue, of both seeing and acting well. Here we are warned of the "half-sight of science" and the "half-force" of religion which severely diminish our vision and agency (45, 49, 47).

Science, Emerson claims, is half-blinded by an excessive attraction to the means, insofar as it loses sight of the end. Even the most astute naturalist discovers that nature's lessons cannot be learned through the understanding alone, "but [are] arrived at by untaught sallies of the spirit, by a continual self-recovery, and by entire humility" (43). Science is a matter of grace, reception, and intuition as much as tuition. The empirical sciences and idealism, he thinks, provide answers to the question "what is matter?" But they do not answer his other main questions: "whence and whereto Nature?"

According to Emerson's diagnosis, the same partiality afflicts human agency insofar as it "applies to nature, but half its force" (46). By the half-force of religion, like the half-sight of science, Emerson means that most of us relate to nature and exercise power by the understanding rather than reason. He adopts and adapts this distinction from Coleridge, who had done the same with Kant's distinction. For our purposes, it is enough to say that he likens the understanding to half-sight and half-force. We master nature "by penny-wisdom" (46). We have learned the lessons of commodity and extractive economies, the economical use of "fire, wind, water…steam, coal, chemical agriculture…." Alone, this form of power—power to commodify, dominate, control, harness, use, even waste—amounts to a frugal and piecemeal resumption of power. It too fails to address the question "to what end nature?," and creates more problems than it solves. This form of mastery alienates us from nature, God, and neighbor, yes, but also from ourselves. "The reason why the world lacks unity, and lies broken and in heaps," Emerson tells us, "is because man is disunited with himself" (47). Everything, everyone, becomes reduced to its instrumental use, a means to some other (usually economic) end, rather than an end in itself. But he does not leave us in darkness or despair.

Rather, "in the thick of darkness" in antebellum America, Emerson maintained that glimmers of light are never wanting—"examples of the action of man upon nature with his entire force—with reason as well as understanding" (46). As luminous examples of this ascetic, moral, disciplined use of

force, Emerson suggests the history of Jesus Christ, religious and political revolutions, the abolition of the slave-trade, and the wisdom of children. After 1860, he would add John Brown. The problem "of restoring to the world original and eternal beauty, is solved by the redemption of the soul" (47). Redemption is the cure for both the half-sight of science and the half-force of religion.

Theological Virtues

Whereas in *Nature* we find the vision of the Orphic poet at the summit of the spiritual ascent, in Emerson's "Divinity Address" we find a similar ascent to the sublimely beautiful apex of the religious sentiment. The virtues of faith, hope, and love—traditionally theological virtues—are crucial for the ascent to this zenith. Of course, for this erstwhile Unitarian minister, the theological virtues do not have Aquinas's Trinity as their object. Nonetheless, their objects are triune and regard the hypostatic union of the spiritual and material, the ideal and the real. In a sense, these virtues are every bit as much a matter of grace, of participatory reception, as infused virtues are for Aquinas. In "Spiritual Laws," Emerson writes of all virtue: "There is no merit in the matter. Either God is there or he is not there" (132). How then do faith, hope, and love perfect or redeem science and religion?

Emerson's late essay "Worship," like *Nature*, begins and ends in faith and wonder. By 1868, Emerson could see that the "old faiths" had succumbed to an untimely death. Along with the fatal divorce of religion and morality that typified antebellum America, culture had come to be defined by natural science. Just on the other side of the Civil War, he summarized the corruption of antebellum religion: "Here… are churches that proscribe intellect…slave-holding and slave-trading religions; and, even in the decent populations, idolatries wherein the whiteness of the ritual covers scarlet indulgence" (1058). Among the idolatrous (that is, white) religions, "There is no faith in the intellectual, none in the moral universe. There is faith in chemistry, in meat and wine, in wealth, in machinery, in the steam-engine…in public opinion, but not in divine causes" (1059). Corrupt faith is defined by an "acceptance of the lucrative [rather than the moral] standard" (1063). Emerson's keen insight here is that, for better and worse, we put our faith in one thing or another. For even the firmest naturalist or materialist, faithlessness is not an option.

The virtue of faith perfects the natural sciences and religion alike by revealing their affinity and by directing practitioners to their moral and spiritual ends. By Emerson's lights, the discoveries of the natural sciences are of a piece with a "secreter gravitation" of the religious sentiment and are "predetermined to moral issues" (1064). True "religion or worship is the attitude of those who see this unity" (1065). For this reason, it would be near-sighted "to limit our faith in laws to those of gravity, of chemistry, of botany, and so forth." The virtue of faith perfects our vision of natural and divine laws alike.

As with the other virtues, Emerson not only describes hope, but seeks to inspire it in his readers. In *Nature*, he had claimed that the wise writer—a modest name for his ambitious aims—dispenses hope by suggesting new regions of activity, new horizons of thought and action. "An infinite hope" is the greatest gift that all genius bestows.[7] Hope comes as a gift, as grace. The vices opposed to hope are presumption and despair. It is easy to imagine the corroding effect of these vices in the practices of science and religion alike. In science, presumption ends in falsehood and despair in resignation. The same could be said of religion, with equally toxic and alienating effects. Both "Worship" and *Nature* provide hope, not by painting a sanguine portrait of future events, but by pointing out new

7. Ralph Waldo Emerson, *Early Lectures: 1838–1842* (Cambridge, MA: Harvard University Press, 1972), 84.

domains for work, and suggesting that virtuous activity is the end—the only key to heaven, in this life or another.

Love may be the most conspicuous aspect of the journey of ascent and of Emerson's work as a whole. Emerson was tutored by the Apostle Paul and Augustine of Hippo, alongside Plato, Milton, Burke, Coleridge, and Wordsworth. He knows that love is all in all and that faith, hope and love abide, but the greatest of these is love. From *Nature* to "Worship" we find this refrain: "The superiority that has no superior; [the cure of blindness]; the redeemer and instructor of souls, as it is their primal essence, is love" (1064). Absent love, all our activities and causes—scientific, religious, or otherwise—are so much dross. Indeed, love is the distinguishing mark of genius, that which sets it apart from its semblances talent, cleverness, and skill. Emerson concludes "Art," the final essay in first series, with the observation that "When science is learned in love, and its powers are wielded by love, they will appear the supplements and continuations of the material creation" (440). To learn science in love, and wield its powers by love, is to reject the merely economical use, the lucrative standard. Then science, and we might add technology, will appear at one with the material creation. He may as well have said the same of religion. When religious practices are learned in love, and religion's powers are wielded by love, they too will appear unified with the order of nature.

The virtues of faith, hope, and love may have natural and theological analogues, and yet Emerson suggests that both matter for the perfection and unity of science and religion.[8] In the final paragraph of *Nature*, the Orphic poet's final canto is meant to inspire the virtues of faith, love, and hope needed to pursue the beatific vision. By the time we reach this summit, those who have eyes to see and ears to hear may receive the benediction, worth quoting at length (if partially):

> Nature is not fixed but fluid. Spirit alters, moulds, makes it…. Every spirit builds itself a house, and beyond its house a world, and beyond its world a heaven…. Adam called his house heaven and earth; Caesar called his house, Rome; you perhaps call yours…a hundred acres of ploughed land; or a scholar's garret. Yet line for line and point for point your dominion is as great as theirs, though without fine names. Build, therefore, your own world. As fast as you conform your life to the pure idea in your mind, that will unfold its great proportions. A correspondent revolution in things will attend the influx of the spirit…[which shall] carry with it the beauty it visits, and the song which enchants it; it shall draw beautiful faces, warm hearts, wise discourse, and heroic acts, around its way, until evil is no more seen. The kingdom of man over nature, which cometh not with observation,—a dominion such as now is beyond his dream of God,—he shall enter without more wonder than the blind man feels who is gradually restored to perfect sight (48–49).

At this point, our twenty-first century ears should ring with the plausible objections of environmental ethicists and scientists, not to mention Emerson scholars. Are not humanity's divine ambitions and force precisely what have created our current crisis? Is not the poet's final charge to "build your own world" the mantra of so-called industrial progress and environmental degradation, of modern science, technology, and religion run amuck? Did not Emerson officiate the wedding of the Industrial Revolution and colonial conquest, and become godfather of its progeny American nationalism?[9] Did

8. See John R. Bowlin, *Tolerance among the Virtues* (Princeton: Princeton University Press, 2016), especially its final chapter on forbearance as a natural and theological virtue.

9. For these respective views see Laura Dassow Walls, *Emerson's Life in Science: The Culture of Truth* (Ithaca, NY: Cornell University Press, 2003), 105; West, *The American Evasion of Philosophy*, 17.

not *his* gospel create the new religion of American exceptionalism?[10] If theology is part of the problem, is not science our only hope?[11] I cannot respond to each of these concerns with the depth they deserve here. Nonetheless, I think that the vision of the Orphic poet warns against precisely these developments.

From begin to end, Emerson suggests with Augustine that the city of God is from everlasting to everlasting. Those who enjoy the restoration of sight, who build a house, a world, and a heaven in which to dwell, inhabit this kingdom, however provisionally, here and now. Our dominion is no less than that of Adam, Einstein, or Gandhi. But neither is it more or otherwise. It is not the stoic power of withdrawal. Neither is it the corrupt and corrupting power of domination, conquest, or exploitation. Rather, the exhortation to "Build…your own world" is of a piece with the nonconformist, ascetic Pauline counsel to be transformed by the renewing of your mind. The final line of "Art" alludes to the story of Jesus's healing of a blind man in Mark 8:22–25. After Jesus spits on the man's eyes and puts his hands on them, he asks: "Can you see anything?" The man had half-sight. He could see, but his vision was blurry. People walking appeared as trees. So Jesus sets his hands on the man's eyes again and his sight is fully restored. Emerson likens the wonder we will all feel at coming to see fully to that of this blind man. Absent the virtues required for the ascent, we are all blind or have half-sight, whether we know it or not.

Emerson was well attuned to the promise and peril of modern science and religion alike. To some extent, natural scientists must have a disenchanted attitude toward nature. It is this posture, after all, that enables nature to be (to some extent) dissected and known, predicted and controlled. Yet when directed by the lucrative rather than moral standard, this attitude has had quite toxic effects, among theologians and priests no less (if more ironically) than scientists. Unaccompanied by the religious sentiment or the virtues of faith, hope, and love that perfect the scientist and religious practitioner as members of various moral communities, these practices threaten to do more harm than good, to impede rather than enhance human flourishing and the common good. Science and technology may help make the world provisionally livable; they may orient us to the many wondrous nooks and crannies of the universe we inhabit. Alone, they do not make our planet or our cosmos safe or habitable. The religious sentiment does so, not by giving us power to control and dominate, and not by immunizing us from dangers, toils, and snares, but rather by empowering us to live well, even to die well, in their midst.

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10. Richardson, *Emerson*, 226.

11. For one excellent response to this question see Lisa H. Sideris, "Science as Sacred Myth? Ecospirituality in the Anthropocene Age," *Journal for the Study of Religion, Nature and Culture* 9.2 (2015): 136–53.

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CHAPTER 4.

HAVE WE FORGOTTEN ABOUT HAPPINESS? SCIENTIFIC PRACTICE AND THE CONTEMPLATIVE AND ACTIVE LIFE

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In the Developing Virtues and the Practice of Science (DVPS) project, we have been asking: how does the development of virtues relate to one's vocational practices—in our case, specifically laboratory scientists and musicians? The arguably more important question, however, is: what are the ends and goods of the virtues that we seek to know more about and understand in this project? Further, what is the relationship between particular practices and the achievement of those ends? Throughout the DVPS project the team has been concerned, as much as possible, with thinking about the virtues within a particular historical, theological, and philosophical framework that considers virtues not as ends in themselves but as means to something greater, namely happiness.

In this paper I attempt to bring our discussion back into the teleological frame of thinkers like Aristotle and Thomas Aquinas, who thought of happiness not as an activity or practice but as contemplation (*theoria, contemplatio*). Aristotle and Thomas have been two of the most important figures shaping the last half-century's thinking on eudaimonistic and virtue ethics. What do these influential thinkers have to say about the relationship between happiness and activity? The first section of this paper will look at other prominent figures in the Western spiritual and moral tradition, along with Aristotle and Thomas. The second section will focus on the work of twentieth-century philosopher Josef Pieper, who engaged extensively with ancient and medieval figures, along with the psychology of his day, to address philosophical and theological questions. He is also partly credited with the twentieth century retrieval of "virtue ethics." Pieper wrote extensively and influentially on the relationship between virtue, leisure, and work.

Drawing on these figures and ideas, I ask about the relationship between vocational practices and the classical eudaimonistic conception of happiness and the good life. Even if a person develops the virtues necessary to have excellence in practices and activities, would these lead to the good life and happiness that thinkers like Aristotle and Thomas Aquinas would consider actual happiness? When we are discussing happiness, are we talking about the theologically rich ultimate end that is happiness

with God in the beatific vision, or are we talking about penultimate ends? It is to these questions that I first turn.[1]

Contemplation and the Good Life

Aristotle and Thomas have different conceptions of happiness as *theoria* and *contemplatio*, but the idea of happiness as a particular kind of leisurely rational activity remains constant. Aristotle writes:

> If happiness is activity in accordance with excellence, it is reasonable that it should be in accordance with the highest excellence; and this will be that of the best things in us. Whether it be intellect or something else that is this element which is thought to be our natural ruler and guide and to take thought of things noble and divine or only the most divine elements in us, the activity of this in accordance with its proper excellence will be complete happiness. That this activity is contemplative we have already said.[2]

Also,

> Happiness extends, then, just as far as contemplation does, and those to whom contemplation more fully belongs are more truly happy, not accidentally, but in virtue of the contemplation; for this is in itself precious. Happiness, therefore, must be some form of contemplation.[3]

Further, Thomas writes that happiness is not found in the moral virtues but

> the activities of the intellect, which is contemplative…since man applies himself to it for its own sake so that he seeks no further end. This activity also contains a proper pleasure proceeding from itself and augmenting it. So then such contemplative activity of the intellect clearly provides for man the attributes customarily assigned to the happy person: self-sufficiency, leisureliness, and freedom from labor.[4]

Both Aristotle and Thomas frame their discussion of the virtues for the sake of the end that is happiness, which consists in contemplation.[5] How, if at all, does our work relate to happiness, even a penultimate version of it? For Thomas, in the first sense, happiness is a gift given to us by God in his providence and love. Nothing we do adds to our ability to achieve happiness through work. Infused grace is required for this happiness to be achieved in the most robust sense. This end has been decided for us by virtue of our being created by God. As Thomas puts it, we are incapable of not willing it.[6]

1. There has been a growing literature in the field of psychology on happiness. These studies in psychology focus on happiness as "mindfulness" and "flow" and show that leisure and contemplation are important for human flourishing. See Mihaly Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (New York: Harper & Row, 1990); Martin E. P. Seligman, *Flourish: A Visionary New Understanding of Happiness and Well-Being* (New York: Atria Books, 2012).
2. Aristotle, "The Nicomachean Ethics," in *The Complete Works of Aristotle: The Revised Oxford Translation*, volume 2, edited by Jonathan Barnes, translated by W.D. Ross, revised by J.O. Urmson (Princeton, NJ: Princeton University Press, 1984), 1177a11-18.
3. Ibid., 1178b27-31.
4. Thomas Aquinas, *Commentary on Aristotle's "Nicomachean Ethics,"* translated by C. J. Litzinger (Notre Dame: Dumb Ox Books, 1993), §2102–4; Thomas Aquinas, *Summa Theologica*, translated by the Fathers of English Dominican Province (Notre Dame, IN: Ava Maria Press, 1948), II–II, 180.
5. There is a debate within Aristotle scholarship as to whether Aristotle's conception of happiness is dominant or inclusive. As we have seen, at the end of the *Nicomachean Ethics* Aristotle associates the good life and the final end with a life of contemplation. The inclusive view holds that happiness is made up of separate ends, where the dominant view holds that Aristotle conceives of happiness as the possession of one end, namely *theoria*. Because Aristotle's medieval and early modern interpreters read him as holding the dominant view, I will assume that position in this paper. See Anthony Kenny, *Aristotle on the Perfect Life* (Oxford: Oxford University Press, 1996), 19; Julia Annas, "Aristotle on Virtue and Happiness," in *Aristotle's Ethics: Critical Essays*, edited by Nancy Sherman (Lanham, MD: Rowman & Littlefield, 1999), 35–56.
6. Thomas Aquinas, *Summa Contra Gentiles: Providence Part I*, translated by Vernon J. Bourke (Notre Dame, IN: University of Notre Dame Press, 1956), 3, 37; Thomas Aquinas, *Summa Contra Gentiles: Salvation*, translated by Charles J. O'Neil (Notre Dame, IN: Uni-

Happiness and the good life are not for us to attain through the effort of virtue. The meaning of the active life is made through the possibility of contemplation,[7] a contemplation that is something divine,[8] eternal,[9] the attaining of which would fulfill our deepest and boundless thirst and desire. Not to attain it is to despair in the fullest and truest sense of this word.[10] What is being discussed by Thomas is clearly not something that can be possessed in its fullness in this life and requires divine assistance.

What can we say about the relationship between contemplation and our work, practices, and activities in this life? All practical activity, from gaining the means of a livelihood in a job to the practice of developing the virtues, is a means towards some other end outside itself. The end for which these activities and practices seek is non-practical. In this way the active life is fulfilled in the contemplative life.[11] This is not to deny that the active life cannot be incredibly fulfilling, and can even make us happy to a limited extent, but these penultimate happinesses rest in the practice of prudence and right conduct.

What, then, can we say about the relationship of earthly contemplation to vocational practices? There certainly seems to be a place for a conception of contemplation in this life. Thomas Merton notes that a totally escapist contemplation that rejects the sin of any age is a form of sin itself.[12] Josef Pieper, too, makes room for earthly contemplation.[13] Pieper, drawing significantly on ancient and medieval tradition, thought contemplation the purely receptive approach to, and receiving of, reality. This is independent of practical and utilitarian ends. Contemplation is devoted to "revealing, clarifying, and making manifest the reality which has been sighted." These aim at "truth and nothing else. This is the first element of the concept of contemplation: silent perception of reality."[14] What Pieper is emphasizing is the necessary visual component to human flourishing. Contemplation is a perfected non-propositional knowledge that is arrived at by vision.[15] It is not effortful or discursive.[16] Rather, it is restful, and is no longer moving towards its object. "The object is present—as a face or landscape is present to the eye when the gaze 'rests upon it.'"[17]

What does the above description of contemplation have to do with the development of virtue? In

versity of Notre Dame Press, 1956), 4, 92; Aquinas, *ST*, I, 94, 1; 19, 10; 82, 1 ad 3; I–II, 69, 1; 3, 1; 10, 2;13, 6; Josef Pieper, *Happiness and Contemplation*, translated by Clara Winston and Richard Winston (South Bend, IN: St. Augustine's Press, 1998), 20–21.

7. Pieper, *Happiness and Contemplation*, 93–94.
8. Aquinas, *In Eth*, 1, 14; no. 169.
9. Pieper, *Happiness and Contemplation*, 37.
10. Ibid., 32, 40–41; Aquinas, *ST*, I–II, 2, 8.
11. Aquinas, *ST*, II–II, 182, 4.
12. Thomas Merton, *The Inner Experience: Notes on Contemplation* (San Francisco: HarperCollins, 2004), 121.
13. Josef Pieper, "Down-to-Earth Contemplation," in *Problems of Modern Faith: Essays and Addresses*, translated by Jan Van Heurch (Chicago: Franciscan Press, 1986), 149–56.
14. Pieper, *Happiness and Contemplation*, 73.
15. Ibid., 74; Thomas Aquinas, *Summa Contra Gentiles: God*, translated by Anton Pegis (Notre Dame, IN: University of Notre Dame Press, 1956), I, 57 (8); Aquinas, *ST*, I, 59, 1 ad 1. What is meant by vision here is not limited to the eyes. It should rather be taken in a figurative way as encompassing all the human senses. For more on Pieper and his view of vision see Nathaniel A. Warne, "Learning to See Again: Josef Pieper on Philosophy, Prudence and the University," *Journal of Moral Education* 47.3 (2018): 289–303.
16. Pieper, *Happiness and Contemplation*, 74; Aquinas, *SCG: God*, 1:I, 57 (8). Discursive reason is an imperfect form of the intellect.
17. Pieper, *Happiness and Contemplation*, 74.

Plato's *Symposium*, it is contemplative seeing that makes life worth living.[18] Attaining the top of the ladder of love is to contemplate beauty, which is the end of our toil[19] and gives us detachment to realize the smallness of worldly and mortal things.[20] For Plato, it is in contemplation that we beget true virtue.[21] But this does not mean that we do not have social responsibilities and friendships. We come back down the ladder from our contemplation to the people just like the liberated prisoner in *The Republic*.[22] It is in teaching that we come back to our active lives from our place contemplating the good and find the end of earthly contemplation.

Given the above, what can we say about the relationship between virtue, contemplative activity, and activities associated with vocational practices like the practice of science? On the one hand, what is described above is the most robust sense of happiness. This is the ultimate happiness, to see and contemplate God. For the tradition seeing God—who is the good, the true, and the beautiful—is not effort; it is not work or activity. If it is an activity, it is one that requires no effort, has no end beyond itself, and still, in the richest way, engages our rational faculties. In this way practices are not related to happiness. On the other hand, there are certain practices and good work that can add to our ability to experience happiness in this life. Commenting on love in Plato's *Symposium*, Gabriel Roxana Carone notes that the scientist "who contemplates the vastness of the universe comes to realize the narrow dimensions of his own life within it."[23] Perhaps another way of saying this is that when we engage in contemplation we can see the empirical world better. Sixteenth-century theologian St. John of the Cross notes that just as the sun overwhelms the light of the candle, the light of faith possessed in contemplation overwhelms the light of the intellect, which extends only to natural knowledge.[24] Contemplation moves us beyond our senses, beyond the empirical and observable world, beyond science. In the *Spiritual Canticle*, John writes that to seek God you should "pay no attention, neither, partially nor entirely, to anything your faculties can grasp."[25] Because of the weakness of our faculties, the closer we get to contemplation the more they do us little good. Thomas Merton, commenting on St. John, writes that the faith that is associated with the contemplative life is a turning away from God's creatures and creation and towards God. It is a "blacking out of the visible in order to see the invisible." Faith "is a light of such supreme brilliance that it dazzles the mind and darkens all its vision of other realities: but in the end, when we become used to the new light, we gain a new vision of all reality transfigured and elevated in the light of itself."[26]

What has been shown above is that contemplation is what makes up happiness and the good life.

18. Plato, "Symposium," in *Plato: Complete Works*, edited by John M. Cooper, translated by Alexander Nehamas and Paul Woodruff (Indianapolis, IN: Hackett, 1997), 211d2.
19. Ibid., 210e.
20. Ibid., 211e3.
21. Ibid., 212a.
22. Plato, "Republic," in *Plato: Complete Works*, edited by John M. Cooper, translated by G.M.A Grube and D.C.D. Reeve (Indianapolis, IN: Hackett, 1997), VII 520c.
23. Gabriel Roxana Carone, "The Virtues of Platonic Love," in *Plato's Symposium: Issues in Interpretation and Reception*, edited by James Lesher, Debra Nails, and Frisbee Sheffield (Washington, DC: Center for Hellenic Studies, 2006), 219–20.
24. St. John of the Cross, "The Ascent to Mount Carmel," in *The Collected Works of St. John of the Cross*, 3rd. ed., translated by Otilio Rodriguez O.C.D. and Kieran Kavanaugh, O.C.D. (Washington, DC: ICS Publications, 2017), ii, iii, 1.
25. St. John of the Cross, "Spiritual Canticle," in *The Collected Works of St. John of the Cross*, 3rd ed., translated by Kieran Kavanaugh, O.C.D. and Otilio Rodriguez O.C.D. (Washington, DC: ICS Publications, 2017), I, 12; also see Merton, *Inner Experience*, 14ff, 71.
26. Merton, *Inner Experience*, 15–16.

This finds its most complete fulfillment in the next life in the vision of God, but there is room for a form of earthly contemplation. It is here that true virtue, which rightly orders our lives and priorities, can grow and develop. Earthly contemplation is, however, a seriously diminished form of happiness, and following Aristotle, we see that it is both hard to maintain and can be taken away. This point of view does not advocate a dualism between these kinds of lives. In fact, from Plato all the way through to Pieper, the Western philosophical tradition sees that contemplative and active life are intricately related. The active life comes to its fulfillment in the contemplative, and those who contemplate, at least in this life, are obligated to descend the ladder, now possessing true virtue so that they can teach those to whom they return. This view of contemplation also does not deny the importance of the created order, but rather takes it seriously, as creation is intimately connected to God. Earthly contemplation, for instance, takes the form of restful "looking" at the created order, a looking that can inform and sharpen one's vocational practices.

Josef Pieper and Internal and External Activities

There is the potential for some further confusion here concerning the reasoning of both Aristotle and Thomas. In spite of the above summary of their overall thought, both seem to argue, at times explicitly, the position that happiness is an activity or practice. We can see that for Thomas, drawing on Aristotle, happiness is an activity. Thomas cites Aristotle's statement that happiness is an "operation" (*operatio*).[27] This term, in Latin, has a semantic range that could include "activity." Thomas continues on to note that "man's happiness is something created, existing in him, we must needs say that it is an operation. For happiness is man's supreme perfection."[28] Happiness consists in the last "act" of humankind; this, again, he gets from Aristotle. We get a sense that within occidental tradition this particular activity is equated with happiness.

There are some "activities" that contribute, or are at least related to, happiness. What are these activities? According to Pieper, Thomas has in mind activities that are not external, but internal.[29] "Happiness consists in cognitive activity and nothing else."[30] As an action, then, happiness is connected to a broader anthropology and view of reality. This can be seen in three propositions. The *first* is that "happiness means perfection." There is "nothing left to wish for" the ultimate goal has been achieved. The whole of the person is happy and perfected.[31] The *second* proposition, building on the first, is that "perfection means full realization." The person attains her full reality; she becomes "real."[32] *Finally*, to becoming "real" is achieved through action. "'Action is the ultimate realization of the person who acts.' Only by acting does one realize the fullness of their reality."[33] Happiness is a form of acting "which opens all the potentialities of man to fullest realization."[34] It is not about external practices or worldly success. Activity which remains within the self yields results, but these do not show outwardly. "They are fruit which grows within—for example, the *verbum cordis*, the 'heart's word,' the still unvoiced fruit

27. For example see Aristotle, "EN," 1102a5; also see Aquinas, *In Eth*, 224.

28. Aquinas, *ST*, I–II, 3, 2.

29. Pieper, *Happiness and Contemplation*, 55; Aquinas, *ST*, I–II, 3, 2 ad 3.

30. Pieper, *Happiness and Contemplation*, 60.

31. Aquinas, *ST*, I–II, 3, 2.

32. Pieper, *Happiness and Contemplation*, 54; Aquinas, *ST*, I–II, 3, 2.

33. Pieper, *Happiness and Contemplation*, 54.

34. Ibid., 54.

of insight."[35] It is in this kind of activity that the acting person actualizes themselves.[36] The kinds of actions that reach outward perfect the work and not the worker themselves. For Thomas, moral virtues are about external actions and thus strictly speaking not related to the contemplative life: "it is evident that the moral virtues are directed, not to the contemplation of truth but to operation."[37] Moral virtues are subordinated to active happiness. For example, the chief moral virtue, justice, is external as it is directed towards the other.

When we make the above distinction between internal and external activities, this does not mean that one excludes the other. This is not to discourage completely the active life. It is rather the case that this conception of happiness is the "clue to the salvation and redemption of ordinary life."[38] The hierarchical point of view that is assumed by thinkers like Aristotle and Thomas without question holds to the distinction of levels within the created order. But it is part of this hierarchy that the higher does not scorn the lower. Pieper writes:

> Thus the inherent dignity of practice (as opposed to *theoria*) is in no way denied. It is taken for granted that practice is not only meaningful but indispensable; that it rightly fills out man's weekday life; that without it a truly human existence is inconceivable. Without it, indeed, the *vita contemplativa* is unthinkable.[39]

External activity has the potential not only to affect the world, but in doing the work affect the actor.[40] Practice, though, does not become an end in and of itself; this would make it meaningless.

Some virtues relate to social goods here in this life. These political virtues contribute to better political structures and the achievement of penultimate goods. Further, virtues that one may possess as a practitioner of science can also affect the well-being of the larger society. Neither Aristotle, Thomas, nor Pieper denies this. However, infused virtues and contemplative internal activities function in both ends and are able to achieve both political and supernatural happiness. The contemplative life has encompassed within it the moral virtues without being reduced to just these character states. Those who contemplate possess the "true virtue" to be able to reenter the political realm and contribute to the social good life.

Conclusion

This paper has challenged a utilitarian conception of the good life that can only conceive of actions and practices that are for the sake of something outside themselves as contributing to the good life. These practices, and even the moral virtues, are not the good life because these things are not the perfecting activity which is sought after for its own sake, namely a contemplative happiness. This con-

35. Ibid., 56.

36. Ibid., 57.

37. Aquinas, *ST*, II–II, 181, 1; 180, 2.

38. Pieper, *Happiness and Contemplation*, 94–95. See also Chenu's connection between internal and external activities and their perfection, as well as his emphasis on a hylomorphic, over Cartesian, dualism for maintaining a dignity of 'work,' and the 'worker.' Chenu makes a closer connection between contemplative and productive reason than Pieper, but still considers productive reasoning's rightful place to be "secondary." See Marie-Dominique Chenu, O.P., *The Theology of Work: An Exploration*, translated by Lilian Soiron (Chicago: Henry Regnery, 1963), 26ff.

39. Pieper, *Happiness and Contemplation*, 95. For a discussion of the various views of hierarchy and a theological defenses for its importance see Sarah Coakley, *God, Sexuality, and the Self: An Essay "On the Trinity"* (Cambridge: Cambridge University Press, 2013), 320ff.

40. Pieper, *Happiness and Contemplation*, 56–57. For more on the relationship between the intellect and activity see Bernard N. Schumacher, *A Philosophy of Hope: Josef Pieper and the Contemporary Debate on Hope* (New York: Fordham University Press, 2003), 19–20.

templative conception of the good life protects against a view of the world that only prioritizes work, servile activity, and what can be used and consumed. This paper also challenges a methodology that would distort this classical eudaimonist tradition by not representing the thought of these influential figures accurately. For the most part, it is my belief that good theology should be nearly indistinguishable from good history. It is important that we do not attempt to make these historical figures in our own image and attempt to impose on them our values without allowing them to first critique our own culture and assumptions. We should not distort the tradition to serve our agendas, but allow their voices to speak into our own biases. A constructive theology and philosophy that draws on authoritative texts and figures will need to be honest as to where ideas are in continuity with the tradition, and where we need to part ways based on the findings of contemporary scholarship from other fields.[41] The discerning of these moments is no doubt a difficult part of doing theology, but a necessary one. In a similar vein, theologians and philosophers do a disservice to other fields like sociology and psychology that at times draw upon these traditions in their own theoretical work when we do not represent them well.

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41. Theology is, at least in part, descriptive history. Or at least it starts there. One must consider the outdated cultural assumptions of past thinkers. Theology, however, cannot stay there. It must move from the descriptive to the constructive, but in a way that does not do violence to the heart of the thinker's actual thought. One example of this would be Aristotle's position on the naturalness of slavery. His conception of race has been proven by scientists of a variety of fields to be significantly outdated; see Susan Goldberg, ed., *National Geographic Magazine: The Race Issue*, April 2018. Rosalind Hursthouse has suggested that we need to identify which aspects of Aristotle's thought, and the tradition that drew on him, are essential to his ethics and which can be set aside, like his elitism, sexism, and racism. These do not make up the very structure of his thought on human flourishing and virtue. See Rosalind Hursthouse, *On Virtue Ethics* (Oxford: Oxford University Press, 1999), 9.

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PART II.

SCIENCE IN THE EVERYDAY

CHAPTER 5.

TELESCOPES, MICROSCOPES, AND SIMULATIONS: THE EVERYDAY SCIENTIFIC PRACTICE OF DECIDING "WHAT IS REAL?"

FIONAGH THOMSON

Contemporary science presents knowledge as necessarily contingent rather than absolute, and increasingly context- and historically-specific.[1] As such, the sciences promote the practice of continually critiquing, debating, and scrutinizing the current knowledge base through evaluations and assessments that (can) lead to modification, alteration and, at times, radical change in light of new evidence. The method(ology) of deciding what is "real," "true," "authentic," and/or "accurate" in scientific practices remains contested, while the nature and reliability of human senses in scientific observations has been questioned since the ancient Greeks.[2] Consequently, while scientific practice is embraced as a human endeavor, it is simultaneously framed as one that inevitably leads to personal prejudices, misapprehensions, and biases presented as inherent weaknesses, even vices, in rigorous scientific practice. These weaknesses and vices are seen as problems that must be overcome or mediated[3] through various scientific practices and more recently, through implementing machine learning and automated systems.

Drawing on ethnographic fieldwork with astrophysicists (ranging from instrument scientists to astronomers and cosmologists) and microscopists in a United Kingdom university, I explore the everyday scientific practice of deciding "what is real." I focus on everyday interactions between humans through and with technologies in open shared dialogue about the importance of "being human" and "getting it wrong." I pose the question: do the sciences place too much faith in mediated

1. The chapter was written through intense discussions with "participants" in the field, particularly with Cillian and Bob; these, for me, reflected the process of engaging in dialogue-as-play with all its glorious thorny challenges. A heartfelt thank you to all the 'philosopher-physicists' for sharing their thoughts, stories, and time with me—and for questioning me critically, continually, relentlessly, mercilessly—and for making me laugh (a lot). A special thank you to Rayna Rapp (New York University) for unflinching encouragement, support and wisdom.

2. Robert Jütte, *A History of the Senses: From Antiquity to Cyberspace*, translated by James Lynn (Malden: Polity Press, 2005).

3. One notable moment is the removal of 'rhetorick' from Science (by a Royal Society Charter in the 18th century) (see Marshall McLuhan, *The Gutenberg Galaxy: The Making of Typographic Man* [Toronto: University of Toronto Press, 1962]). Attempts to extract the human-ness from scientific practice appear oxymoronic. For while the scientific argument is lauded as the epitome of good scientific practice, the human-ness of dialogue and interpretation is deemed inappropriate and often removed from formal discussions, educational curriculum, and academic publications in the sciences. (See Torie Shanks, *Authority Figures: Rhetoric and Experience in John Locke's Political Thought.* [University Park: University of Pennsylvania State University Press, 2014]).

visual images and/or computer simulations in deciding "what is real?" I highlight the key role of Aristotle's practical wisdom (an intellectual virtue and inherently human endeavor) through Hans-Georg Gadamer's concept of dialogue-as-play, a concept that extends beyond individual human bodies and requires an ability to listen and to embrace and manage deep uncertainty.

Setting the Scene: An Ethnographer in Astrophysics

I approach this topic as an ethnographer and human geographer working within the everyday world, which I understand to be complex, unfolding, and entangled (more than the sum of its parts).[4] My interest is in what people do rather than what they think they do as they move through the everyday world.[5] I focus on the minutiae, the detail, the seemingly mundane, and view the field of study to be historically and materially situated—that is, not confined by the four walls of the immediate environment. Ethnographers do not (initially) extrapolate our findings beyond our fieldwork setting. As such, descriptions of the field offer an important background against which to read our findings.

For eighteen months, I have been based at a United Kingdom academic institution, and specifically in a three-floor astrophysics building, designed by an award-winning international architect. The building houses communities of instrument scientists, astronomers/observers, and cosmologists from around the world.[6] On the ground floor are the instrument research scientists, who are all trained astrophysicists, and a small number of space science engineers; the remaining engineers are based in an industrial site ten miles away. Many in this community work in the field of adaptive optics for large ground-based telescopes[7] as part of multi-million Euro international projects. Some specialize in cutting-edge research into Free Space Optical Communications via satellites.[8]

On the first floor are observers who mainly work in the field of extragalactic astronomy, rather than investigating our "nearby" solar system; they study stellar mass billions of light years away. Working on their desktop computers, the observers analyze and interpret data taken from astronomical instruments hosted at different observatories on mountaintop locations in locations like the Spanish islands, Chile, and Hawaii, and on space-based telescopes (for example, the Hubble). Each observer is trained in a highly specialized field of astrophysics, and studies a specific astronomical structure or phenomenon using data from a bespoke instrument that has been designed to capture targeted wavelengths at a specific point of the electromagnetic spectrum. Every year, a team or department of astronomers apply to space and/or ground-based observatories for time 'on-sky' to use a specific astronomical instrument for their research needs.[9]

On the top floor are the cosmologists, mostly theoreticians and mathematicians, who develop com-

4. I enter the field viewing meaning-making as partially accessible and tacit knowledge as foundational (Thomson 2007).
5. Ethnographers traditionally focus on acts, what is happening in that moment, rather than intentions. That appears to place my work in direct contrast to virtues ethics, since, following Aristotle, virtues are bound up with an individual's character rather than her actions. This is an issue for further discussion beyond this chapter.
6. Each group refers to itself as "a community."
7. The Earth's atmosphere consists of over a hundred layers of air at different temperatures that interact and cause large-scale movements of air masses (turbulence). This turbulence distorts telescope images as light passes through the atmosphere. Adaptive optics, using laser guide stars, predicts in real-time, then recreates the image by adjusting the telescope mirrors.
8. FSOC via satellites is the concept of replacing radio waves with lasers to create faster, cheaper, and more secure communications.
9. Astronomers submit an application outlining a detailed case for why they should be given the time, the experience of the team members, and the merits of their experiment for advancing the field of astrophysics.

puter simulations to test out theories of how (they believe) the universe works, and also to support observers in deciding where to point the telescopes to get the best results during a night of observing. Time on-sky at ground-based telescopes can be expensive, from €2,000 a night at smaller older observatories to €100,000 a night for larger modern observatories, with the potential for bad weather ruining astronomical seeing. Space-based telescopes provide higher resolution images, but to be allocated time here is highly competitive and costly. The cosmology simulations are calculated using supercomputers housed in their own three-story building, with a sophisticated water-cooling system on the roof mandated by the heat generated by the computers: one simulation run can take sixty-four computers running continually thirty-two days to complete. Many of the observers and cosmologists on the first and second floor work closely together within their own highly specialized fields. Younger generations of observers spend significantly less time on-sky (at observatories); increasingly their time is spent in front of computer screens, coding.[10]

The building was designed around light, movement, and creating space for people to talk both informally (corridors, sofas, kitchens) and formally (small glass-fronted meeting rooms and break-out corners). The first and second floor have large open central spaces, with sofas and standing tables for coffee breaks and informal meetings. The offices are around the four walls, with sole occupancy reserved for permanent staff and shared offices for postdoctoral fellows and PhD students. Many people work with their doors open unless they have a meeting or don't wish to be disturbed. The ground floor has no large open space and in its place is a long rectangular room, with glass on two sides, used almost daily (mostly by observers and cosmologists) for presentations or for postgraduate classes.

On each of the three floors, whiteboards are in every office and public space and are covered with drawings, sketches, and formulas. There is a wooden terrace with flower beds on the top floor; it is open to anyone in the building, although mostly the first and second floors use it. Every day at 11 a.m. and 4 p.m., the physicists on the first and second floors emerge from their offices and gather around the standing (poser) tables or sit on sofas. They exchange news, both social and work, and have coffee and biscuits together. Fifteen minutes before the morning coffee time, there is a short informal journal club to critique two or three of the many new papers uploaded daily to the international astronomy archive.

The ground floor has no designated coffee or meeting space, as the large meeting room takes up most of the central space. The claimed coffee space is a small open area beside the front door that was originally designed to welcome visitors. Notably, there is no whiteboard to sketch ideas on. Coffee times are ad hoc to fit in with lab times. The instrument research scientists interact less with the other floors, for a number of reasons including different working patterns. Core time is spent walking between their offices (where they create/craft computer simulations) and windowless laboratories in the adjacent building (to test the results of the simulations with on-bench models), before shipping instruments overseas to test on-sky (in astronomical observatories).

My office is on the ground floor; I share it with an astrophysicist/optical design engineer. Most days, I have "coffee and a chat" with the instrument scientists, and I usually walk/jog up the stairs to catch the fifteen-minute "astro-journal club." I attend as many talks, journal clubs, informal discussions, or

10. When astronomers are on-sky at the observatory, they rarely operate the telescope or instrument themselves due to the high expense and the need to collect the best data possible. For example, at the VLT (Very Large Telescope) in Chile, a visiting astronomer will observe through the hands-on support of a telescope operator and the facility's night astronomer.

meetings throughout the building as I can. The meetings are many, and times overlap. Discussions are highly technical, and specialized and bespoke images, plots, and simulations are used as key discussion tools. Few images/plots have a standard format; many are colorful creations, and almost none have detailed labelling. A Q&A usually ensues to clarify the details.

As part of this fieldwork, I spent two weeks in an observatory (on-sky at night) in Spain with two instrument scientists (Cillian and Bob) who were commissioning (testing) an instrument as part of a Free Space Optical Communications study (see Figures 1 and 2). I also attended the largest biannual international conference on telescopes and space instrumentation (this year located in the United States). I participated in two weeklong workshops in the building: one with the adaptive optics community and one with cosmologists on the "realistic" nature of different mock galaxies (computer simulations of how the universe works) in large-scale surveys. During the first three months of the fieldwork, I spent time in a microscope suite and attended a three-day symposium in Germany with soft matter physicists, around the nature of microscope images. In this chapter, I draw mainly on findings from my time in astrophysics, beginning with a short scenario based on my fieldwork with Cillian and Bob[11] (two instrument scientists/astrophysics) and the everyday question: "but is it real?"

11. All names are pseudonyms and relevant participants have approved this chapter.

Figure 1. On-sky tests: propagating a sodium laser seventy-five kilometers upwards (Photo: Author).

Figure 2. Preparing for a night-on-sky; Cillian beside the laser container (Photo: Author).

"But Is It Real?": Ethnographer's Observations, Instrument Scientists' Thoughts

Cillian has spent the morning walking back and forth between the two computer screens on his desk, where he is running simulation software, and the lab in the nearby building, where a camera is set up on a test bench. He is preparing to go on-sky to test the full instrument the following week in a British/Spanish/Dutch-owned mountain-based observatory in the Spanish islands. He did not buy and test the camera himself and so he is double-checking every aspect of the kit: shutter mode and type, frame rate as a function of size of image, and so forth. On the right computer screen he opens the black terminal screen to start a dialogue with the camera in the lab in the adjacent building. The terminal screen is empty, except for the blinking white cursor waiting for the first command. He pauses as he tries to remember the correct command. Cillian, like most of the instrument scientists and astrophysicists, prefers to work directly with the terminal. It shows all the inner workings of the software code. There are no algorithms built in to guide the user around the software, but working directly with basic commands and running code is considered more transparent and, therefore, makes it easier to find mistakes and faults.

While waiting for the camera (software) to respond, Cillian opens a power spectrum plot from research data taken at the observatory four months previously. He suddenly sits up straight, leans forward and stares at the power spectrum plot, and quietly says "the downlink is all noise." Bob retorts "that's interesting" without raising his head and carries on scribbling on a student's draft paper in red pen. Cillian brings up another plot on the computer screen, and then another, and another—then says "it's the same." Bob carries on reading, scribbling and muttering under his breath. Cillian's increasing silent frustration, and Bob's non-response, means something is wrong. I move closer to look at the image. The plot has one horizontal line half way up the x-axis; it's flat with no discernable pattern. Cillian brings up another plot on the screen, stares, sighs, puts his chin in his hand and says: "but is it real?"

Bob finally raises his head and leans over. They look at each other, look back at the plot on the screen, and Cillian says "…but why?" He opens the terminal on the right-hand screen and starts to "do calculations." For ten minutes, he taps away, darting his head up and down from keyboard to screen, pausing briefly while calculations run, then continues tapping away. Bob comes over and asks, "have you tried…?" For the next thirty minutes, Cillian does numerous calculations on the computer, with Bob travelling the two meters to Cillian's desk on his wheeled office chair with one well-honed push, then back to his desk to continue scribbling. Finally, Cillian sits back and says, "…it only goes up to 10 hertz…." Bob, without missing a beat, says "well that'll be the problem." They turn slowly to look at each other, then rock back in their chairs and chuckle (as I have seen many times on-sky, or in the office, when either something is going badly wrong, every attempt to solve a problem fails, or they have just solved a complicated problem). Cillian turns his head looks at me and laughs with relief.

To a passing visitor outside of the field, Cillian's question ("but is it real?") could be perceived as a short dialogue between Cillian and Bob, drawing on the plots, images, and calculations on the computer screen in that moment alone. Instead, this four-word question is part of the rigorous analysis of a six-year research project and provides a brief window into layers of work, discussions with others (in meetings, corridors, coffee rooms, lifts, via skype, slack, and emails); hours of experiments on-sky in astronomical observatories overseas; and moments grabbed reading thousands of short papers uploaded daily to the astronomy archive (accessed by astrophysics around the world and discussed daily at journal clubs over coffee).

Rejecting Authenticity: Constructed Nature of Images/Data?

When Cillian poses the question, "but is it real?," he is not asking (himself), "is the plot authentic?" (That is, is the plot or image replicating or mirroring exactly what is "out there" in the external world and, therefore, offering up a perfect representation of the world for the viewer to grasp immediately.) As with microscopes, images gathered from all telescopes (ground or space-based) are constructed, created, and often enhanced through color, to create an image/tool that can only be interpreted by skilled observers through a shared forum as part of wider data analyses drawing on numerous sources of information. Few professional observers today "look" through a telescope and "see" objects in the night sky. Instead contemporary astronomers, or more accurately astrophysicists, observe through computer screens, either in the observatory through the hands-on skill and knowledge of a resident telescope operator and a resident night-time astronomer or, increasingly, in their offices hundreds or thousands of miles away.

Almost all contemporary astronomical images are constructed from information (light/photons) captured from targeted frequencies along the breadth of the electromagnetic spectrum; ranging from high-frequency, rarely-glimpsed gamma rays to slow-frequency, commonly-occurring radio waves (see Figure 3.) Each wavelength of photons offers different information and also (re)acts differently and, as such, bespoke specialized instruments are required to capture, and process the targeted photons. For example, collecting fast-moving gamma rays is akin to capturing a rare species of tiger that runs like lightning and moves round, over, and through every trap set in its path. It is difficult. If you don't know where to observe, using a carefully crafted instrument, and you blink—it's gone. In contrast, radio waves are more abundant. But while these wavelengths are easier to capture, they are also wider, and can only be collected by telescopes with large apertures the size of football fields.

Figure 3. Ground and space-based telescopes along the electromagnetic spectrum (Photos: Observatory images from NASA, ESA (Herschel and Planck), Lavochkin Association (Specktr-R), HESS Collaboration (HESS), Salt Foundation (SALT), Rick Peterson/WMKO (Keck), Germini Observatory/AURA (Gemini), CARMA team (CARMA), and NRAO/AUI (Greenbank and VLA); background image from NASA).

Recently, in an attempt to create richer/more accurate data sources, images from different telescopes have been superimposed on each other. These images are referred to as multi-message observations, now a key funding term. For example, Figure 4, the composite image of the Crab Nebula, a supernova remnant, was created by combining data from five telescopes spanning nearly the entire breadth of the electromagnetic spectrum: the Karl G. Jansky Very Large Array (radio), the Spitzer Space Telescope (infrared), the Hubble Space Telescope (visible/optical), the XMM-Newton Observatory (X-ray), and the Chandra X-ray Observatory (Gamma). The color pallet is bright, human-made, and intended to create contrast between the different structures in the astronomical objects observed. The coloring of images is not new, nor is debate about the appropriateness of altering these images. The nineteenth-century astronomer T.H. Webb stated that his eighteenth-century predecessor William Herschel, the father of modern-day astronomy, was "rather too fond of red tints." It is not known if Webb objected to the particular color used or to the act of changing the image at all.[12]

12. Richard Holmes, *The Age of Wonder: How the Romantic Generation Discovered the Beauty and Terror of Science* (New York: Pantheon Books, 2008).

Figure 4. Image of the Crab Nebula: combined data from five different telescopes: VLA (radio) in red; Spitzer Space Telescope (infrared) in yellow; Hubble Space Telescope (visible) in green; XMM-Newton (ultraviolet) in blue; and Chandra X-ray Observatory (X-ray) in purple (Photos: NASA, ESA, G. Dubner (IAFE, CONICET-University of Buenos Aires) et al.; A. Loll et al.; T. Temim et al.; F. Seward et al.; VLA/ NRAO/AUI/NSF; Chandra/CXC; Spitzer/JPL-Caltech; XMM-Newton/ESA; and Hubble/STScI).

Until recently, astronomers/"natural philosophers" observed within the visible part of the electromagnetic spectrum that forms only 10% of the spectrum as known today (see Figure 3).[13] Theoretically, the human eye can perceive these wavelengths, but in reality, the raw data from captured photons is a blur of white light and grainy images (background noise) to the human eye. The raw data/images from optical telescopes require extensive post-processing in order to extract the signal from this background noise before any scientific interpretations can begin and meanings be inferred. Seeing/perceiving information does not equate to knowing[14] or understanding.[15] Moreover, for all ground-based optical telescopes, there is the added complication of atmospheric seeing. Looking up through the atmosphere, the images are distorted. To human eyes, the stars appear to move back and forth (known to astronomers as "wobble") and the light intensity alters ("twinkle"). Adaptive optics

13. Astronomy and astronomers from Aristotle to Hubble have been constrained by the knowledge held at that specific period, and also by the instrumentation available to observe the night sky.

14. The focus here is not on the neurological, biological, and psychological research that proposes how the eye sees and the brain processes information, which currently dominates mainstream science research and public discussions on understanding.

15. Ian Hacking, "Do We See Through a Microscope?," *Pacific Philosophical Quarterly* 62 (1981): 305–22; Don Idhe, *Bodies in Technology* (Minneapolis: University of Minnesota Press, 2002); Fionagh Thomson and John McGhee, "Seeing Me: The Role of Transparent Bodies in the Medical Consultation," *Studies in Material Thinking* 13.6 (2015), available at https://www.materialthinking.org/papers/207.

corrects the former by reconstructing the image in the telescope, but currently there is no solution to "stopping the stars from twinkling."[16]

To identify, differentiate and assign meanings to colored telescope images is a skill in astronomical qualitative data (image) analysis, learned on the job and inaccessible to the uninitiated. There is a further perceived complexity to interpreting contemporary astronomical images, as compared to the astronomical worlds of Galileo, Newton and Herschel, who located and identified different types of structures in the "night sky." These astronomers, who were also instrument scientists, cosmologists, and natural philosophers, lived before the carving-up of world knowledge into silos through academic disciplines.[17] In marked contrast, contemporary professional astronomers and instrument research scientists are specialists guided by modern physics, driven by the desire to know how these processes are happening, and often view unmediated human vision as unreliable, unreplicable and untestible.[18] As such, telescope images are considered to be only the first step in analysis. The image (qualitative data) is further transformed, often creatively, into various graphs, plots and diagrams (quantitative data) that are considered to be more transparent and reliable. As Cillian told me, after reviewing my fieldwork photos during an observatory visit and noticing I had photographed the telescope image and ignored the adjacent power spectrum plot:

> When you first looked at [the computer screen in the observatory control panel] you saw an image and assumed that was the most important part … but that's the least important part of the data … we have to try and process this data in order to decide if something is real or not or if it's an artifact or which component fits into which … and then compare it to theory. If it doesn't fit with theory then something is wrong.

Constructing Reality through Dialogue: The Good, the Bad and the Unknown

For these instrument research scientists in astrophysics, few images/plots are unquestioningly accepted as a trusted source of accurate or precise data. Instead a complex multi-layered dialogue begins by silently, often tacitly, asking the question: is this what we expected [based on our current understanding of what we believe to be true]? Rarely is the answer a resounding and unquestioning: yes, that is what we expected to observe. Here, the concept of "what is true" or "the truth" corresponds to current accepted theories in the field. But while these theories offer guidance during the dialogue as the instrument scientists decide if the image/plot is real, it would be a mistake for the reader to assume that these truths are doctrines, set in stone and immovable. When Cillian says "…if it doesn't fit with theory then something is wrong," he is not implying that the theory is inherently correct and the image is incorrect.[19]

To begin deciding if sources of information (image, plot, diagram, conversation, or material entity) are real, Cillian and others in the astrophysics community engage in the analytical and methodological practice of revisiting what has happened before, usually starting by identifying sites of potential mistakes and known systematic and systemic errors. What triggers this process is noticing that something is "not quite right," and the immediate reaction is often visceral: a sudden straightening of the

16. Cillian and Bob are currently working on how to "stop the stars" from twinkling to improve the ability of FSOC with lasers (Osborn & Thomson, 2019).
17. David Harvey, "Cosmopolitanism and the Banality of Geographical Evils," *Public Culture* 12.1 (2000): 529–64.
18. Ian Hacking, "Do We See Through a Microscope?" *Pacific Philosophical Quarterly* 62 (1981): 305–22.
19. However, it would take a great deal of intense dialogue, and disagreement, across the international community to change a normative theory in the field.

back, drawing back of shoulders, peering into a computer screen, and/or a long deep sigh. But before they can conclude whether or not "it is real" and before the overarching dialogue begins between what has been observed (in the data) and what is expected to be observed (in the theory), a further (fundamental) question needs to be answered: is the data in the image/plot accurate/precise? For Cillian and Bob, the chosen term depends on whether they are building and testing the bespoke instrument (low technology readiness or LTR) or testing the capacity of the final instrument (high technology readiness or HTR). During LTR, measurements must be precise, so that they know each component of the instrument, no matter how small, is doing exactly what they intended it to do. Through testing every working part, from simulations to on-bench and finally on-sky, the data collected at every step must be precise, although not necessarily accurate. It can even be wrong (inaccurate). The term *accuracy* becomes important during the HTR stages and for observers when analyzing the data from an on-sky instrument.

When Cillian and Bob began checking the precision of the data in the power spectrum plot, as described earlier, every step that had created the plot was traced back and forth and discussed in minute detail; every calculation was checked and double-checked and became part of a complex multi-layered dialogue. They drew on their own knowledge and experience (for example, conversations with their past selves through lab diaries and individual or shared memories) and that of other colleagues (archived web-based discussion threads and diaries) across time and across space (for example, a telephone call or real-time virtual discussion threads with the international community). The instrument scientists that I have met will pick up a phone without hesitation to call someone in another country. Often they "ping a message" through a real-time chatline (including slack or google hangouts) or "fire off" an email. Responses back are often immediate. These networks of communication are informal, fluid, highly complex, and multiple in nature.[20] Dialogues stop and start spontaneously due, in part, to the work schedule of many instrument scientists (and engineers), who work on multiple projects at the same time and have to learn how to interweave projects together, grabbing moments to complete different tasks.

I have observed similar multi-layered dialogues in meetings or talks with observers and cosmologists, either together or independently, where the focus is on the accuracy of the data, the sensitivity of the instruments, and the selection bias of samples. During the week-long workshop on mock galaxies, the cosmologists discussed the reality of theoretical simulation, some aspects of which cannot be ratified by observational data as the instrumentation has not yet been developed to collect the faint light that has travelled from distant astronomical structures. Instead, discussions revolve around the reality of the images in relation to theoretical knowns and unknowns. Intense debates can break out over whether the error is systematic or systemic—a necessary distinction so that the cosmologists know how to account for these errors in the final analysis. Underpinning many discussions is a deep concern that the simulations should represent the observational data. During presentations on new ways of modelling the universe, if a presenter fails to highlight any errors or unknowns, it is not uncommon for seasoned cosmologists to ask, rhetorically: "Well, your model is elegant, but can it cope with the messiness and chaos of the real universe?"[21]

20. Detailed notes and action points are written up after most conversations and shared with those involved, although attempting to unravel these lines of communication is not trivial.

21. Within astrophysics, getting things wrong and making mistakes is not inherently perceived to be bad science, as these can fuel dialogues, formulate new questions, and demand different ways of looking at the problem. In contrast, not knowing where your mis-

Similar multi-layered dialogues occurred in the microscope labs. Jen is a professional microscopist with over thirty-five years' experience, particularly on the electron microscope. During extensive analysis sessions, she would lean forward, peer at the image in the microscope (shown on a 20-inch computer screen) and ask (herself): "uhm … is it real?" In these situations, she has noticed something unexpected and is trying to determine if this unusual object in the image is a foreign body (an artifact), and has been introduced during the preparation process, or is part of the original biological specimen. In one situation, Jen shouts to the assistant in the next room: "who stained the sample, you or a student?" When the return answer was "me," she mutters: "okay, so no contamination there…(long pause)…Did we change the people supplying the grids? The last lot were no good. We did? Okay, so it's not that." The assistant, with whom she has worked for ten years, walks into the microscope room. They both peer at the computer screen and carefully consider each potential site of contamination during the preparation process that has taken Jen over a week to complete: how the sample was prepared, were the fluids fresh. Every minute detail of how the final sample had been prepared, how it was placed in the tube and then in the microscope in that specific moment and time, was questioned—until they decided together that the foreign body (artifact) was part of the original biological sample. Watching these dialogues unfold was similar to observing detectives at work, looking over the shoulders of Miss Marple, Hercule Poirot, or Sherlock Holmes. Not all dialogues played out like this. For example, I observed a visiting PhD student silently panic when Jen began asking routine questions about the origin of the biological sample as she started to prepare the sample for the microscope. The student looked away into the corner and responded: "My supervisor thinks everything is okay, they just want me to run these…. I just need one more set of results…supporting previous findings."[22]

These descriptions of the style of dialogue may indicate a linear, rational, and cognitive process for deciding what is real. In practice, however, these dialogues are complex, fluid, highly intuitive, iterative, and embodied. Rather than thinking-then-doing, fieldwork participants (instrument scientists, astrophysicists, and microscopists) were frequently thinking-through-doing.

Thinking-Through-Doing: Whiteboards, Dancing, and Origami

Throughout my time in the field, the physicists that I spent time with would often begin explaining an idea to me, then would pause, pick up a whiteboard marker, and ask "may I?" I would nod, and they would start to draw, sketching out ideas considered too difficult to describe verbally. Or, as I observed, they were often thinking through their ideas as they drew/sketched. Working publicly on a whiteboard can be difficult for new students as they have to share their work openly. Sometimes I would meet students sketching on whiteboards in open spaces late in the evening so that no one would see their work, and they always rubbed it off before leaving.

At times, I found myself completely outside a whiteboard conversation (or whiteboard party, as Cillian calls them) not because I lacked knowledge of a specific concept or I couldn't read the mathematical formulas, but because the astrophysicists (cosmologists, observers and instrument scientists) would communicate in half-sentences. One speaker would begin a sentence and after a few words, the lis-

takes are and not identifying what you do not know can be perceived as "sloppy" and the sign of an inexperienced, naïve student or sometimes a mediocre astrophysicist.

22. At other times, researchers are looking for a "pretty image" to include in the final stages of a paper. In this situation, if a reviewer asks a question about the image, the researcher has to ask the microscopist to find the answer. Whether the microscopist's name is then added to the paper is at the authors' discretion.

tener would say "'oh yes"' or "you mean, like this," and draw a sketch. One memorable moment occurred when an observer and a cosmologist, who work closely together, solved a thorny problem through a high-speed dialogue composed of words, hand and body movements, and silent mutual staring at the board, interspersed with sketches and formulas that covered a wall-sized whiteboard in a matter of minutes. In remembering thise episode, I am reminded of watching a video of the abstract artist Jackson Pollock at work. Pollock covered expansive canvases in streaks of seemingly random brushstrokes and splashes of paint, in no particular linear order, working close to the canvas, but not stopping in one position for long. When he finished and the camera zoomed back, the work, to me, formed a harmonious whole. At the time, while watching the observer and cosmologist, I was fixed to the spot, mesmerized, in particular, as their individual bodies, speech, and hands appeared to merge into one being.

I have encountered similar experiences of being with Cillian and Bob in the mountain-top observatories when they were commissioning new instruments. They work between two observatories, located 426 meters apart, and "jump in" a car to make the five-minute journey. Once at the observatory, they run up and down stairs and through a maze of rooms performing tasks (for example, searching for or testing, tracing, or installing cables) that require a keen understanding of the instrument, the observatories, and the research project. If additional knowledge/experience is needed to solve a problem, no matter how small, they "call a friend" in the community. Moving at high speed, they communicate almost telepathically. At times they left me scrabbling to gather my things (camera, bag, coat) as, after pondering a problem together, they suddenly got up and sprinted out the door.[23] I have numerous photos of them working together. At times, it is difficult to tell which hands or arms belong to which body; the biological and the technological merge as they work out the problem (see Figure 5). Afterwards, when we review fieldwork photos, they have limited memory of what has happened.[24]

23. On my first visit, sometimes I couldn't remember which observatory I was in as they moved so quickly.

24. Initially they often challenged my recollections of fieldwork, but after reviewing photos, they started to include my photos as *aide-memoires* when retracing steps backwards at later dates (at the observatory or in the UK office).

Figure 5. Cillian and Bob working at high speed and as one, communicating "telepathically" (Photo: Author).

Whiteboard parties are not the only way that (astro)physicists think through ideas. One of the cosmologists in the building uses the Japanese art of paper folding (origami) to explain the nature of the cosmic web.[25] Commentators compare his use of origami to an analogy, a scientific show and tell, to

25. On megaparsec scales the matter and galaxy distribution is not uniform, but defines an intricate multiscale interconnected network that is known as the cosmic web.

explain to others the interconnected foldings in different galaxies. But when we spoke together about how he developed this concept, it emerged that endless hours of paper-folding (he taught himself from online videos), and experimenting/playing with different patterns of folding, had enabled him to think through the layered nature of the cosmic web. This embodied way of being/thinking mirrors the work[26] of the foundational astronomer William Herschel, who was also a professional musician, composer, and teacher.[27] It is thought that Herschel composed symphonies as a way of exploring his thinking on the complex and unknown nature of the universe. Herschel's younger sister, Caroline was an accomplished astronomer and singer, and the twentieth century physicists Max Planx and Albert Einstein were outstanding musicians who extolled the virtues of music in their working lives. Perhaps unsurprisingly, many of the physicists in the building are also highly accomplished musicians, singers, photographers, and dancers, some to professional standards. When explaining concepts in talks or over coffee, they frequently use their hands, arms, or upper or whole bodies to imitate the dynamic nature of different astronomical structures and processes. Many engage in a form of "interpretive dance." However, precision in choice of words is also a prized skill, and woe betide any student who uses the wrong term in a talk. Words matter, and playing with words and creating new ones is part of their everyday practice, in particular in devising acronyms for new research projects and instruments. But words (spoken/written) are only part of the dialogue.

I have also observed this embodied way of working with experienced microscopists, who, when observing and analyzing images, focus and refocus the microscope by "twiddling" the fine focus dials, simultaneously scanning back and forth across the grid. This requires extreme dexterity and they are often working with both hands at once, each in different directions, as difficult as the classic exercise of patting the head and stroking the stomach. This is a form of thinking-through-doing, an important ritual recognised by (some) microscope designers, who in redesigning a high-resolution full-automated microscope choose to keep the manual fine-focus dial to allow the skilled microscopists to make the final adjustments to the image. As a designer and former microscopist told me: "it [the manual fine-focusing] is part of observing, analyzing the image."

This concept of thinking-through-doing with and through the material world has been well documented, in particular in the arts.[28] The anthropologist Tim Ingold has written about "thinking-through-making,"[29] although he extends this concept only to his definition of "makers" (artists, architects, and craftspeople) and openly dismisses the sciences.[30] In contrast, I propose that this concept can be widened and better explicated through the work of Hans-Georg Gadamer, an eminent twentieth century German hermeneutic phenomenologist, and his lesser-known concept of dialogue-as-play.

26. He "discovered" Uranus and proposed the concept of deep space, like an ocean, as well as the notion that the stars were moving and not static.

27. Caroline Herschel began her astronomical work as her brother's assistant, but became an astronomer in her right, discovering eight comets. In 1828, the Royal Astronomical Society awarded her the gold medal.

28. Numerous commentators have developed various concepts of inter and intra-materiality. See, for example, Bruno Latour's Actor Network Theory and Anne-Marie Mol's multiple bodies, developed in *The Body Multiple: Onthology in Medical Practice* (Durham, NC: Duke University Press, 2002). Many commentators who wrote during the cultural turn, the performative turn, the material turn, and now, the post-humanist turn aimed (and aim) to redress the logocentric view of western knowledge and dominance of the word (spoken or written). Consequently, in this work, with the exception of Mol, spoken language is often pushed to the background in order to highlight the material and embodied.

29. Tim Ingold, *Making: Anthropology, Archaeology, Art and Architecture* (Oxon: Routledge, 2013).

30. See Tim Ingold, "From Science to Art and Back Again: The Pendulum of an Anthropologist," *Anuac* 5.1 (2016): 5–23.

For me, this dynamic concept and form of practical wisdom illuminates the nature of many rigorous dialogues around deciding what is real in everyday scientific practices, as encountered in the field.

Dialogue-As-Play: Everyday Practical Wisdom Beyond Spoken Words

Hans-Georg Gadamer (1900–2002) was a leading continental philosopher. His work in "philosophical hermeneutics" extended our understanding of our everyday lives and explored the detail of everyday existence through shared dialogue. Gadamer's dialogue is dynamic, dialectic, and interpretive. Key elements of authentic dialogue include openness toward others and respect for differing viewpoints, gained through listening.[31] Crucial ethical conditions of genuine understanding include being open to learning new ideas from others that could radically change our understanding of the world around us.[32] Gadamer employed the analogy of play, in which the "players" are caught up with, and lose themselves in, their experiences, a dynamic that holds the potential to transform all players. This form of dialogue moves beyond words as instrumental and engages all our human senses, beyond the contemporary five.[33] These dialogues are not confined to human beings alone and engage the material world (including the visceral body and everyday tools/technologies).

As we move through and interact with our everyday worlds, we travel back and forth through (historical) time and space, encountering embedded rituals, traditions, prejudices. Some we subvert through devising "go-arounds," others we embrace or choose not to or cannot subvert/alter for whatever reasons. Dialogue-as-play is dynamic, never-ending, often based on tacit knowledge, and therefore remains partially or wholly unspoken. Here, the concept of play is not akin to the contemporary view of (child's) play: "to engage in activity for enjoyment and recreation rather than a serious or practical purpose."[34] Importantly, the playing-of-the-game rather than the player alone co-creates meaning through shared dialogue[35] that, following Aristotle, privileges listening above the seeing/speaking that has dominated Western philosophy.[36] Underpinning dialogue-as-play is the practice of approaching dialogue knowing that one does not and indeed cannot know everything.

Following Aristotle, Gadamer proposed that all philosophy starts from praxis (human practice) and that hermeneutics is essentially practical philosophy. In its simplest form, according to Aristotle, practical wisdom is the ability to negotiate and make sense of the everyday world through thoughtful deliberation, judging well for the common good, and acting decisively with foresight.[37] For Gadamer, human beings must continually interpret their everyday world, as we are neither neutral, independent, nor objective observers, but rather existential finite interpreters, always expressing linguistically our relation to the world.[38] Gadamer is often perceived to have focused on language as only spo-

31. Monica Vilhauer, *Gadamer's Ethics of Play: Hermeneutics and the Other* (Lexington, KY: Lexington Books, 2010).
32. Philip Gardner, "Hermeneutics and History," *Discourse Studies* 13.5 (2011): 575–81.
33. Fionagh Thomson, "The Mirror & the Lake: (Creating a Space to Speak for) Gadamer's Philosophical Hermeneutics to Explore the Role of Dialogue as Practical Wisdom—During the 'Good' Medical Consultation," *Philosophy, Theology, and the Sciences* 5.2 (2018): 239–64.
34. This is the definition given in the *Oxford English Dictionary*.
35. Fred Dallmayr, "The Enigma of Health: Hans-Georg Gadamer at 100," *The Review of Politics* 62.2 (2000): 327–50.
36. Donatella Di Cesare, *Gadamer: A Philosophical Portrait*, translated by Niall Keane (Bloomington: Indiana University Press, 2013).
37. Lauren Swayne Barthold, *Gadamer's Dialectical Hermeneutics* (Plymouth, UK: Lexington Books, 2010).
38. Santiago Zabala, *The Remains of Being: Hermeneutic Ontology after Metaphysics* (New York: Columbia University Press, 2009).

ken words, which he preferred over written text.[39] In a recent paper on the nature of dialogue in the "good" medical consultation, I extend dialogue-as-play to include the somatic body and technologies-to-hand that, I argue, are not at odds[40] with Gadamer's work.[41]

During this fieldwork, however, I observed intense disagreement during high-energy discussions that, on first appearance, seems to clash with Gadamer's work, as he viewed dialogue-as-play to be about solidarity[42] and partisan ways of being.[43] The French philosopher Jacques Derrida, one of Gadamer's fiercest critiques, lambasted him for promoting the idea that there is one truth and that through dialogue there can be consensus and agreement.[44] Derrida argued that there remained, always, a violence expressed through diversity of viewpoints.[45] However, Gadamer's dialogue-as-play within a "fusion of horizons" leads to the merging (not augmenting or cohering) of different worldviews through dynamic modes of interpretation that create new ways of understanding. The core to this concept is agreement on the matter under discussion, but this can translate into agreeing to come together to engage with the topic openly while listening to the other(s), including agreeing to disagree.[46]

Diversity of views, and creating space for them, is the epitome of good scientific practice. Dialogue-as-play is needed to negotiate the uncertainties in scientific research in the everyday world, by being certain about what we do and do not know.[47] Moreover, in contrast to microscopists or biologists, experimental astrophysicists and instrument scientists cannot set up or carry out traditional lab experiments, nor can they (arguably) control their sample or any variables. The astronomical observatories atop mountains are, in effect, their labs, and variables cannot be perturbed or controlled within the vastness of the night sky (or the day sky, for solar telescopes). Within this dynamic environment, where conditions cannot be replicated, the calibration process and knowing the precision, accuracy, and sensitivity of the instrumentation is paramount.

Practical Wisdom thru Dialogue-as-Play: the Unknown, Transparency, and Design Values

Unknowns and known unknowns dominate, and are openly discussed, within the specialized fields and scientific practices of astrophysics. This practice can be extended to microscopy and, arguably, to the diverse fields that make up "the sciences". Engaging in rigorous everyday scientific practice is complex, diverse, and challenging; therein lies its beauty. In response to the unknown, unexpected, and unsolved, and key to rigorous analyses, experienced instrument makers/astrophysicists in this

39. John Arthos, *The Inner Word in Gadamer's Hermeneutics* (Notre Dame, IN: University of Notre Dame Press. 2009).
40. In the last decade of his life, in 1992 at the age of 91, he wrote the essay "Towards a Phenomenology of Ritual and Language." Here, he (ex)claims that he had focused too much on language and too little on the 'lifeworld' where one encounters action no less than language (David Vessey, "Gadamer and the Fusion of Horizons," *International Journal of Philosophical Studies* 17.4 [2009]: 525–36).
41. Gardner, "Hermeneutics and History."
42. Hans-Georg Gadamer, *The Enigma of Health: The Art of Healing in a Scientific Age* (Redwood City, CA: Stanford University Press, 1996).
43. Darren Walhof, "Friendship, Otherness, and Gadamer's Politics of Solidarity," *Political Theory* 34.5 (2006): 569–593.
44. Robert Bernstein, "The Conversation That Never Happened (Gadamer/Derrida)," *The Review of Metaphysics* 61.3 (2008): 577–603.
45. Chantelle Schwartz and Paul Cilliers, "Dialogue Disrupted: Derrida, Gadamer and the Ethics of Discussion," *South African Journal of Philosophy* 22.1 (2003): 1–18.
46. Vessey, "Gadamer and the Fusion of Horizons."
47. Chad Orzel, "The Certainty of Uncertainty: Scientists Know Exactly How Well We Don't Know Things," *Forbes*, October 8, 2015, https://www.forbes.com/sites/chadorzel/2015/10/08/the-certainty-of-uncertainty-scientists-know-exactly-how-well-we-dont-know-things/.

fieldwork, unapologetically embrace discuss and (attempt to) account for primary mistakes (in contrast to stereotypical portrayals in the media). This practice leads to new concepts and ideas, from which new directions can evolve. As such—and here I return to where I began—contemporary "good" scientific practice views knowledge as inherently contingent rather than absolute in nature. Consequently, within everyday scientific practices the skilled craft of engaging in dialogue-as-play is considered important in deciphering *which sources of information are real* i.e. data, images, papers, informal and formal discussions. (Here, dialogue moves beyond individual bodies, spoken words, and gestures to include the somatic body and technologies-to-hand.) Through dialogue-as-play, we make sense of, engage with, submit to, accept, challenge, and alter (although never "tame") our dynamic, chaotic everyday world. Importantly, through dialogue-as-play scientists (can) gain, maintain and develop practical wisdom, leading to "good" or virtuous everyday scientific practices.

Methodologically, practical wisdom is challenging to study empirically, as it is enacted in the moment, cannot be taught, and is fluid and temporary in nature and, therefore, often remains unspoken. Initial findings indicate that potential conduits for practical wisdom (in this field) include: creating space(s) for rigorous questioning of the "reality" of each information source; an informal mentoring system that counteracts the normative concept of "the correct answer" and encourages individuals/groups to face any fear of failure, to speak out, put ideas forward, and engage critically; and developing transparent and open technical systems, accessible to an interconnected network of makers and users, as required.

Inevitably, there are barriers to dialogue-as-play, some of which are (deeply) embedded within our everyday lives in some form or other. For example, mainstream science education,[48] policy documents, public engagement events, and the media frequently, albeit unwittingly, often present the sciences as a monotheistic set of disciplines, based on various forms of absolute knowledge, with one common language. Here, dialogue-as-play rarely thrives since dialogue appears less about listening openly, understanding the other, and accepting that one cannot know everything, and is more about convincing non-believers of the one truth. Any mentoring system also need to be bespoke to the learner as few methods fit all learning styles, for example, the "sink or swim" model. Returning briefly to the question I raised at the start of this chapter, one embedded barrier to dialogue-as-play is the practice of assigning too much (blind) faith to the meaning of an image, plot, or graph, without critical detailed analysis within an interconnected network of information sources. Notably, however, intense critical questioning, outlined in the earlier scenario with Cillian and Bob, was a common occurrence in this fieldwork (with the exception of inexperienced students). But for reasons beyond the scope of this chapter, there is an increasing divide and decreasing communication between the makers of instrumentation and the observers who use the kit and who increasingly work away from the observatories.[49]

Underpinning these barriers is the omnipotent presence of an oxymoron in the sciences, mentioned

48. One barrier is a national education system that undervalues the importance of dialogue (and critical/creative thinking) in preparing younger generations to enter the world of high-level scientific research, and instead promotes, and encourages, an automated unreflective practice of rote learning facts in order to pass exams (Fionagh Thomson, "Are Children's Methodologies keeping them in Their Place?," *Children's Geographies* 5.3 [2008]: 207–18).

49. Limited recognition of the symbiotic relationship between human bodies and human knowledge within technological design and development and the absence of dialogue-as-play and practical wisdom can lead to obsolete technologies and even the suppression of human well-being and knowledge.

at the start of this chapter: scientific practices are framed as a human endeavor, but one that views human senses and sensibilities as inherent weaknesses, even vices, in rigorous scientific practice. These weaknesses and vices must be overcome or mediated through various scientific practices, including machine learning and automated systems. Consequently, future questions include:

1. If scientific practices are inherently a human endeavour, then how do we learn to trust and reintegrate human senses into everyday scientific practices that are considered rigorous, reliable, and ethical?
2. In an increasingly specialised and fragmented world of knowledges, disciplines, and subdisciplines, how do we decrease the widening division between those who design, build, and develop and those who commission and use?
3. If practical wisdom cannot be taught, and must be learned on-the-job and enacted in the moment, how do we "teach" machine learning systems that currently rely on well defined, logical, generic algorithms?

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CHAPTER 6.

HOW EASY IS IT TO BE INTELLECTUALLY HUMBLE IN OUR DAILY LIVES?

ERANDA JAYAWICKREME

In this essay, I propose that one important component of humility involves being aware of the limits of your own knowledge.[1] Possessing such *intellectual humility* is central to being humble (I am not alone in this belief; Valerie Tiberius has also made this point).[2] Building on Daniel Kuebler's insights in this volume, I believe this specific epistemic virtue is critical to doing good science. Being able to think clearly about the world involves the cultivation of intellectual virtues promoting unbiased, rational thought. Contemporary scientists have, moreover, increasingly understood wise reasoning in terms of unbiased thought and have specifically argued that such thinking can be facilitated through the enactment of intellectual humility.[3]

It turns out that there are a number of definitions of intellectual humility in the literature, but my preferred definition casts intellectual humility in terms of a disposition to be alert to, admit to, and take responsibility for cognitive limitations and mistakes.[4] This variant of humility has been found to correlate with benefits in education, social relationships, forgiveness, and religious tolerance. It is also closely aligned with the intellectual strengths of open-mindedness and curiosity, and the interrelations between these becomes clear when one considers that intellectual humility can be seen as a subset of open-mindedness, and open-mindedness in turn a subset of curiosity. This view is based on the perception, in many cases, that one cannot be intellectually humble without being both curious

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2. Valerie Tiberius, "Wisdom and Humility," *Annals of the New York Academy of Sciences* 1384.1 (2016): 113–16.

3. See Igor Grossmann, Tanja M. Gerlach, and Jaap J.A. Denissen, "Wise Reasoning in the Face of Everyday Life Challenges," *Social Psychological and Personality Science* 7.7 (2016): 611–22; Elizabeth J. Krumrei-Mancuso and Steven V. Rouse, "The Development and Validation of the Comprehensive Intellectual Humility Scale," *Journal of Personality Assessment* 98.2 (2016): 209–21; Mark R. Leary, Kate J. Diebels, Erin K. Davisson, Katrina P. Jongman-Sereno, Jennifer C. Isherwood, Kaitlin T. Raimi, Samantha A. Deffler, and Rick H. Hoyle, "Cognitive and Interpersonal Features of Intellectual Humility," *Personality and Social Psychology Bulletin* 43.6 (2017): 793–813.

4. Dennis Whitcomb, Heather Battaly, Jason Baehr, and Daniel Howard-Snyder, "Intellectual Humility: Owning Our Limitations," *Philosophy and Phenomenological Research* 94.3 (2017): 509–39; but for an alternate view see Robert C. Roberts and William Jay Wood, *Intellectual Virtues: An Essay in Regulative Epistemology* (Oxford: Oxford University Press, 2007).

and open-minded. From a developmental standpoint, moreover, open-mindedness may be a prerequisite for intellectual humility. On the other hand, as the philosopher Jason Baehr mentioned to me a few years ago, one could imagine someone being intellectually humble (that is, they might freely acknowledge their cognitive limitations when pressed) but not particularly curious about the world. Moreover, it seems that one's motivation to manifest intellectual humility is likely predicated on one's willingness to evaluate different and novel types of information, that is, to be open-minded. Finding clarity on these distinctions may require a career's worth of investigation.

However, an additional question that I believe merits investigation is the following: which social contexts are more likely to elicit intellectual humility?[5] Typically, current empirical research on intellectual humility has conceptualized it as a stable, trait-like virtue.[6] On this account, some people are typically more or less humble than others. However, although it is indeed likely that individuals differ in their characteristic levels of intellectual humility, there is also reason to believe that this virtue can be manifested in response to specific situations. If we begin from the premise that some situations are more likely to promote intellectual humility than others, then what are the *situational contingencies* that promote intellectual humility in adults?

It may be worth explaining here what I mean by a *situational contingency*. It refers to a systematic relationship between a given thought, feeling, or behavior that a person enacts on the one hand, and a given characteristic of the situation on the other. For example, an individual may experience an increase in intellectual humility when debating a political issue with a friend. In this example, there is a contingency of intellectually humble thoughts, feelings, and behaviors (example items: "I viewed the challenging of my ideas as an opportunity to grow and learn"; "I felt that it was important to work through competing solutions to the problem"; "I complimented the good ideas of those who disagreed with me") as a function of engagement with that specific situation. Such contingencies do not represent the trait of intellectual humility; rather, they refer to changes in the thoughts, feelings, and behaviors characteristic of the trait of intellectual humility that describes the way the individual is being at the moment. So, the focus here is on whether intellectually engaging situations (as reported by the participant) increase the extent to which individuals can be described as intellectually humble while they are in the situation.

Our team speculated that compared to the situational contingencies associated with other personality traits such as conscientiousness, situational contingencies of intellectual humility would be unlikely to occur as frequently, since we likely do not encounter situations relevant to owning our cognitive limitations as often as we would situations relevant to other traits. Thus, we conducted a three-week study in which a sample of 111 undergraduate students between 18 and 22 years of age (M = 19.06, SD = 0.94) filled out a questionnaire sent to their smartphones about their thoughts, feelings, and behaviors twice a day (typically studies collect assessment between five and ten times per day). We were interested in their manifestations of intellectual humility and the situational contingencies associated with these manifestations. Specifically, participants were asked about the situations they had been in over the previous twelve hours and the extent to which those experiences made them feel intellectually humble. We developed the questionnaire so as to capture the central thoughts, feelings,

5. See Zachry et al., "Situation-Based Contingencies Underlying Wisdom-Content Manifestations."

6. See Krumrei-Mancuso and Rouse, "The Development and Validation of the Comprehensive Intellectual Humility Scale," and Leary et al., "Cognitive and Interpersonal Features of Intellectual Humility."

and behaviors associated with intellectual humility (to be alert to, admit to, and take responsibility for cognitive limitations and mistakes).

What did our study find?[7] It turned out that seeing interpersonal situations as disagreeable, rather than amicable, caused intellectual humility to go down. But seeing the interlocutor in a given situation as a moral actor caused intellectual humility to go up. Perception of one's interlocutor was actually the best predictor of intellectual humility. Additionally, we found that people varied significantly in their manifestation of intellectual humility from questionnaire to questionnaire. In fact, they differed more from their own assessments at other time points than they did from other people. This confirmed that intellectual humility can be seen as a "tool" manifested in relevant situations—it can be deployed when circumstances demand—as opposed to a "fixed" trait.

Of course, this is just one study, and more work needs to be done (including replications of this study itself). But some interesting future directions present themselves. Igor Grossmann and his colleagues, for example, have shown that the broad construct of wise reasoning (including intellectual humility, as I noted earlier, although he used different assessments to study it) increases in situations when subjects reflect on *other people's* challenges as opposed to their own challenges.[8] Additionally, his own diary studies have shown evidence for increased wise reasoning in situations where work colleagues or friends were present, as opposed to when strangers were present. Future work should examine these contingencies, and further capture the manifestations of intellectual humility in different aspects of daily life.

Additionally, I think we need to integrate research on intellectual humility and other dimensions of wisdom with current integrative approaches to personality. For example, Whole Trait Theory[9] claims that individual differences in manifestations of trait-relevant behavior (such as intellectual humility as captured by the study described above) can be explained by specific social-cognitive mechanisms—that is, the specific ways in which people process, store, and apply information about people and situations. Given that successful interventions to increase intellectual humility will require knowledge of how such mechanisms can be successfully manipulated, I think this project will be an especially important one. Studies that replicate existing findings such as the ones reported here as well as those that successfully "scale up" interventions based on basic research[10] will be essential for translating basic research for societal benefit.

Finally, I confess to initially finding the results of this study somewhat disappointing. Despite the fact that we seem capable of expressing intellectual humble thoughts, feelings, and behaviors to different degrees across situations, one lesson of this research seems to be that being intellectual humble is hard. Why do I say this? It seems that we find it easy to manifest it in "easy" situations (for exam-

7. For details interested readers can refer to Zachry et al., "Situation-Based Contingencies Underlying Wisdom-Content Manifestations."

8. See Grossmann, Gerlach, and Denissen, "Wise Reasoning in the Face of Everyday Life Challenges."

9. William Fleeson and Eranda Jayawickreme, "Whole Trait Theory," *Journal of Research in Personality* 56 (2015): 82–92; Eranda Jayawickreme and William Fleeson, "Does Whole Trait Theory Work for the Virtues," in *Moral Psychology: Virtue and Happiness*, edited by Walter Sinnott-Armstrong and Christian B. Miller (Cambridge, MA: MIT Press, 2017), 75–103; Eranda Jayawickreme, Corinne E. Zachry, and William Fleeson, "Whole Trait Theory: An Integrative Approach to Examining Personality Structure and Process," *Personality and Individual Differences* 136 (2019): 2–11.

10. Gregory M. Walton and Timothy D. Wilson, "Wise Interventions: Psychological Remedies for Social and Personal Problems," *Psychological Review* 125.5 (2018): 617.

ple, when the other individual is perceived as moral and therefore trustworthy) but struggle to deploy in situations where intellectual humility could be most valuable (for example, when an interpersonal situation is disagreeable). There are likely other factors that distinguish those individuals who can manage to exhibit intellectual humility in "hard" situations from the rest. Additionally, these results may vary by age and experience—I should note that our study focused on undergraduate students. Future research with samples from different age groups and backgrounds can answer this question, and hopefully help us develop ways to promote it in society.

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CHAPTER 7.

ETHICAL VIRTUES IN SCIENTIFIC REPRESENTATION

CHAR BRECEVIC

Theoretical virtues assume an important role in philosophy of science. Virtues such as accuracy, simplicity, robustness, fruitfulness, and elegance are often appealed to in cases of underdetermination to justify the selection of one theory among a set of equally empirically adequate alternatives.[1] Given the predominance of the semantic view of theories, in which theories are a collection of models and models are a class of representations, these same theoretical virtues are often applied to scientific representations.[2] Ethical virtues such as prudence, temperance, courage, justice, magnanimity, or humility, however, are rarely, if ever, discussed in the representation literature. Even if one granted that the adoption of certain scientific theories entails ethical consequences in certain social contexts, the endeavor to describe mind-independent truths about the world challenges the idea that ethical virtues need to be within the purview of the philosopher's analysis. But given that the practice of science is value-laden, that the interpretations of scientific representations are usually not univocal, and that these representations can be moved into spaces populated by nonexpert audiences, I argue that failing to consider ethical virtues in the discussion of scientific representation is problematic—especially with respect to those representations of esoteric scientific knowledge that strongly shape public conceptions of possible futures.

I will be adopting an exemplification view of representation, in which a representational vehicle exemplifies literally or metaphorically instantiated properties which are then imputed onto a target

1. See Thomas Kuhn, "Objectivity, Value Judgment, and Theory Choice," in *The Essential Tension: Selected Studies in Scientific Tradition and Change* (Chicago: University of Chicago Press, 1977), 320–29; Ernan McMullin,"The Virtues of a Good Theory," in *The Routledge Companion to Philosophy of Science*, edited by Martin Curd and Stathis Psillos (London: Routledge, 2008), 498–508; Stahis Psillos, *Scientific Realism: How Science Tracks Truth* (London: Routledge, 1999); Bas C. van Fraassen, *The Scientific Image* (Oxford: Oxford University Press, 1980).

2. This is especially true of accuracy considerations. Since many philosophers are interested in distinguishing representations from misrepresentations and non-representations, questions concerning accuracy are frequently addressed in the literature. For semantic accounts that either theorize about or make use of these virtues, see Newton C. A. Da Costa and Steven French, "The Model-Theoretic Approach to the Philosophy of Science," *Philosophy of Science* 57.2 (1990): 248–65; Steven French and James Ladyman, "Reinflating the Semantic Approach," *International Studies in the Philosophy of Science* 13.2 (1999): 103–21; Patrick Suppes, "A Comparison of the Meaning and Uses of Models in Mathematics and the Empirical Sciences," *Synthese* 12.2-3 (September 1960): 287–301; Michael Weisberg, *Simulation and Similarity: Using Models to Understand the World* (Oxford: Oxford University Press, 2013).

system of interest.[3] Thus, by representation, I mean an object under an interpretation that then serves as a representational vehicle for a target system.[4] Importantly, in comparison to other theories, the exemplification view is considerably more lenient about what counts as a representation. Consequently, I contend that any images, graphs, diagrams, models, videos, texts, or other forms of media denoting targets within the domain of science, insofar as they satisfy the criteria of denotation, exemplification, and imputation, can be rightfully categorized as scientific representations. All representations within this class of scientific representations are not functionally or stylistically equivalent. Rather, what I am suggesting, to use Sheila Jasanoff's terminology, is that because scientific ideas are *coproduced* with ideas about science, popular representations of science, although usually not functioning in a technical capacity, are not irrelevant to the philosopher of science interested in scientific representation more generally. To put this point more strongly, if we are seriously committed to the task of integrating certain virtues into scientific practice, we must ensure that those representations denoting scientific content are themselves exemplifying these virtues. With this in mind, I will now direct my attention to a popular scientific representation of CRISPR-Cas9 that I believe fails to represent in a virtuous manner.

In the second decade of the twenty-first century, the life sciences entered into the age of CRISPR. In his 1998 book *Consilience*, sociobiologist E.O. Wilson announced that "genetic evolution is about to become conscious and volitional, and usher in a new epoch in the history of life."[5] Although the unmet promises of the Human Genome Project left many doubting whether or not this new epoch had actually arrived, within fifteen years that doubt would begin to dissipate with the discovery of CRISPR-Cas9 (from this point forward, referred to as CRISPR), a molecular tool adapted from bacteria and capable of executing gene modification with great precision. Initially, the study of the CRISPR system was rather benign. Researchers were not seeking a way to use this newfound knowledge for medicinal purposes, let alone genetic editing, but were interested in exploring curious phenomena in marsh bacteria, solving problems associated with biowarfare, and improving yogurt manufacturing.[6] Fast forwarding to 2012, after a culmination of work contributing to its development, scientists claimed "the Cas9 endonuclease can be programmed with guide RNA engineered as a single transcript to target and cleave any [double-stranded] DNA sequence of interest. The system is efficient, versatile, and programmable…."[7] Although CRISPR was not the first tool capable of modifying genes, what sets it apart is its increased precision, low cost, and malleability for meeting virtually any experimentalist's needs.[8]

3. For more detailed accounts see Catherine Z. Elgin, "Telling Instances," in *Beyond Mimesis and Convention: Representation in Art and Science*, edited by Roman Frigg and Matthew C. Hunter (Berlin: Springer, 2010), 1–18, and Roman Frigg and James Nguyen, "Of Barrels and Pipes: Representation-As in Art and Science," in *Thinking about Science, Reflecting on Art: Bringing Aesthetics and Philosophy of Science Together*, edited by Otávio Bueno, George Darby, Steven French, and Dean Rickles (London: Routledge, 2018), 41–61. These authors refer to their accounts as Representation-As and DEKI (Denotation-Exemplification-Keying Up-Imputation), respectively.

4. An example that makes this clear is the MONIAC (Monetary National Income Analogue Computer) designed by economist William Phillips to represent national economic processes. The machine is composed of pipes and tanks that allow for the movement and collection of water. The pipes, tanks, and water are objects that do not represent an economy unless an agent interprets them as such (for example, interpreting water as money or interpreting the filling of a particular tank with water as national savings). Once an agent does interpret them as such, these objects become objects under an interpretation (that is, representations).

5. E.O. Wilson, *Consilience: The Unity of Knowledge* (New York: Vintage Books, 1998), 205.

6. Eric S. Lander, "The Heroes of CRISPR," *Cell* 164 (January 14, 2016): 26.

7. Martin Jinek, et al., "A Programmable Dual-RNA Guided DNA Endonuclease in Adaptive Bacterial Immunity," *Science* 337.6096 (August 17, 2012): 820.

8. Rajan M. Gutpa and Kiran Musunuru, "Expanding the Genetic Editing Tool Kit: ZFNs, TALENs, and CRISPR-Cas9," *Journal of Clinical Investigation* 124.10 (October 2014): 4154–61.

The range of applications is astounding, with many commentators arguing that "the only limitation today is people's ability to think of creative ways to harness [CRISPR]."[9]

Unsurprisingly, as with any novel technology that promises unprecedented power and control over human problems, questions concerning how this technology ought to be used and who has the authority to make such decisions quickly surfaced.[10] With CRISPR, this concern is particularly salient, not only because the kind of genetic manipulation involved is considered simple and reliable, but also because it is incredibly inexpensive compared to other available technologies—allowing self-proclaimed "Do-It-Yourself" biologists and biohackers to carry out these procedures in their own homes.[11] Recognizing the serious ethical and logistical questions arising from the use of CRISPR, biochemist Jennifer Doudna has spearheaded an effort to educate the general public about what CRISPR technologies entail, both scientifically and ethically, arguing that "it will be imperative that nonexperts understand the basics of this technology sufficiently well to facilitate rational public discourse."[12]

What, then, should the nonexpert understand about CRISPR? What message is most appropriate to share with those lacking formal science backgrounds if the aim is to minimize misinformation and foster justified insights into what genes are and what can be done with them? Given that CRISPR technology has been increasingly sensationalized over the past several years, there is no lack of resources available to evaluate how CRISPR is being portrayed in both technical and popular literatures. However, because of her explicit emphasis on the necessity of educating nonexperts as a way to promote rational debate, I will focus on the claims made in Doudna's latest popular science book (with Samuel Sternberg), *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution.* I take this narrow domain of analysis to be reasonable, considering that Doudna is one of the leading scientists in the development of CRISPR technology and, as she herself asks, "Who besides the scientists using the technique would be able to lead an open conversation about its repercussions?"[13] Her insistence that society cannot make decisions about matters it does not understand, coupled with her view that scientists must be the ones "to introduce and demystify their technical accomplishments,"[14] supports the conclusion that the contents of this book ought to be representative of what Doudna believes nonexperts should know about CRISPR technologies.

One need only read the cover of the book to suspect what the answer might be; the title presents a conjunction of *gene editing* and *the unthinkable power to control evolution*, which, for the authors, is tautological. But the themes of power, control, and future successes are also found throughout, indicating that the bold title was not simply serving as a means of catching potential readers' eyes. For example, in a chapter titled "Command and Control," Doudna shares reflections she had while flying home from her first meeting in Cambridge to found a company for CRISPR-based therapies. She begins by noting that CRISPR is a biologist's dream come true and states:

9. Elizabeth Pennisi, "The CRISPR Craze," *Science* 341.6148 (August 23, 2013): 836.
10. Alta R. Charo, "Yellow Lights for Emerging Technologies," *Science* 349.6246 (July 24, 2015): 384–85.
11. Heidi Ledford, "Biohackers Gear Up for Genome Editing," Nature 524 (August 27, 2015): 398–99.
12. Jennifer A. Doudna and Emmanuelle Charpentier, "Genome Editing: The New Frontier of Genome Engineering with CRISPR-Cas9," Science 346.6213 (November 28, 2014): 12580967.
13. Jennifer A. Doudna, "My Whirlwind Year with CRISPR," *Nature* 528 (December 2015): 470.
14. Jennifer A. Doudna and Samuel H. Sternberg, *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution* (New York: Houghton Mifflin Harcourt, 2017), 205.

> I could already see a new era of *genetic command and control* on the horizon—an era in which CRISPR would transform biologists' shared toolkit by *endowing them with the power to rewrite the genome virtually any way they desired*. Instead of remaining an unwieldly, uninterpretable document, the genome would become as malleable as a piece of literary prose at the mercy of an editor's red pen.[15]

Here, the mention of power and control is straightforward. CRISPR provides the means by which particular genetic sequences can be altered, engendering a novel kind of control over biological processes. Perhaps more striking, however, is the framing of unaltered genetic sequences as unwieldly and uninterpretable—that is, of course, until CRISPR transforms these sequences into malleable prose whose fate is at the mercy of nearly omnipotent scientists. There is a clear invocation of a power structure involving genes and geneticists, with no doubts as to what hierarchical ordering Doudna is implying. Further, the mention of an editor's red pen seems to introduce a normative dimension to genetic modification. Considering that red pen marks on literary prose are often associated with corrections made to a given text—highlighting mistakes for the sake of improving the quality of the work—one interpretation of this passage is that unmediated nature is of an inferior kind to that under the reign of rational control.

Importantly, these thematic elements of power, control, and the privileging of rationality over nature are not isolated to this passage, but are instead found throughout. For instance, Doudna describes the use of CRISPR to control cellular behaviors and outputs as metaphorically similar to the manipulation of a puppet, in which the "invisible strings give a marionettist near complete control over [its] actions and movements."[16] Echoing Pennisi, Doudna claims that, with the use of CRISPR, "scientists can now exert nearly complete control over both the composition of the genome and its output…. It often feels like the genome-engineering applications made possible by CRISPR are *limited only by our collective imagination*."[17] With the expansion of this powerful technology, "no letter of DNA in the genome, no gene or combination of genes is beyond reach."[18] With such possibilities within our grasp, Doudna predicts that "it won't be long before CRISPR allows us *to bend nature to our will* in the way that humans have dreamed of since prehistory."[19] In the concluding paragraphs, Doudna consummates her argument by uniting these themes into a simple, visionary statement:

> Gone are the days when life was shaped exclusively by the plodding forces of evolution. We're standing on the cusp of a new era, one in which *we will have primary authority* over life's genetic makeup and all its vibrant and varied outputs. Indeed, we are already supplanting the *deaf, dumb, and blind system* that has shaped genetic material on our planet for eons and replacing it with a *conscious, intentional system of human-directed* evolution.[20]

What is crucial to observe here is the implicit indication that there is a separation between humans—or more specifically, geneticists—and nature. While it would be too strong to claim that Doudna is making use of a material distinction, the possession of authority over life requires some distinction in kind between humans and nature more generally; after all, if there were no distinction, it is unclear how one could be subordinate to the other. Given her contrast between natural and

15. Ibid., 90. Emphasis added.
16. Ibid., 108.
17. Ibid., 110. Emphasis added.
18. Ibid., 111.
19. Ibid., 118. Emphasis added.
20. Ibid., 243. Emphasis added.

human-directed evolution, in which the former is slow, "deaf, dumb, and blind," while the latter is conscious and intentional, I argue the distinction is meant to be a *rational* one. This is further corroborated by another comment in which the reader is told: "nature is less an engineer than a tinkerer, and a fairly sloppy one at that."[21] Disease and physical deformities are construed as evidence for the irrational and careless workings of nature, which, according to Doudna, "can seem like outright cruelty."[22] Fortunately, the lay audience is assured, CRISPR technologies will introduce a rationality into this otherwise irrational evolutionary process, promising improved human lives through the eradication of genetic diseases, solving of hunger crises, and curing of cancers.[23] Although many will be resistant to harnessing this power, talking about natural genomes "as if they were part of a precious evolutionary inheritance, something to be cherished and conserved,"[24] the reader is reminded that the stakes are simply too high to not even consider the use of this awesome power to alleviate human suffering—a power that lies in the rational mediation of the genome.

While Doudna's CRISPR-representation may be evaluated with respect to theoretical virtues such as accuracy or simplicity, my central claim is that it can, and should, be evaluated with respect to ethical virtues as well. Although some may find it too strong to accuse *A Crack in Creation* of being univocally vicious, I do not think it is unreasonable to assert that the commanding tone used when presenting the acquisition of the awesome powers afforded by CRISPR does not in any straightforward way exemplify, say, temperance, humility, or magnanimity. The resounding rhetoric of anthropocentric power and control supports the charge of intemperance and arrogance, as do the applications of CRISPR technologies that Doudna mentions but does not explicitly question in any moral sense—e.g. genetically engineering species that have previously gone extinct, inducing diseases in nonhuman subjects for the sake of research that does not serve those subjects, etc. Although it would be too strong of a claim to suggest that nonexpert readers would unquestionably accept Doudna's conclusions for themselves—given that public audiences are not homogenous in any meaningful respect—one may reasonably assume that readers with high levels of trustworthiness in scientists like Doudna may fail to question the rhetoric presented to them—and therefore will not question the possible futures they are invited to envision.

I want to emphasize that my analysis of Doudna's *A Crack in Creation* is not an attempt to reduce her work to mere CRISPR propaganda. Nor is it my aim to suggest that Doudna is a crazed, overzealous scientist intoxicated by grand biotechnological visions. To her credit, the book does provide the kind of basic knowledge about CRISPR she argues all nonexperts should have. She provides some historical background concerning the discovery and development of CRISPR, a first-hand account of her own experiences working towards these ends, and insights into the potential applications and ethical concerns associated with this technology. These are no small tasks and there will always be disagreements as to how knowledge concerning complex biotechnologies can be best relayed to nonexperts. Nevertheless, what is equally important to recognize is that, since this knowledge can be represented in more than one way, Doudna's frequent reliance on themes of power, control, promise, and rationality is not a matter of coincidence.

21. Ibid., 228.
22. Ibid., 228.
23. Ibid., 240.
24. Ibid., 229.

In fact, these themes are pervasive across historical and contemporary works in the biological sciences. For example, in the late nineteenth century, Francis Galton was fixated on the burden of original sin. He understood this sin as that which is responsible for the atavistic tendencies preventing individuals from achieving moral ends of the highest order. Historian Daniel Kevles argues that Galton believed freedom was possible through human control over heredity, claiming that:

> [T]o Galton's mind, the scientific doctrine of evolution destroyed the religious doctrine of the fall from grace. He appropriated Darwin to argue that man, instead of falling from a high estate, was 'rapidly rising from a low one'…. According to Galton, 'what Nature does blindly, slowly, and ruthlessly, man may do providently, quickly, and kindly.'[25]

Galton's dedication to increasing statistical precision and predictive power in the science of heritable traits was undergirded by a desire to make possible the exertion of control over one's fate. Similar themes can be found in the grand biotechnological visions of J.B.S. Haldane in his *Daedelus, or Science and the Future*. Writing in 1924, prior to any scientific evidence for the material basis of the gene, these visions involve various applications of genetic engineering to solve problems ranging from the domain of medicine to the domain of agriculture. Haldane champions science as "man's gradual conquest, first of space and time, then of matter as such, then of his own body and those of other living beings, and finally the subjugation of the dark and evil elements in his own soul."[26] He concludes, rather audaciously, that the ultimate aim of the biological sciences is a killing of the gods. Biologist Robert Sinsheimer, writing in 1969 on the promises of biotechnology, states that "for the first time in all time, a living creature understands its origin and can undertake to design its future…. Even in the ancient myths man was constrained by his essence. He could not rise above his nature to chart his destiny. Today we can envision that chance and choice."[27] In a similar vein, writing in the early 1970s, biologist Francois Jacob claims that "with the accumulation of knowledge, man has become the first product of evolution capable of controlling evolution."[28]

One may argue that what made this theme of power and control particularly salient in the twentieth century was the increasing mathematization of the biological sciences, culminating in the Modern Synthesis.[29] Additionally, one may point to the fact that the decades following the reintroduction of Mendelian genetics led to greater specificity of the hereditary principle, beginning with its localization to the chromosomes, its identification as DNA, and the subsequent discovery of the collinearity between codons and amino acids. By the 1960s, controlling life was, for some, simply a matter of decoding the hidden language of genes and rewriting that code to fit desired ends.[30] Importantly, however, this fixation on power and control has remained rather consistent over the past hundred years, even when the material basis of the gene was considered hypothetical.

Noticing the similarity in the envisioned futures accompanying such desires for power and control, Maurizio Esposito writes:

> For many past geneticists and contemporary scientists, a place without illnesses, without criminals or crimes,

25. Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (Berkeley: University of California Press, 1985), 13.
26. J.B.S. Haldane, *Daedalus or Science & the Future* (New York: E.P. Dutton & Company, 1924), 82.
27. Robert L. Sinsheimer, "The Prospect of Designed Genetic Change," *American Scientist* 57.1 (Spring 1969): 134.
28. Francois Jacob, *The Logic of Life: A History of Heredity* (New York: Pantheon Books, 1973), 322.
29. Garland E. Allen, *Life Science in the Twentieth Century* (Cambridge: Cambridge University Press, 1978).
30. Evelyn Fox Keller, *Refiguring Life: Metaphors of Twentieth-Century Biology* (New York: Columbia University Press, 1995).

> yet enjoying an unlimited quantity of food and energy is not an unrealizable promise if science is properly applied to politics and society. These visions are not simply the product of science-fiction writers, journalist's overstatements, or the exaggeration of few crank scientists. If we look seriously at the history of genetics, we realize that this rhetoric of futurity is an integral part of the discipline whereby prediction and control are the main epistemic values.[31]

This rhetoric of futurity captures all of the promises and expectations arising from the conceivability of manipulating some hereditary unit for the sake of dominating life in all its facets. That this rhetoric rarely maps onto reality in a felicitous fashion is unproblematic, because the abstract visions and the material bases upon which they may materialize have become increasingly bifurcated, both ontologically and temporally.[32] In other words, these promises necessarily operate in a reality that has not yet come and, in principle, never will. It is of critical importance, however, that these biotechnological visions are predicated on simple, easily manipulable biological systems. Without controllable or programmable units in predictable biological models, the imagined space of a rationally governed world becomes unfathomable. This explains the conceptual allure of the gene, in which its promise of causally explaining higher-order manifestations of life provide a "seductive empowerment" to those interested in creating and maintaining technocratic visions.[33] Thus, the concept of the gene has operated less with the intention of accurately explaining the science of heredity and more with the intention of shaping social expectations. Although the gene has assumed many referents, leading to an ambiguity of what is meant by the term, what remains constant is its promise of "prediction, control, and effective manipulation."[34]

To summarize using Mauricio Esposito's terminology, the rhetoric of futurity has been entangled in the discourse surrounding genetic science for over a century. Given this thematic conservation across the dramatic changes in genetic knowledge, I argue that if the rhetoric surrounding genetic science is to be challenged—that is, if we are to question whether or not the possible futures we are invited to envision are ones *we ought to be* orienting ourselves towards—then the central concern is representational rather than epistemological or scientific. What this rhetorical continuity indicates is a need to pay greater attention to the presentation of relevant scientific representations, especially with respect to the virtues or vices being exemplified, both knowingly and unknowingly. Indeed, in works that entertain possible futures, the entanglement of the ethical with the representational is quite clear. It is because the rhetoric of futurity denotes a future that has not yet arrived and, either explicitly or implicitly, moralizes this future that the theoretical virtues alone are ill-equipped to evaluate certain scientific representations. Supplementing the evaluation of representations with ethical virtues allows for critical questions to surface: Is this representation of present or future genetic science virtuous? Would an exemplar of virtuous practice find these dominating visions of power and control virtuous? How might this science be represented such that the virtues it exemplifies correspond to those which scientists endeavor to cultivate in their own practices?[35]

31. Maurizio Esposito, "Expectation and Futurity: The Remarkable Success of Genetic Determinism," *Studies in History and Philosophy of Biological and Biomedical Sciences* 62 (2017): 2.

32. Kaushik Sunder Rajan, *Biocapital: The Constitution of Postgenomic Life* (Durham, NC: Duke University Press, 2006).

33. L.E. Kay, *The Molecular Vision of Life: Caltech, the Rockefeller Foundation and the Rise of the New Biology* (New York: Oxford University Press, 1993), 17.

34. Esposito, "Expectation and Futurity," 8.

35. The careful reader will notice that there is some equivocation in the use of *virtuous* here. It is one thing to say that a representation is *virtuous*1 because it is a good representation: "this book on biotechnology represents biotechnology well". It is another to say that it

Amélie Rorty argues, in an Aristotelian vein, that virtue involves doing the right thing, at the right time, in the right way, and for the right reason. Consequently, it is not surprising that "speaking persuasively—rightly and reasonably saying the right things in the right way at the right time—is a central part of acting rightly."[36] To this, I would add that the virtuous person must not only say the right things, but *also be able to show* the right things in the right way at the right times and for the right reasons. It is because scientists like Doudna are often granted epistemic authority by nonexpert audiences that her position as constructor of scientific representations holds a moral charge. Now that opportunities to engage with genetic technology and information are manifesting across medical settings and public spaces, Doudna's rhetoric, whether intended or not, has potential to influence the attitudes, beliefs, and desires of her readers as they try to determine how they ought to orient themselves towards these biotechnological possibilities now unfolding into actualities. The language of virtue is apposite here because it succinctly captures what is at stake with visionary representations concerning biotechnological futures: the misdirection of desires to potentially vicious ends. If there is an endeavor to establish or foster a set of just, temperate, humble, or merciful scientific practices, we must ensure that the representations used to convey scientific content meaningfully are also just, temperate, humble, and merciful.

To conclude, I recognize that I have merely scratched the surface of the possibility of evaluating scientific representations with respect to ethical virtues. Undeniably, there are many questions that require far more discussion than is possible here. For example, are the ethical virtues intrinsic to the representations themselves or do they only enter in at the level of interpretation? How do we determine whether or not a particular virtue is in fact instantiated in a given representation and how do we evaluate its appropriateness in a given context? And which virtues ought to be evaluated? Should there be normative constraints on the stylistic choices used to construct representations? What would prove more efficacious: altering the design of representations so as to make manifest certain ethical virtues or improving moral education and media literacy in nonexpert audiences? In what ways are virtues instantiated or exemplified differently across popular and technical scientific representations? These are interesting questions that I believe are worth our time and attention. However, for now, my conclusion remains modest but resolute: if it is virtuous scientific practices that are sought, scientific representations must also be virtuous. Scientists must endeavor not only to act and speak well, but to represent well.

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is *virtuous*2 because it itself exemplifies a particular virtue: "the extended metaphor used in this book on biotechnology readily exemplifies humility". It is yet another to say that a representation is virtuous because it was constructed or interpreted by a *virtuous*3 person: "the author of this book on biotechnology is humble". Simply put, *virtuous*1 is nothing but a synonym for good, *virtuous*2 describes a virtue that is a feature of a representational system that is quasi-independent of viewers/users (I say quasi-independent since the account of representation I have been using will not allow for full independence), and *virtuous*3 describes virtues concerning thoughts and actions of a deliberative agent. These distinct uses of *virtuous* are not synonymous with one another. Although I cannot develop this further here due to space limitations, if one has been sufficiently persuaded by my claim that evaluating certain scientific representations with respect to ethical virtues is a worthwhile effort, I think it suffices to say that determining how these different senses of *virtuous* interact with one another would be among the aims of future study. For example, it is possible that an analysis of the ethical virtues operating in scientific representations may characterize a particular case in the following manner: a *virtuous*3 scientist purposefully designs a *virtuous*2 representation to ensure that it functions as a *virtuous*1 representation when viewed by certain audiences. More work needs to be done to figure out the details of such an analysis. I am grateful to the anonymous referees for calling attention to this point.

36. Amélie Rorty, "Aristotle on the Virtues of Rhetoric," *The Review of Metaphysics* 64.4 (June 2011): 715.

and social values in science. She is interested in questions concerning the function of exemplification and the role of interpretation in representational practices, especially with respect to the life sciences and medicine. In particular, her work aims to reveal how social values shape interpretative practices in various scientific contexts and determine whether there is an ethical dimension to representation construction and presentation.

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PART III.

VIRTUE ETHICS AND SCIENTIFIC EDUCATION

CHAPTER 8.

THE ROLE OF ETHNOGRAPHIES IN DEVELOPING VIRTUE ETHICS FOR THE LIFE SCIENCES

LOUISE BEZUIDENHOUT AND DORI BEELER

There has been a lot of recent interest in virtue ethics as an alternative to deontological framings of responsible conduct of research for the life sciences.[1] Proponents of this approach suggest that virtue ethics offers a more holistic interpretation of responsibility that focuses on character development rather than rule-following. In this way, it is suggested that virtue ethics offers a way to talk about science that does not impose unnatural boundaries between the individual as self and the individual as scientist. Moreover, by focusing on situational conduct, it offers an important way of discussing responsible actions within daily laboratory life. Despite the benefits to be accrued through the use of virtue ethics, opponents criticize this approach for being difficult to teach and discuss. These objections arise from the situatedness of virtue ethics: students learn through doing, and actions can only be understood in context. In order to counter this concern, many proponents of virtue ethics for the life sciences are turning to textual accounts of "exemplary scientists" as a means of demonstrating virtuous behavior in context.

This chapter takes issue with the current selection of exemplars for two key reasons. First, we feel that these discussions tend to use the longitudinal achievements of successful scientists as a proxy for exemplarism. In this way, they marginalize exemplary individuals who embody other key areas of science, such as mentorship, teaching, and community building. Our second objection relates to the narratives currently in use. These tend to be auto/biographies of scientists that do not systematically present their socio-historical context in detail. Nor do they explicitly foreground the position of the author in the text. As an alternative to these problematic texts, we suggest that the rising number of ethnographic accounts of laboratory practices should be recognized as important tools for virtue ethics teaching and discussion. These texts differ from auto/biographies and popular texts as they are methodologically rigorous and present detailed descriptions of ordinary, daily laboratory life. We demonstrate these differences using two texts focusing on the invention of polymerase chain reaction (PCR): an ethnography, *Making PCR*, and an autobiography, *Dancing Naked in the Mind Field*. We show

1. This publication was made possible through the support of a grant from Templeton Religion Trust. The opinions expressed in this publication are those of the author and do not necessarily reflect the views of Templeton Religion Trust (grant number TRT088). The authors declare that they have no conflict of interest.

how a secondary data analysis of these texts can be used by students and teachers to unpack aspects of virtue ethics in relation to daily conduct as well as more broadly with relation to misconduct. We conclude by suggesting types of ethnographic studies that could be very beneficial for developing a robust virtue ethics account of scientific practice.

Good Conduct is Just the Absence of Bad Conduct…Right?

In recent years there has been a lot of discussion about what constitutes a "responsible scientist." High-profile examples of scientific misconduct, such as the case of Hwang Woo-suk and issues relating to the reproducibility and reliability of science,[2] have all led to increasing concern about trust in science. Similarly, the anthrax letters of 2001[3] elicited valuable concerns about "bad eggs" within the scientific community who could use their privileged positions to do harm. The response to these concerns has been manifold, and recent decades have seen an explosion of academic research, policy documents, codes of conduct and legislation surrounding this subject.[4] At the heart of this deluge of literature is an attempt to define the responsibilities of individual scientists and the scientific community to each other and to society at large. In effect, it grapples with two key questions: *what does it mean to be a responsible scientist* and *what is responsible science?*

Most approaches to scientific ethics adopt a principle-based approach where ethical conduct is taken as synonymous with "adherence to ethical rules, duties or responsibilities."[5] The use of deontological ethics thus commits practitioners to a universalist and rule-oriented approach. As defined by Alexander and Moore: "deontology is one of those kinds of normative theories regarding which choices are morally required, forbidden, or permitted. In other words, deontology falls within the domain of moral theories that guide and assess our choices of what we ought to do."[6] It is salient to recognize that actions and consequences are assessed by an external rule-based metric removed from individual contexts of action. Kantian deontology, for example, is driven by the categorical imperative: act according to that maxim by which you can also will that it would become a universal law.[7] This affiliation has been strongly influenced by medical ethics and the adoption of the "4 Principles" approach advanced by Beauchamp and Childress in their 1979 book *Principles of Biomedical Ethics.*[8] As a result, there has been a recent flood of ethics guidelines and codes of conduct for scientists developed by institutions, professional bodies (such as the American Chemical Society), and (inter)national organizations (such as the National Academies of Sciences and the International Council of Scientific Unions).

Deontology, it may be suggested, defines good conduct as enactment of morally right actions that stem from people's duties as defined externally of context. It is important to recognize the importance of character in the enactment of good conduct from a deontological perspective, as it is the *motives*

2. See Editorial, "Reducing Our Irreproducibility," *Nature* 496.7446 (2013): 398.
3. E.M. Meslin, "Bioterrorism and Bioethics: Challenges for Industry, Government and Society," *Journal of Commercial Biotechnology* 9.2 (2003): 101–09.
4. Such as National Academies of Science, *On Being a Scientist: A Guide to Responsible Conduct in Research* (Washington, DC: National Academies Press, 2012).
5. David Resnik, "Ethical Virtues in Scientific Research," *Accountability in Research* 19.6 (2012): 329.
6. Larry Alexander and Michael Moore, "Deontological Ethics," in *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta (Winter 2016 Edition), https://plato.stanford.edu/archives/win2016/entries/ethics-deontological.
7. Immanuel Kant, "First Section: Transition from the Common Rational Knowledge of Morals to the Philosophical," in *Groundwork of the Metaphysic of Morals* (London: Hutchinson University Library, 1785 [1959]).
8. Tom Beauchamp and James Childress, *Principles of Biomedical Ethics* (Oxford: Oxford University Press, 1979).

of the person who carries out the action that are the locus of moral import. Indeed, as highlighted by Kant: "Nothing in the world—indeed nothing even beyond the world—can possibly be conceived which could be called good without qualification except a *good will*."[9] While this issue of *good will* is, of course, extensively discussed within Kantian scholarship, within life science ethics issues of character have been largely reduced to statements of intent: scientists should be motivated to further the benefits accrued from scientific research, and avoid the potential harms that could arise from their research. The "good-intent" approach is further fostered by the evolution of the "FFP" (fabrification, falsification and plagiarism) discussions that distinguish misconduct from poor conduct on the basis of intent to cause harm.[10]

Within science curricula the space given to scientific ethics remains highly variable. Indeed, there have been many criticisms regarding the "patchy and unstandardized" nature of formal science ethics instruction.[11] Continual strains on university finances, lack of qualified personnel and already overcrowded curricula make teaching scientists ethics extremely challenging. Notwithstanding these challenges, there are a rising number of courses teaching science ethics. These courses commonly adopt a principle-based approach to introduce students to key areas of responsible conduct of research. These include scientific misconduct (including the "FFP" misdemeanors of fabrication, falsification and plagiarism), working with human or animal subjects, and issues relating to conflicts of interest.[12] They also commonly cover contemporary social issues, such as stem cell research and gene editing, for example.

While the strengths of principlism are widely recognized,[13] there has also been considerable concern that such approaches to ethics training continue to leave students underprepared for the daily challenges they will encounter in research.[14] In particular, concerns have been raised about the de-contextualized nature of ethics training and the lack of direction for implementing high-level ethical principles to identify and address the daily challenges of scientific research. To these well-elaborated concerns, we add our own: that current approaches of life science ethics training tend to focus on defining *misconduct,* rather than offering guidance on *good conduct*. Because many common ethical rules are framed as negatives ("you shall not"), students can mistakenly equate *good conduct* with the absence of *bad/misconduct.* In the following section we will elaborate on this mis-equation in more detail.

Talking About Trust and Character in Science Ethics

Discussions about good conduct in science are hard. Many policies and regulations are written so as to define prohibited negative behavior rather than to outline good behavior. Moreover, codes of conduct that do describe the attributes of a "good" scientist tend to be very generalized and de-contextualized. Indeed, the extreme variability of research contexts and communities makes this gener-

9. Kant, "First Section: Transition from the Common Rational Knowledge of Morals to the Philosophical," 9.
10. In 2000 the Office of Science and Technology Policy defined misconduct as "fabrication, falsification, or plagiarism (FFP) in proposing, performing, or reviewing research, or in reporting research results" (http://www.ostp.gov/html/001207_3.html).
11. National Research Council, *Challenges and Opportunities for Education About Dual-Use Issues* (Washington, DC: National Academies Press, 2011).
12. Adil Shamoo and David Resnik, *Responsible Conduct of Research* (Oxford: Oxford University Press, 2002).
13. Resnik, "Ethical Virtues in Scientific Research."
14. National Research Council, *Challenges and Opportunities for Education About Dual-Use Issues*.

alization understandable. Nonetheless, the vagueness of what good science conduct *is* does not help students and teachers of life science ethics. Many students find the vague appeals to the scientific collective alienating, and they struggle to translate and integrate these ideas into their daily research practices. Little discussion is available about what constitutes mediocre, acceptable, proficient, and excellent conduct.

As a result, the deontological tools available to students and teachers are largely a set of rules and requirements. This has a number of implications, including an ethics that is *outwardly focused* on compliance with rules. Ethical duties are structured so as to minimize the harm (and maximize the benefit) that individual scientists' actions may have for their discipline and for society. Little, if anything, is said about the responsibility for personal development, either as a scientist or more holistically. The implication is that the character of the scientist comes *a priori,* not requiring any future trajectory for development. Indeed, while it may be implicitly assumed that personal benefits come from "being a scientist," such assumptions are nebulous and require substantial further consideration.

Secondly, largely in consequence of the rule-based focus of ethics discourse, scientific ethics continues to focus on misconduct, misdemeanors, and rule-breaking, and their roles in innovation and discovery. Science students are taught what *not* to do, what rules cannot be broken, and what constitutes unacceptable behavior. Point in fact, much of the content of ethics pedagogy makes use of case studies that detail considerable misconduct—and interestingly, many are out of the frame of reference of most science students. For instance, common case studies relating to biosecurity involve examples such as the resurrected Spanish flu viruses.[15] While appropriately demonstrating ethical concerns, they may be so removed from the work being done by the students in question that they struggle to connect the ethical teaching to their own daily practices. As a result, scientific ethics tends to overlook many of the routine and repetitive practices that make up daily research and their opportunities for fostering character development.

The third difficulty with this approach is related to contemporary understandings of scientific research. Shifts in Science and Technology Studies (STS),[16] the History and Philosophy of Science (HPS),[17] and increasing science/society dialogue have contributed to the abandonment of value-free framings[18] of science[19] in favor of more socially-oriented descriptions.[20] Nonetheless, despite increas-

15. Jeffrey Taubenberger, et al, "Initial Genetic Characterization of the 1918 'Spanish' Influenza Virus," *Science* 275.5307 (1997): 1793–96.

16. Barry Barnes, *Interests and the Growth of Knowledge* (London: Routledge, 1977); Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton, NJ: Princeton University Press, 1979).

17. Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1970); Sandra Harding, *The Science Question in Feminism* (Ithaca, NY: Cornell University Press, 1986).

18. Earlier framings of science promoted the notion of an objective, value-free science that was based on "evidence and reasoning, not on moral, political or other values" (David Resnik and Kevin Elliott, "The Ethical Challenges of Socially Responsible Science," *Accountability in Research* 23.1 (2016): 32).

19. Helen E. Longino, *Science as Social Knowledge* (Princeton, NJ: Princeton University Press, 1990); Heather Douglas, "The Irreducible Complexity of Objectivity," *Synthese* 138.3 (2004): 453–73.

20. Contemporary discussions about value-laden science tend to focus predominantly on non-epistemic values—moral, political, social or economic—in scientific judgement and decision-making. In particular, the rise in policy governing scientific research increasingly raises questions about the roles that non-epistemic values can and should play in research design, application and re-use. The influence of non-epistemic values on research has been increasingly well-documented by STS researchers in fields such as stem cell research, synthetic biology and reproductive technologies (Olivia Harvey, "Regulating Stem-cell Research and Human Cloning in an Australian Context: An Exercise in Protecting the Status of the Human Subject," *New Genetics and Society* 24.2 [2005]: 125–35). In

ingly compelling discussions about varieties of expertise and the porous boundaries of science,[21] scientific ethics continues to make use of clearly demarcated distinctions between "science" and "society." As a result, "the scientist" becomes an entity almost separate from the individual human who inhabits the role. Consequently, little is said about how scientists mediate their roles as members of society, or manage the competing responsibilities that necessarily accompany the plethora of roles each individual has.[22] Interestingly, despite the emerging discussions about the role of non-epistemic values in science, there appears to be little attention given to how being uniquely trained as scientists shapes who people are as individuals both inside and outside of the laboratory. If science doesn't stop at the door, and scientists don't cease to be who they are when they exit the lab, how can we understand an ethics of science that takes into account scientists as complex and unique individuals? How can we understand scientists as individuals for whom the practice of science is only one of a number of different practices[23] and who are embedded in complex networks of responsibility?[24]

Virtue Ethics: A Path Out of the Quandary?

What is evidently needed is a way of talking about character and conduct in a more holistic manner, one that takes into account the ability of individuals to move across different boundaries into different settings. What is needed is an ethics that focuses on assessing what kind of people we are and should be. Virtue ethics offers a robust response to the quandary, enabling a means of talking about holistic character development rather than providing rules or de-contextualized instances of practice. Virtue ethics makes use of highly contextually-driven discourse on the acquisition of a plethora of different virtues. These may be understood as character traits, the enactment of which facilitates ethical behavior *in situ.* The acquisition of virtues by an individual occurs through continual striving and the observation of virtuous behavior in others. The acquisition of these virtues is always oriented towards the achievement of a state of "flourishing" in which the ends particular to that individual are realized.

To achieve a state of "flourishing," and thus be an individual who has reached moral maturity, requires the development of proper character. As highlighted by Aristotle: "we learn by doing…states of character arise out of like activities…. It makes no small difference, then, if we form habits of one kind or of another from our very youth; it makes a very great difference, or rather all the difference."[25] Virtue ethics thus differs from deontological approaches in that the emphasis on rules of conduct is de-emphasized in favor of an awareness of "right behavior" within a specific context and in response to specific circumstances. Moreover, it emphasizes the need for holistic character development in the

contrast, while epistemic values have long been recognized as important in scientific research, the role of non-epistemic values in data-generating research activities remains contentious. The Sociology of Scientific Knowledge movement strongly promoted the notion of social constructivism, as is well-described in, for example, David Bloor, "Sociology of Scientific Knowledge," in *Handbook of Epistemology*, edited by Ilkka Niiniluoto, Jan Wolenski, and Matti Sintonen (Dordrecht: Kluwer Academic Publishers, 2004), 919–62. Nonetheless, many contemporary authors continue to promote a "value-neutrality" within epistemic activities to safeguard reproducible and reliable data production. See Harding, *The Science Question in Feminism*; Resnik and Elliott, "The Ethical Challenges of Socially Responsible Science."

21. Harry Collins, *Are We All Scientific Experts Now?* (Cambridge, UK: Polity Press, 2014).
22. Elaine Howard Ecklund, *Science vs Religion: What Scientists Really Think*. Oxford: Oxford University Press, 2010.
23. Louise Bezuidenhout and Nathaniel Warne, "Should We All Be Scientists? Re-Thinking Laboratory Research as a Calling," *Science and Engineering Ethics* 24.4 (2018): 1161–79.
24. Larry May, *The Socially Responsive Self: Social Theory and Professional Ethics* (Chicago: University of Chicago Press, 1996).
25. Aristotle, *Nicomachean Ethics*, 29.

evolution of an ethically responsible individual, in contrast to character development that emphasizes rule-following.

In relation to life science ethics, both a deontology and virtue ethics approach are oriented towards the same outcomes: socially responsible and responsive science. Nonetheless, when unpacked it becomes apparent that these two approaches offer markedly contrasting interpretations of ethically responsible conduct within scientific research as well as how best to foster the development of ethically responsible scientists. While deontological approaches, via intensive courses and codes of conduct, emphasize compliance and uniformity of practice, virtue ethics, by emphasizing contextual behavior and the importance of exemplars, emphasizes the development of individual self-reflection to find the appropriate action *in situ.*

These two positions, while contrasting, do not necessarily have to be contradictory. Indeed, authors such as David Resnik[26] have detailed the value of considering both perspectives. Nonetheless, virtue ethics has made very little inroad into life science ethics discussions for a number of different reasons. First and foremost, the absence of virtue ethics in discussions about the life sciences is not an isolated instance. Indeed, virtue discourse has been largely marginalized from many areas of ethics discourse, demonstrating a twentieth century preference for highly operationalizable and generalizable ethics pronouncements. Despite the resurgence of interest that accompanied seminal texts such as Alasdair MacIntyre's *After Virtue*,[27] Rosalind Hursthouse's *On Virtue Ethics,*[28] and James Laidlaw's *The Subject of Virtue*,[29] virtue ethics remains on the fringe of most discussions of ethics in science. It is likely that this is due, at least in part, to the recognized difficulties of operationalizing a virtue focus in ethics training and the ever-present threat of relativism.[30] Although a growing number of authors are starting to revisit virtue ethics as a means to understand right conduct, both within science practice[31] and beyond, it remains marginalized in ethics education approaches.

The Difficulties of Teaching Responsible Conduct Through Virtue Ethics

One of the key issues keeping virtue ethics on the fringe of mainstream professional ethics is the perception that it is "difficult to teach." Students of any practical virtue ethics training program need to be educated in how to understand virtues, how to identify them in daily activities, and how to apply them to achieve virtuous outcomes. As expected, teaching virtue ethics can be challenging, as instructors need to facilitate a process of character development within the individual student. Unlike deontology or utilitarianism, there are no absolute rules that can be used to determine right behavior for any individual in any context. Instead, to lead a life of virtue involves "a commitment to learning to be virtuous, further developing one's virtue, and maintaining what virtues one has."[32] As Aristotle famously

26. Resnik, "Ethical Virtues in Scientific Research."

27. Alasdair MacIntyre, *After Virtue: a Study in Moral Theory* (Notre Dame, IN: University of Notre Dame Press, 1984).

28. Rosalind Hursthouse, *On Virtue Ethics* (Oxford: Oxford University Press, 1999).

29. James Laidlaw, *The Subject of Virtue: An Anthropology of Ethics and Freedom* (Cambridge: Cambridge University Press, 2013).

30. Ibid.

31. For example: Bruce MacFarlane, *Researching with Integrity: The Ethics of Academic Inquiry* (London: Routledge, 2008); Resnik, "Ethical Virtues in Scientific Research"; Louise Bezuidenhout, "The Relational Responsibilities of Scientists: (Re)Considering Science as a Practice," *Research Ethics* 13.2 (2017): 65–83.

32. Christine Swanton, *Cultivating Virtue* (Oxford: Oxford University Press, 2014), 2.

notes, there is an important similarity between virtue and skill: both are practical, and can be learned only by practice, by actually doing what needs to be done.[33]

The need for self-motivation and repetition in the development of virtues causes two problems for virtue ethics that remain highly debated. The first is the "self-centeredness objection," whereby individuals are motivated to "the pursuit of one's own virtue, since her *own eudaimonia* (flourishing) is what a virtuous agent pursues. The virtuous agent is thus primarily concerned with her own virtue, and thereby with cultivating and maintaining it. But surely, it is thought, she should have as her primary focus such things as caring for friends, repaying debts because that is just, being a good parent."[34]

The second problem relates to the fact that virtue ethics cannot account for many right acts of the self-improving but not yet virtuous agent. These are acts that are intuitively thought to be right (such as breaking the promise that is best in the circumstances to break when one has culpably made conflicting ones), but would not be performed by a virtuous agent (who does not culpably make conflicting promises). In particular, standard virtue-ethical criteria of right action, according to the objection, are incompatible with the possibility that non-virtuous agents can perform right acts that would not be performed by virtuous agents. Such acts may be fitting for agents in the process of cultivating virtue, or who need to somehow rectify previous wrong acts.

In order to sidestep problems relating to teaching, virtue ethics places a strong emphasis on importance of good role models within the learning process. The virtuous agent acts as a role model and the student of virtue emulates his or her example. Initially this is a process of habituating oneself in right action, but this leads to the development of virtue, where true virtue involves choice, understanding, and knowledge. This process of gradual learning is discussed in more detail by Julia Annas:

> …Even simple building skills are not easy or effortless to learn; they involve more than copying a role model and then learning by repetition how to do it routinely. We need experience and practice, and we have to learn from someone who can teach us. But from the start something is conveyed in the teaching which is not grasped by the person who merely tries to do exactly what the teacher does. The learner needs to trust the teacher to be doing the right thing to follow and copy, and to be conveying the right information and ways of doing things. And further, from the start the learner of a skill needs also what I have called the drive to aspire, manifesting itself first in the need the learner has to understand what she is doing if she is to learn properly. The learner needs to *understand* what in the role model to follow, what the point is of doing something this way rather than that, what is crucial to the teacher's way of doing things a particular way and what is not.[35]

Virtue ethics thus relies strongly on the role of exemplars as a means of guiding action. The role of exemplars has recently become a topic of increased discussion in relation to developing a virtue ethics narrative for responsible scientific research. These "exemplary scientists" are commonly described as embodying "the virtues that dispose them towards the ideal practice of science's distinctive methods for achieving its goals."[36] Virtue ethics tends to agree that role modeling is probably best done in personal mentoring relationships where exemplars guide and shape the actions of their students. This is

33. Julia Annas, *Intelligent Virtue* (Oxford: Oxford University Press, 2011), 16.

34. Swanton, *Cultivating Virtue*, 2.

35. Annas, *Intelligent Virtue*, 17.

36. Robert Pennock and Michael O'Rourke, "Developing a Scientific Virtue-Based Approach to Science Ethics Training," *Science and Engineering Ethics* 23.1 (2017): 245.

all well and good, but there can be no guarantee that students will have access to an exemplar in their learning environment.

In light of the challenges identified above, recent authors have suggested that this process of role modeling "can be approximated in the classroom by what may be thought of as a virtual apprenticeship with exemplary scientists."[37] What is meant by this is that classroom instructors use historical texts such as autobiographies and biographies to introduce students to "scientific giants like Charles Darwin and Albert Einstein, but including less well-known figures such as Barbara McClintock and Richard Feynman."[38] This, it is thought, helps students see how the scientific virtues are broadly exemplified.

While such an approach may be an engaging means of piquing students' interests, the extent to which an auto/biographical text can serve as an exemplar must be debated.[39] Four key problematic issues must be recognized:

1. Selecting exemplars and understanding virtues in a manner that is not longitudinal or de-contextual;
2. Not being able to interrogate motivations;
3. Understanding the socio-historical context of the narrative as well as the subject;
4. Separating the author from the subject.

Selecting exemplars for use in education must be recognized as a highly political activity. As exemplars necessarily embody certain virtues, selecting specific individuals over others foregrounds a specific vision of scientific research. Simply selecting highly successful and internationally recognized scientists presents students with a confusing conflation of virtue and success—namely, suggesting that being virtuous somehow leads to success, or vice versa. Presenting successful scientists as a *fait accompli* also prohibits students from engaging with the daily struggles of individual scientists who are not yet virtuous. Narrating a "path to greatness" makes use of a teleological lens through which all actions are weighed. This causes the right acts of the self-improving but not yet virtuous agent to be interpreted as having future significance. Using highly successful scientists as exemplars also downplays other key areas of science, such as mentorship and teaching,[40] and overlooks the plethora of highly virtuous scientists specializing in these areas. Providing students with these "ideal" rather than real cases may not be the best way to get students to identify with the virtues under discussion or enable them to understand how to act upon them in their daily lives.

The second major challenge of using texts as proxies for exemplars is that students are not necessarily able to question the motives and motivations of the subject under study. Without these discussions, it

37. Ibid., 249.

38. Ibid., 250.

39. The difficulties of using historical exemplars in teaching ethics to scientists is also well-elaborated in Kuebler's chapter in this volume. While he recognizes the value of Pennock and O'Rourke's proposal to use virtue ethics to adapt RCR teaching to foster internal motivation for ethical behaviour, he highlights the limitations of using texts instead of role models in situ. He says: "While this can be helpful, the training would be more impactful if a real-life role model is seen as invested in the scientific virtue-based approach training and leads these scientific virtue-based reflections."

40. Bezuidenhout, "The Relational Responsibilities of Scientists."

is possible that students will not be able to navigate the "self-centeredness objection" discussed above. In addition, it is well-recognized that acquiring virtues requires that the expert provide the learner with reasons for their actions.[41] As discussed by Annas:

> The learner in virtue, like the learner in a practical skill, needs to understand what she is doing, to achieve the ability to do it for herself, and to do it in a way that improves as she meets challenges, rather than coming out with predictable repetition. This comes about when the virtue is conveyed by the giving and receiving of reasons, in contrast with the non-rational picking up of a knack.[42]

The inability to interrogate the reasons behind specific actions opens students up to misinterpretation or speculation, both of which can undermine the integrity of any ethics instruction.

The final two concerns relate to the contextualization of written texts. Virtue ethics foregrounds the importance of context in understanding virtuous actions. Indeed, identifying the *appropriate action* for a specific time and space separates it from other ethical theories. This contextuality is foregrounded in MacIntyre's *After Virtue*, which concludes that accounts of virtue require a prior understanding of the social and moral features of the society in which it occurred. The need for such contextualization is important not only when understanding the narrative of a specific individual's life, but also for understanding the *motivations of the author who wrote the text.*

The discussion above draws attention to some of the challenges of using auto/biographical texts as proxies for exemplars in virtue ethics instruction. In particular, it highlights the need for rigorous contextualization when examining narrative accounts of "exemplary science." We now propose how the social sciences can offer a way out of this impasse, by providing a methodologically rigorous approach to contextualization. In particular, the following sections detail how secondary data analysis of ethnographic studies, in tandem with auto/biographical texts, can prove a valuable resource for students of virtue ethics. In using previously published material we are able to revisit that data with new questions.[43] Ultimately, this serves to make clear where opportunities have been lost and how we can, with a virtue ethics lens, resituate the relationship between virtue and science. Previously published data can include documents such as diaries, written life histories,[44] popular texts, and to some extent the published findings of previous studies. For our case study, we will make use of two key texts: the scientist Kary Mullis's autobiography *Dancing Naked in the Mind Field*[45] and Paul Rabinow's ethnographic study *Making PCR.*[46] *Dancing Naked in the Mind Field* provides insight into the motivations, actions, and intentions of the inventor of polymerase chain reaction (PCR). The second text, *Making PCR,* is an inside look at the people, place, situatedness, and temporal arc[47] of the molecular biology laboratory where Mullis performed his Nobel-winning work. Mullis is often presented to students as an exemplar of scientific discovery. However, *Making PCR* and his autobiography might

41. Bezuidenhout and Warne, "Should We All Be Scientists?"; Louise Bezuidenhout, et al, "Docility as a Primary Virtue in Scientific Research," *Minerva* 57.1 (2018): 67–84.

42. Annas, *Intelligent Virtue*, 20.

43. Janet Heaton, "Secondary Analysis of Qualitative Data: An Overview," *Historical Social Research/Historische Sozialforschung* 33 (2008): 33-45.

44. David Silverman, ed., *Qualitative Research* (London: Sage, 2016).

45. Kary Mullis, *Dancing Naked in the Mind Field* (London: Bloomsbury, 2010).

46. Paul Rabinow, *Making PCR: A Story of Biotechnology* (Chicago: University of Chicago Press, 1996).

47. Cheryl Mattingly, *Moral Laboratories: Family Peril and the Struggle for a Good Life* (Berkeley: University of California Press, 2014).

indicate otherwise, especially in light of our argument that sees scientists not simply as scientists, but as complex and unique individuals.

A Role for Ethnographies of Science: Considering Kary Mullis

Kary Mullis is a Nobel prize-winning biochemist who is best known for developing the polymerase chain reaction (PCR), unquestionably one of the most important tools in molecular biology. In contrast to many of his peers, Mullis has actively promoted his reputation as an "*avant-garde*" scientist. He has openly admitted to taking LSD and has railed against the commercialization of science. In recent years, he has come under fire for his views on a wide range of subjects, including AIDS, climate change denialism, and belief in aliens.

Mullis, the News, and Dancing Naked in the Mind Field

Despite these recent controversies, Mullis is widely hailed as a hero for his breakthrough discovery. Until recently, depictions of Mullis in the press were largely the indulgent depictions of an unconventional genius. Most biochemistry students will, at some point, have heard the story of Mullis's "eureka" moment while he was driving to a cabin in California with his girlfriend. This story is narrated in textbooks, as well as by Mullis himself. In a 1990 article he spent considerable time shaping this narrative, saying:

> I stopped the car at a turnout overlooking Anderson Valley. From the glove compartment I pulled a pencil and paper—I needed to check my calculations. Jennifer, my sleepy passenger, objected groggily to the delay and the light, but I exclaimed that I had discovered something fantastic. Nonplussed, she went back to sleep. I confirmed that two to the twentieth power really was over a million and drove on. About a mile farther down the road I realized something else about the products of the reaction. After a few rounds of extending the primers, dissociating the extension products, rehybridizing new primers and extending them, the length of the exponentially accumulating DNA strands would be fixed because their ends would be sharply defined by the five-prime ends of the oligonucleotide primers. I could replicate larger fragments of the original DNA sample by designing primers that hybridized farther apart on it. The fragments would always be discrete entities of a specified length. I stopped the car again and started drawing lines of DNA molecules hybridizing and extending, the products of one cycle becoming the templates for the next in a chain reaction.… Jennifer protested again from the edge of sleep. "You're not going to believe this," I crowed. "It's incredible." She refused to wake up. I proceeded to the cabin without further stops: The deep end of Anderson Valley is where the redwoods start and where the "ne'er-do-wells" have always lived. My discovery made me feel as though I was about to break out of that old valley tradition. It was difficult for me to sleep that night with deoxyribonuclear bombs exploding in my brain.[48]

In his autobiography, *Dancing Naked in the Mind Field,* as well as numerous biographical texts, Mullis goes on to describe how his then-employer Cetus did not sufficiently recognize or reward his breakthrough (Mullis was only paid $10,000 for his discovery). Both Mullis's self-presentation and that of numerous other authors position him as a visionary individual whose contribution to science was under-appreciated by his colleagues and employer.

Despite Cetus's muted enthusiasm, the narrative continues, Mullis continued to work on his PCR invention. Mullis's tendency to disregard authority—both in this and other cases—is recognized, however; the discovery of PCR is often used as a retrospective justification of this character trait. Consider, for example, this recollection from Dr. Corey Levenson, a former colleague: "Most people

48. Kary Mullis, "The Unusual Origin of the Polymerase Chain Reaction," *Scientific American* 262 (1990): 61.

who launch into an unfamiliar area would first speak to recognized authorities and get all the background. Kary saw that as a waste of time. He figured it would take less time to do the experiments himself."[49] Similarly, while Mullis and his then-employer, Cetus, parted acrimoniously, depictions of the split tend to focus on Mullis's boundless energy and genius winning out against attempts to stifle it. This image of the maverick genius is one that Mullis continues to carefully curate.

Descriptions of Mullis that focus on his invention of the PCR technique valorize the inspiration that Mullis received, his ability to piece together seemingly disjointed pieces of information, and his determination to realize his vision regardless of a lack of support from colleagues or employers. These texts could therefore be interpreted as exemplifying virtues such as reasoning and discovery, as Mullis clearly demonstrates his ability to arrive at new insights and move beyond what was accepted by others. He could also be taken to be an exemplar for the virtue of *gnome*, or the knowledge of when to act in exception to the law.

This Mullis-centric version of the PCR story is compelling, and continues to spark the imagination of students. Nonetheless, the limitations of this narrative as a reliable source for virtue ethics discussion are obvious. As the biographical texts rely on interviews, they are actively filtered by both narrators and authors. This story is also de-contextualized from actual events. What is undoubtedly missing from these depictions of the invention of PCR is a robust understanding of the socio-political context in which Mullis was working during his time at Cetus as narrated from a transparent, multi-perspectival view. Also missing is an understanding of how and why Mullis came to play the role of the *avant-garde* genius in the public's imagination. Rabinow's ethnography, then, represents a critical corrective.

Making PCR

If we can't judge scientists solely on their academic output, we need to ask who is telling their stories and why. How do these depictions of "exemplary scientists" fit into broader socio-technical imaginaries of both scientific presents and futures? *Making PCR* is key for this discussion in that it offers a different depiction of Mullis's invention, his scientific work, and his character, a depiction that includes his colleagues and managers at Cetus and the era in which these events took place. It also demonstrates that "scientific discovery is not only vulnerable to cliquishness and petty rivalries but is also, in fact, sometimes dependent on them."[50]

So, what was behind the invention of PCR and how does Mullis's self-representation of these events differ from that of others involved in this ethnographic account? In exploring the invention of PCR, the people involved, and the organizational milieu in which science was conducted, Rabinow speaks pointedly to the social nature of scientific practice. He problematizes the notion of "who has the authority—and responsibility—to represent experience and knowledge"[51] within this social setting. As he demonstrates through in-depth interviews of colleagues and managers, the authority, responsibility, and representation of the knowledge that became PCR was still, at the time of writing, highly contested. Many of the laboratory technicians and scientists (including in particular Henry Erlich, a

49. Nicholas Wade, "Scientist at Work/Kary Mullis: After 'the Eureka,' a Nobelist Drops Out," *New York Times*, September 15, 1998, https://www.nytimes.com/1998/09/15/science/scientist-at-work-kary-mullis-after-the-eureka-a-nobelist-drops-out.html.

50. Eugenia Tsao, "Walking the Walk: On the Epistemological Merits of Literary Ethnography," *Anthropology and Humanism* 36.2 (2011): 186.

51. Rabinow, *Making PCR*, 17.

senior scientist at Cetus), contend that "PCR is, in fact, one of the classic examples of teamwork. Many people contributed: the people in my lab, various engineers, Gelfand's group, Sninsky, White. If Kary had acknowledged these people, it would be easier to take."[52]

Erlich here refers to the Nobel Prize Mullis received independently of anyone else involved in PCR's development. It seems that "committees and science journalists like the idea of associating a unique idea with a unique person, the lone genius."[53] In the case of PCR this established a contested reality as Mullis and those that crossed paths with him over the years of PCR's development foregrounded different narrative moments. Industry labs like that at Cetus were organized specifically to mimic a university setting and reduce any cultural differences between the two spaces. However, unlike academia, Cetus fostered an environment of non-hierarchical interdisciplinarity as "an abstract good"[54] that supported creativity, sharing of ideas, and the fostering of collegiality.

By offering a detailed account of the socio-cultural environment of Cetus, as well as the actions surrounding the development of the PCR technique, Rabinow offers a contrasting narrative to that presented by Mullis and the popular press. Critically reading *Making PCR* enables students to view Mullis's actions within their specific socio-cultural context and prevents judging his actions either teleologically or in isolation. Rabinow's account is perhaps more a narrative of vices than virtues, but nonetheless presents students with a compelling way of understanding good/bad/misconduct within the complicated spaces of laboratories.

Learning to Read Ethnographies for Virtue Ethics

The PCR case study highlights the important role that ethnographies can play in virtue ethics discourse and pedagogy. Nonetheless, many students and educators—both of science and virtue ethics—are unfamiliar with this methodology. In the next section we offer a brief description of ethnography as a methodology, highlighting the specific areas in which ethnographies are useful for the study of exemplars and virtue ethics.

How Does an Ethnography Differ from Other Narrative Accounts of Science?

Ethnographies are studies of social interactions, behaviors, and perceptions that occur within groups, teams, organizations, and communities.[55] An ethnography typically involves the researcher spending long periods of time embedded within a specific culture, documenting and frequently participating in social arrangements and actions. The central aim of an ethnographic study is to provide rich, holistic insights into people's views and actions, as well as the nature (that is the sights, sounds, and so on) of the location they inhabit, through the collection of detailed observations and interviews.[56] In this way, ethnography contrasts with other empirical methodologies as it generates highly detailed qualitative accounts of a specific context, rather than relying on de-contextualized interviews or recollections of past events.

While ethnographies often focus on a specific topic, they do not set out to test a hypothesis. Rather,

52. Ibid., 161.

53. Ibid.

54. Ibid., 36.

55. Scott Reeves, Ayelet Kuper, and Brian David Hodges, "Qualitative Research Methodologies: Ethnography," *BMJ* 337 (2008): 1020a.

56. Ibid.

the researchers gather "unstructured data" from their observations and a theory emerges from the analytical categories generated during the data analysis. The typical ethnography is holistic, and therefore includes notes on history, environment and socio-cultural climate. In all cases, it should be reflexive, make a substantial contribution toward the understanding of the social life of humans, have an aesthetic impact on the reader, and express a credible reality.

The ethnographic method is different from other ways of conducting social science approach for a number of reasons:

- It is field-based and observations take place *in situ*;
- The researcher is involved in the daily community life and is thus both an observer and a participant of a society or community;
- It uses a range of data collection tools, including observation, interviews, and imaging. Data are used to generate descriptive detail from which hypotheses will emerge (inductive);
- It requires a long-term commitment;
- It is holistic and aims to yield the fullest possible portrait of the group under study.

Ethnographies thus offer an important contrast to narratives that focus on either "eureka moments" or long-term achievements. Many ethnographies provide detailed descriptions of laboratory practice and enable the reader to understand how laboratories function on a daily basis.[57] This provides readers with a realistic understanding of the complex social landscape of laboratories and the important role that social negotiation and mediation play in successful science.[58] This, in turn, offers a differing perspective on exemplars, as the person who is the most collegial, caring, and critical for the well-being of the laboratory may be the technician or postdoctoral fellow rather than the principal investigator.

Understanding Positionality

When conducting ethnographic studies, researchers will typically embed and immerse themselves within specific cultures. In doing so, they can easily fall into a number of methodological traps that will bias their research. For instance, they can "go native," meaning that they become too personally involved in the culture and thus lose perspective. Alternatively, they can enter the field with a specific agenda in mind, and therefore bias their study by trying to apply a specific lens to their observations. Because of the difficulties of mediating this position, known as the "insider/outsider problem," ethnographers spend considerable time and effort in clarifying their "position" within their texts. Good ethnographies provide readers with detailed descriptions of how the researcher gathered and analyzed the data, and how this experience contributed to the final narrative. The conscious positionality of ethnographic authors is of considerable benefit to students of virtue ethics. Interpreting virtuous action is difficult enough when one observes it first-hand. Having to interpret it via the account of another is extremely challenging, particularly when one is not clear on the motivations of the narra-

57. Latour and Woolgar, *Laboratory Life*; Michael Lynch, *Art and Artefact in Laboratory Science: A Study of Shop Work and Shop Talk in a Laboratory* (London: Routledge, 1984); Sharon Traweek, *Beamtimes and Lifetimes: The World of High Energy Physics* (Cambridge, MA: Harvard University Press, 1988); Karin Knorr Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press, 1999).

58. Bezuidenhout, et al., "Docility as a Primary Virtue in Scientific Research."

tor. The transparency offered by ethnographic positionality is an important means of avoiding misinterpretation.

Secondary Analysis of Texts and Datasets

Conducting an ethnography involves using a range of data collection tools, including participant observation, interviews, and imaging. As ethnographies involve inductive reasoning, it can be expected that the ethnographer will generate far more data than will be presented in any written text. These data are curated and stored for future analysis. They therefore represent a valuable resource for secondary analysis, and may be used, for example, to generate detailed case studies about daily laboratory life for use in virtue ethics instruction.

Similarly, the corpus of ethnographies of science can be reanalyzed for use in virtue ethics discussions. Classic texts such as Traweek's *Beamtimes and Lifetimes*,[59] while not explicitly focusing on virtue or ethics, provide detailed descriptions of character, social interactions, and power dynamics among scientists in research settings. They therefore offer an important resource for students wishing to understand virtuous action within complex socio-political hierarchies. Indeed, in reviewing many ethnographies of science, we find repeated previously unnoticed opportunities to discuss and analyze ethnographic data in terms of virtue theory. This omission, stemming from the questions being explicitly asked by the authors, does not mean that their data and narratives cannot be reanalyzed for future virtue discussions.

The Future of Ethnographies in Virtue Ethics

The previous sections offered an account of how ethnographies represent a useful tool for virtue ethics instruction by offering a way of accessing exemplary behavior from transparent and contextually-detailed texts. In this way, they represent an important opportunity for instruction in the responsible conduct of research than does not either rely on rule-based systems or teleological/self-reported examples of virtuous/excellent conduct. Nonetheless, there are relatively few ethnographies of science, and even fewer that consider ethical issues. There are none at the moment that offer a virtue ethics narrative for daily laboratory life. In this section we briefly touch on some of the areas that will need to be addressed in order to foster a future for ethnographies in science virtue ethics discourse.

The detailed, contextual descriptions of laboratory life represent an exciting way to expand virtue ethics discussions about the life sciences. Indeed, current discussions often struggle with a lack of contextuality and are reduced to constructing hypothetical lists of "important virtues for science" that are not unlike the codes of conduct generated in deontological responsible conduct of research discussions. Generating a robust corpus of scientific ethnographies will allow consideration of a number of current challenges for developing a virtue ethics narrative for responsible research conduct. These would include:

1. Focusing discussions on daily practice as the locus of good/poor/misconduct and highlighting the small social exchanges that cumulatively contribute to positive or negative outcomes;
2. Breaking the spurious connection between virtue and academic success; offering critical insight into exemplar discussions, not just judged on outcomes, but humanized;

59. Traweek, *Beamtimes and Lifetimes*.

3. Critically deconstructing spurious boundaries between laboratory/science and the outside world and highlighting the importance of character consistency;
4. Emphasizing the complicated temporal arc of the socio-cultural-political environment in which any scientist has to operate;
5. Debunking the idea of the laboratory somehow being a hallowed, sterile and privileged space, and representing it as just as messy as the outside world, perhaps even more so;
6. Understanding the influence of the power dynamics situated within the hierarchical network of science.

Detailed accounts of daily laboratory life break down the "icons of science" that are regularly offered up to the public to justify trust in science. Ethnographies not only "humanize" these icons and show their fallibility, but also foreground the fact that most of the science that the public comes across is not like that presented as iconic, but is palpably fallible. Increasing exposure (of both students and the public) to ethnographies will enhance the awareness, acceptance, and gainful valuation of scientific failures *as well as* successes.

What Kinds of Ethnographies are Needed for Scientific Virtue Ethics?

In light of the shift toward postmodern interpretive ethnography, we recognize a number of ethnographies outside of the Science and Technology Studies literature that explore the moral discourse of the contemporary world—for example, Daniel Chambliss' *Beyond Caring*[60] and Cheryl Mattingly's *Moral Laboratories.*[61] While other ethnographies are situated in virtue ethics,[62] Mattingly and Chambliss are distinctly focused on the moral worlds of individuals who are working towards being a particular type of person in their community. For Chambliss this involves an understanding of the "moral geography of hospital nursing"[63] and in Mattingly's work this amounts to "cultivating virtues to be, for example, a 'good enough' parent."[64] Such works are important as they offer insight into what could constitute a virtue ethics ethnography of science.

Chambliss is distinctly concerned with the moral world of nursing within an organizational setting—the hospital. In this space, he outlines the context of what "normal" looks like for nurses in their daily practice and how this changes their perspective of what moral issues are at stake, as compared to a layperson. Ultimately, as paid employees of the hospital nurses are expected to have a level of submission to higher authorities and organizational policies. This creates political conflict between their moral imperative as good nurses to provide care and the organization's authority over broader ethical decisions. This entanglement of politics and ethics within an organizational setting is very relevant to laboratory science, and detailed studies of how the physical, social, and organizational structures of laboratories affect scientists' autonomy and agency are needed. In particular, such studies are vital to constructing robust understandings of how to evaluate "virtuous behavior" within contexts—assuming that the environment plays an active role in shaping possible behavioral outcomes.

60. Daniel Chambliss, *Beyond Caring* (Chicago: University of Chicago Press, 1996).
61. Mattingly, *Moral Laboratories*.
62. For example, see Arthur Kleinman, *What Really Matters: Living a Moral Life Amidst Uncertainty and Danger* (Oxford: Oxford University Press, 2006) and Paul Brodwin, *Everyday Ethics* (Berkeley: University of California Press, 2012).
63. Chambliss, *Beyond Caring*, 10.
64. Mattingly, *Moral Laboratories*, 5.

Mattingly, meanwhile, offers a detailed description of African American families in Los Angeles and the care required to raise good children and be good parents. She argues that moral thriving "depends on the cultivation of wisdom that will allow an agent to discern what is worthy to pursue in her life amid various circumstances"[65] and, importantly, within a community. Studies such as these, which focus on the communal development of norms and meaning, are of considerable importance to science virtue ethics. These notions of worth are, in other words, intersubjectively held within members of a community. Moral assumptions are not exclusive to the individual. Scientists, like nurses or parents, do not work alone or in a vacuum; they work with others within their unique setting.

Mattingly points the way for understanding how character is cultivated in everyday life. For instance, what sometimes appears mundane or invisible "must be placed within a larger temporal arc,"[66] or, as we discussed in a previous section, the broader socio-political contexts that underpin the situation. It is through the negotiations of everyday performances that moral deliberations and transformations take place. The seemingly mundane day-to-day activity of laboratory work can precipitate moral tragedy, not because extreme situations are happening in unusual circumstances, but rather because of ordinary, seemingly innocuous moral dilemmas that occur in the larger temporal arc of, for example research funding, the activities leading to the production of knowledge, and the social life of the lab. Studies that interrogate the entangled nature of politics and ethics within an organizational setting are of critical importance for the future of scientific virtue ethics discourse. Indeed, virtue ethics needs ethnographies that provide a credible account of a cultural, social, individual, or communal sense of the "real."[67]

Conclusion

This chapter has explored the use of ethnographies in discussions on responsible conduct of research. Ethnographies are largely overlooked by educators and ethicists alike, yet represent a wealth of detailed contextual material about daily laboratory life that can be put to work in virtue ethics discussions. While we recognize that ethnographic texts can be intimidating to those unfamiliar with the methodology, we hope that our brief discussion on how to read ethnographic texts will interest others in examining these texts further. We feel that virtue ethics discussions will be considerably strengthened by the incorporation of these valuable texts. Their use in teaching as exemplar studies will also enable virtue ethics to avoid the pitfalls of current science ethics pedagogy, namely de-contextualization and a teleological focus on final outputs and successes over daily practice.

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65. Ibid., 9.

66. Mattingly, *Moral Laboratories*, 117.

67. Laurel Richardson, "Evaluating Ethnography," *Qualitative Inquiry* 6.2 (2000): 253–55.

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CHAPTER 9.

MAINTAINING VIRTUE IN MODERN SCIENTIFIC PRACTICE: PROVIDING A FOUNDATION TO MOVE FORWARD

DANIEL KUEBLER

The current communal scientific enterprise is often associated with a specific set of scientific virtues including, among others, honesty, objectivity, skepticism, curiosity, meticulousness, fortitude, and collegiality. These virtues are seen as essential for the maintenance and continual development of the practice of modern science.[1] However, the historical and social context in which a scientist is embedded can alter the perceived value of these virtues and make it more or less difficult to put these virtues into practice.[2] At present, the modern landscape of scientific research with its hypercompetitive environment for government funds and academic positions,[3] as well as the growing ties between industry and academia, has made the maintenance of these virtues more challenging.

The increasing number of academic fraud cases[4] as well as the documented difficulties of reproducing published results[5] are just two troubling issues that have emerged from this environment. The scientific community has attempted to address these issues in a variety of ways,[6] but the remedies tend to focus on legalistic and policing solutions rather than examining how best to cultivate virtuous habits.[7] While training that stresses normative rules and accountability can influence behavior, it has its limits. The difficulty of policing the rapidly expanding body of scientific research means that the risks asso-

1. Robert T. Pennock and Michael O'Rourke, "Developing a Scientific Virtue-Based Approach to Science Ethics Training," *Science and Engineering Ethics* 23.1 (2017): 243–62; Robert T. Pennock, "Scientific Integrity and Science Museums," *Museums and Social Issues* 1.1 (2006): 7–18.
2. Lorraine Daston and Peter Galison, *Objectivity* (Cambridge, MA: MIT Press, 2007).
3. Bruce Alberts, Mark W. Kirschner, Shirley Tilghman, and Harold Varmus, "Rescuing US Biomedical Research From Its Systemic Flaws," *Proceedings of the National Academy of Sciences USA* 111.16 (2014): 5773–77.
4. Ferric C. Fang, R. Grant Steen, and Arturo Casadevall, "Misconduct Accounts for the Majority of Retracted Scientific Publications," *Proceedings of the National Academy of Sciences USA* 109.42 (2012): 17028–33; Daniele Fanelli, "How Many Scientists Fabricate and Falsify Research? A Systematic Review and Meta-Analysis of Survey Data," *PLoS One* 4.5 (2009): e5738.
5. Monya Baker, "Is There a Reproducibility Crisis?," *Nature Reviews Immunology* 533 (2016): 452–54; C. Glenn Begley and Lee M. Ellis, "Raise Standards for Preclinical Cancer Research," *Nature* 483 (2012): 531–33.
6. David B. Resnik, Elizabeth Wager, and Grace E. Kissling, "Retraction Policies of Top Scientific Journals Ranked by Impact Factor," *Journal of the Medical Library Associ*ation 103.3 (2015): 136–39.
7. Pennock and O'Rourke, "Developing a Scientific Virtue-Based Approach to Science Ethics Training," 243–62; Nicholas H. Steneck, *ORI Introduction to the Responsible Conduct of Research*, revised edition (Washington, DC: U.S. Government Printing Office, 2007).

ciated with unethical behavior are relatively low relative to the perceived benefits individual scientists can acquire in terms of money and career advancement. In such an environment, explaining how to be ethical in research and describing the consequences of getting caught does not necessarily help develop the requisite internal rationale for why one should behave in a virtuous manner. Without an appreciation of the intrinsic value of virtuous behavior,[8] the temptation to cut corners can prove too alluring in the current environment. It seems that new systems are needed to address these challenges. In particular, there is a need to develop curriculum that focuses on the intrinsic value of living a virtuous life and implement it long before individuals embark upon a scientific career.[9] In addition, there is a need to explore different financial models that can alleviate the considerable pressure on practicing scientists to act unethically.

While the practice of science in the late twentieth and early twenty-first century has created unique challenges, it is important to recognize that practice of science has always been influenced, for better or worse, by cultural and social pressures and norms. While some believe that prior to the twentieth century, scientists tended to be dispassionate intellectuals, only concerned with the pursuit of knowledge and unencumbered by ego and reputation, the history of science proves otherwise. Galileo's classic treatise *The Assayer* is a case in point. While today it is widely regarded as a pivotal work outlining the modern understanding of science and the scientific method, it was largely written to belittle the views of the Jesuit astronomer Ozario Grassi. Grassi, unlike Galileo, correctly believed that comets were distant astronomical objects moving out beyond the moon. Rather than producing a dispassionate treatise on astronomy, Galileo used the text to lash out at Grassi and his views. As Robert Westfall put it, *The Assayer* is "one of the all-time masterpieces of sarcastic invective,"[10] while Dom Paschal Scotti has described the book's author as "a querulous old man more interested in scoring debating points than enjoying truth for its own sake."[11] Despite the brilliance of its contents, the book is clearly not an example of the contemporary scientific virtues of objectivity, skepticism, curiosity, or collegiality.

As long as science remains a human enterprise, the pride and envy on display in *The Assayer* will continue to plague the practice. However, in addition to these age-old human vices, practitioners of science in the twenty-first century must operate under unprecedented levels of financial pressure. Whether it is attracting government research dollars amidst growing competition, publishing papers to secure and hold an academic position, holding onto intellectual property, or maintaining industry collaborations, financial concerns have come to dominate the scientific landscape.

This is not to deny that monetary concerns have always impacted the practice of science. For example, in Galileo's time, astronomy was essential for the refinement of calendars and the development of navigational tools. This made the study of astronomy extremely valuable to both church and state leaders, the leading patrons of science at the time. In addition, scientists were subject to the dictates of their financial patrons. As Galileo lamented while employed by the Venetian republic, "It is impossible to obtain wages from a republic, however splendid and generous it may be, without having duties

8. Edmund D. Pellegrino, "Toward a Virtue-Based Normative Ethics," *Kennedy Institue of Ethics Journal* 5.3 (1995): 253–77.
9. Pennock and O'Rourke, "Developing a Scientific Virtue-Based Approach to Science Ethics Training," 243–62; Nur Yeliz Gülcan, "Discussing the Importance of Teaching Ethics in Education," *Procedia– Social and Behavioral Sciences* 174 (2015): 2622–25.
10. Richard S. Westfall, *Essays on the Trial of Galileo* (Notre Dame, IN: University of Notre Dame Press, 1989).
11. Dom Paschal Scotti, *Galileo Revisited: The Galileo Affair in Context* (San Francisco: Ignatius Press, 2017).

attached."[12] Replace the word "republic" with "university," and Galileo's line would not seem out of place if spoken by a faculty member at a modern R1.

Despite this, the fact that until the twentieth century a significant percentage of scientists were either financially independent, well-supported by patrons, or clergymen meant that financial issues had a fundamentally different impact on the scientific research of the time. While researchers had to be responsive to their patrons or the church, many often had the freedom to research on topics of their choosing without any financial concerns. Darwin, for instance, never had to worry about his next paycheck, affording himself ample time to spend researching and writing about the life of worms.[13]

Such a situation stands in stark contrast to the financial pressures facing today's academic scientists. First, there are far more scientists being trained than there are academic positions available. Given that a single faculty member may train twenty or more Ph.D students during his or her career, unless there is an exponential increase in faculty positions, this scenario will continue to produce a glut of well-qualified Ph.Ds on the market. In fact, studies have found that only 20% of recent biomedical Ph.D graduates have ended up in academic positions, and the average age at which they find their first tenure-track job is 37.[14]

Even if one does land a faculty position, the financial pressures do not necessarily ease. The prospects of acquiring and maintaining grant funding are equally daunting. While the NIH grant funding rate was near 30% through the early 2000s, the funding rate has been stuck at or below 20% since 2009. While the absolute number of NIH grants has seen a modest increase, the funding rate has hovered around 19% for the last four years.[15]

A PNAS article authored by four eminent scientists, three of whom are members of the National Academy of Sciences, summed up the adverse effects this hypercompetitive environment is having on science:

> As competition for jobs and promotions increases, the inflated value given to publishing in a small number of so-called 'high impact' journals has put pressure on authors to rush into print, cut corners, exaggerate their findings, and overstate the significance of their work. Such publication practices, abetted by the hypercompetitive grant system and job market, are changing the atmosphere in many laboratories in disturbing ways. The recent worrisome reports of substantial numbers of research publications whose results cannot be replicated are likely symptoms of today's highly pressured environment for research.[16]

In addition to what has been called the "replication crisis" in science,[17] although there is considerable debate over whether this is an actual crisis or if it is merely a normal by-product of doing large amounts of science in a complex world,[18] there has been an increase in scientific papers being

12. Galileo Galilei, *Discoveries and Opinions of Galileo*, translated by Stillman Drake (New York: Anchor Books, 1957).
13. Charles Darwin, *The Formation of Vegetable Mould, Through the Action of Worms, with Observations on Their Habits* (New York: D. Appleton and Company, 1915).
14. *Biomedical Research Workforce Working Group Report* (Bethesda, MD: National Insititutes of Health, 2012).
15. Mike Lauer, "FY 2017 by the Numbers," March 7, 2018, https://nexus.od.nih.gov/all/2018/03/07/fy-2017-by-the-numbers/.
16. Alberts, Kirschner, Tilghman, and Varmus, "Rescuing US Biomedical Research From Its Systemic Flaws," 5773–77.
17. Baker, "Is There a Reproducibility Crisis?," 452–54.
18. Daniele Fanelli, "Is Science Really Facing a Reproducibility Crisis, and Do We Need It To?," *Proceedings of the National Academy of Sciences USA* 115.11 (2018): 2628–31.

retracted for fraud, suspected fraud, plagiarism, and duplicate publication over the past twenty years.[19] Some of this increase is attributable to the increase in the number of publications coupled with the additional scrutiny that institutions and journals have implemented recently. However, even when controlling for these factors, a recent study on retractions concluded that the rise is at least in part due to changes in the behavior of individual authors.[20]

Another study on scientific retractions found that the majority were the result of scientific misconduct, with fraud (43%) leading the way, followed by duplicate publication (14%) and then plagiarism (10%).[21] The authors of this study found that only 21% of retractions were due to error. A study investigating retractions in cancer research came to a similar conclusion, finding both a marked increase in the percentage of cancer research papers retracted over the past twenty years and a high percentage, over 60%, retracted for research misconduct.[22]

What is even more troubling is that, if survey results are to believed, most cases of data manipulation and fraud likely go undetected. In a 2012 study of scientists who had published in or peer reviewed for the journal *BMJ*, 13% indicated they had knowledge of their colleagues "inappropriately adjusting, excluding, altering, or fabricating data" in order to publish.[23] A similar meta-analysis published in *PLOS One* found an even higher percentage of scientists, roughly 20%, who had witnessed questionable research practices. In addition, 2% of respondents admitted to fabricating data themselves and 10% admitted to other questionable practices such as plagiarism.[24]

The willingness of scientists to deliberately fabricate data is deeply troubling.[25] In one study of University of California-San Francisco post-doctoral fellows, 17% indicated a willingness "to select or omit data to improve their results."[26] Another study found that 81% of biomedical research trainees at the University of California-San Diego indicated a willingness to do the same in order to gain grant funding or publish a paper."[27]

Given the discrepancies between the number of papers retracted for fraud and the percentage of scientists who admit to having manipulated data, it appears that the vast majority of fraud and data manipulation cases go undetected. If the survey data are accurate, a not insignificant portion of scientists believe that the risks associated with unethical behavior—the likelihood of getting caught—are

19. Fang, Steen, and Casadevall, "Misconduct Accounts for the Majority of Retracted Scientific Publications," 17028–33; Aniket Tavare, "Scientific Misconduct Is Worryingly Prevalent in The UK, Shows BMJ Survey," *BMJ* 344 (2012): e377; R. Grant Steen, Arturo Casadevall, and Ferric C. Feng, "Why Has the Number of Scientific Retractions Increased?," *PLoS One* 8.7 (2013): e68397.
20. Steen, Casadevall, and Feng, "Why Has the Number of Scientific Retractions Increased?"
21. Fang, Steen, and Casadevall, "Misconduct Accounts for the Majority of Retracted Scientific Publications," 17028–33
22. Anthony Bozzo, Kamil Bali, Nathan Evaniew, and Michelle Ghert, "Retractions in Cancer Research: A Systematic Survey," *Research Integrity and Peer Review* 2 (2017): 5.
23. Tavare, "Scientific Misconduct Is Worryingly Prevalent in The UK, Shows BMJ Survey."
24. Fanelli, "How Many Scientists Fabricate and Falsify Research? A Systematic Review and Meta-Analysis of Survey Data."
25. Daniele Fanelli, "How Many Scientists Fabricate and Falsify Research? A Systematic Review and Meta-Analysis of Survey Data," *PLoS One* 4.5 (2009): e5738.
26. Susan Eastwood, Pamela Derish, Evangeline Leash, and Stephen Ordway, "Ethical Issues in Biomedical Research: Perceptions and Practices of Postdoctoral Research Fellows Responding to a Survey," *Science and Engineering Ethics* 2.1 (1996): 89–114.
27. Michael W. Kalichman and Paul J. Friedman, "A Pilot Study of Biomedical Trainees' Perceptions Concerning Research Ethics," *Academic Medicine* 67 (1992): 769–75.

sufficiently low relative to the perceived benefits they can acquire in terms of career advancement and financial gain.

Another factor impacting this willingness to selectively modify data is the amount of industry money influencing scientific research. With diminishing government funds to support research, many investigators are turning to industry collaborations.[28] While there is nothing intrinsically wrong with this type of arrangement, incentives to rush a publication or withhold publication for financial gain are hard to resist. One study of eight hundred biotech faculty found that 47% had performed industry consulting work, 25% had received industry grants and, even more concerning, 8% had an ownership stake in a company associated with their research.[29] Another study found that among the department chairs at medical schools and teaching hospitals, 60% had relationships with industry, with 27% serving as a consultant, another 27% being members scientific advisory boards, 14% being paid speakers, 11% being board members, 9% being founders, and 7% being company officers.[30]

While conflict of interest disclosures are now standard when giving scientific presentations or publishing papers, this level of influence raises significant concerns about data integrity, due to both conscious and subconscious bias. In *The Scientific Life: A Moral History of a Late Modern Vocation,* Steven Shapin summed up the biggest issues associated with these collaborations:

> From the 1970s, concerns were…expressed that the intrusion into the university of commercial considerations and commercial ties would lead to a wall of secrecy where once there had been an unchallenged commitment to openness. Others feared for the objectivity of science. Scientists would, it was thought, produce not Truth but the results wanted by their sponsoring commercial concerns. Commercial sponsorship or subvention might be the condition for certain research programs being carried out at all, and so academics with conflicts of interest had the motive to produce biased knowledge.[31]

This does not implicate all industry/academic collaborations, given that there are potential benefits, for example the synergistic use of resources and expertise. However, the money involved certainly raises concerns regarding objectivity.

From the lack of academic positions to the reduction of available grant funding to the influence of industry money, the current academic scientific landscape tends to work against the ethical practice of science. While effectively reversing this trend will require a multi-pronged approach, any attempt to reinvigorate a communal sense of the scientific virtues amongst the academic community would be helpful in addressing the problem. The implementation of modified responsible conduct of research (RCR) training represents one option to do this. In many cases, RCR training simply focuses on sets of rules and regulations that are necessary for the effective practice science.[32] However, this type of training is unlikely to work in the current environment, as it does little to foster an inherent motivation for ethical behavior. It may provide an external rationale, the fear of punishment by regulatory or

28. Committee on Conflict of Interest in Medical Research Education and Practice, "Conflicts of Interest in Biomedical Research," in *Conflict of Interest in Medical Research, Education, and Practice*, edited by Bernard Lo and Marilyn J. Field (Washington, DC: National Academies Press, 2009).

29. Sheldon Krimsky, *Science in the Private Interest: Has the Lure of Profits Corrupted Biomedical Research?* (Lanham, MD: Rowman & Littlefield, 2003); Adam Liska, "The Myth and the Meaning of Science as a Vocation," *Ultimate Reality and Meaning* 28.2 (2005): 149–64.

30. Eric G. Campbell, et al, "Institutional Academic-Industry Relationships," *JAMA* 298.15 (2007): 1779–86.

31. Steven Shapin, *The Scientific Life: A Moral History of a Late Modern Vocation* (Chicago: University of Chicago Press, 2009).

32. Steneck, *ORI Introduction to the Responsible Conduct of Research*.

university ethics committees, but when the likelihood of being caught is low, particularly for cases of subtle data manipulation, the external imposition of rules and regulations provides little motivation or incentive. In fact, the ability of reviewers or funding agencies to effectively police all cases of data manipulation or fraud, short of repeating every experiment that is submitted, is virtually impossible. As a result, rules-based training and a reliance on enforcement hold little promise for curbing the current problems.

With such a lopsided risk/reward calculus, any RCR program that can aid in developing an internal motivation for ethical behavior is key. A promising option on this front is the virtue-based RCR described by Robert Pennock and Michael O'Rourke.[33] In virtue-based programs, an emphasis is placed on the benefits that accrue to individuals and the scientific community if one lives out the scientific virtues, the character traits that allow the practice of science to flourish. As I mentioned in the introduction, while there is no universally agreed-upon list of scientific virtues, they typically include such things as honesty, objectivity, skepticism, curiosity, meticulousness, and fortitude.

If scientists take the time during RCR training to reflect on how certain behaviors, for example, transparency, objectivity, and honesty, are critical for the goals of their chosen discipline, they are much more likely to generate an internal motivation to act ethically. They do so not out of fear of consequences or repercussions, but out of a desire to advance their disciplines and to be exemplary practitioners of their disciplines. Such internal motivations, though, are much more likely to develop if this training comes from a mentor or expert within the field who is recognized as an exemplary practitioner of science. Such role models are sorely needed and can have a huge impact. As Prof. Dr. Hanno Würbel, Director of the University of Bern's Division of Animal Welfare, points out:

> Role models, not guidelines, nourish and sustain the lack of transparency that has created a crisis of confidence in research. As a young scientist, you do not plan to fish for data that confirms a premise and then publish irreproducible study results upon which others build new experiments. You go into a laboratory and watch what more senior people do; listen to the language; observe practices, learn about the importance to your colleagues and the institution—and career—of multiple high-profile publications. Young scientists do not set out to harm science; they just learn the unwritten rules.[34]

This is similar to Pennock and O'Rourke's proposed exemplar approach "centered on exemplary persons who embody the relevant virtues." However, they advocate using famous scientists (Darwin, McClintock, Feynman, Einstein) who displayed key virtues as exemplars. While this can be helpful, even Pennock and O'Rourke acknowledge the training would be more impactful if a real-life role model is seen as invested in the scientific virtue-based approach training and leads these scientific virtue-based reflections.[35] While scientific exemplars can be influential, when real-world dilemmas inevitably arise, famous exemplars can too often be discounted as quaint practitioners out of touch with the unique challenges facing modern scientists. Incorporating real embodied exemplars who work in the same university, building, or lab, can have a more profound impact on the career of a trainee and the decisions he or she might make. It also affords the possibility of repeated interactions and mentoring opportunities when young scientists are faced with critical decisions.

33. Pennock and O'Rourke, "Developing a Scientific Virtue-Based Approach to Science Ethics Training," 243–62.

34. Helen Kelly, "Rigor and Transparency in Biomedical Research: How the NIH Is Taking No Prisoners," *Laboratory Equipment*, May 20, 2017, https://www.laboratoryequipment.com/article/2017/05/rigor-transparency-biomedical-research

35. Stephanie J. Bird, "Mentors, Advisors and Supervisors: Their Role in Teaching Responsible Research Conduct," *Science and Engineering Ethics* 7.4 (2001): 455–68.

While the scientific virtue-based RCR training has benefits over rule-based methods, it does have its limitations and is not the only tool needed to help reinvigorate the practice of the scientific virtues. Even Pennock and O'Rourke, who advocate this type of approach, recognize its limits: "We do not claim that presenting a set of scientific virtues will be sufficient in and of itself to produce ethical behavior in science… [O]ne cannot side-step the practical and political complexities that researchers must confront in messy real-world circumstances as well as external pressures that can threaten even core scientific values."[36]

It is worth emphasizing two specific pressures/real-world circumstances that must be addressed in order to cultivate the scientific virtues within twenty-first century scientific practice. The first has to do with factors affecting the culture as a whole. While there are a number of issues internal to scientific practice that can be seen as drivers of the increased number of fraud and scientific malpractice cases, this increase has coincided roughly with a concomitant increase in a variety of white-collar crimes. The US Federal Trade Commission's Consumer Sentinel Network collected a total of 3,083,379 consumer complaints in 2015, which represents an 850% increase since the network began reporting in 2001.(30) Likewise, a recent white-collar crime victimization study (NW3C's 2010 National Public Survey on White Collar Crime) found that 24.2% of American households reported experiencing at least one form of white-collar crime, which was defined as credit card fraud, price fraud, repair fraud, internet fraud, business fraud, securities fraud, and mortgage fraud.[37] Similarly, the level of health care fraud has increased over the past twenty years.[38]

While there is debate regarding how much of this increase is real and how much is an artifact of increased scrutiny, the incidences of white-collar fraud seem to be increasing in parallel with cases of scientific fraud. The fact that fraud is a significant issue across a number of professional disciplines suggests that it is part of a larger societal problem that needs to be addressed long before the onset of scientific training. In fact, many have argued that waiting until college or graduate school to begin professional ethics training is too late.[39] Starting virtue ethics curriculum at an early age may be more effective in the long run for a variety of reasons. First, it exposes students to these concepts at a formative age when they are just starting to internalize ethical decision-making frameworks and address questions like "why should I act in a certain manner?" or "what is the end or goal of life?" Second, this early education approach provides a foundation upon which scientific virtue-based RCR can later build. Repeated presentation of and engagement with these topics is more likely to have a lasting effect on behavior than one class or seminar in graduate school.

At present, a variety of programs have been developed and piloted to introduce either ethical theory in general, or practical ethical decision making, at the high school, middle school and even grade school level.[40] Some of these programs specifically focus on virtue ethics, while others look at a range of eth-

36. Pennock and O'Rourke, "Developing a Scientific Virtue-Based Approach to Science Ethics Training," 243–62.

37. Rodney Huff, Christian Desilets, and John Kane, "National Public Survey on White Collar Crime, 2010" (Fairmont, WV: National White Collar Crime Center, 2010), https://www.nw3c.org/docs/research/2010-national-public-survey-on-white-collar-crime.pdf?sfvrsn=8.

38. "Prosecutions of Health Care Fraud Law Reach New High in FY 2013," *TRACReports*, January 14, 2014, https://trac.syr.edu/whatsnew/email.140114.html.

39. Rhakesh Khurana, *From Higher Aims to Hired Hands: The Social Transformation of American Business Schools and the Unfulfilled Promise of Management as a Profession* (Princeton, NJ: Princeton University Press, 2007).

40. Nancy Matchett and Mark Overmeyer, "Youth Ethics Series Curriculum," 2011, http://www.coloradohumanities.org/sites/default/

ical theories. While these programs have met with mixed results, there is a clear interest in developing materials for this age group and much work remains to be done in identifying effective programs.[41]

While there is a need for this type of education early on, once students reach the undergraduate level this type of education should not cease. A philosophical course that deals with ethical theories, particularly virtue ethics, should be required for all students entering scientific professions. Unfortunately, distributed core requirements make it all too common that scientific practitioners have never been exposed to a philosophy course, let alone an ethics course throughout the entirety of their education. Equally importantly, though, would be the inclusion of ethical components in courses across the science curriculum. The Society for Ethics Across the Curriculum has been holding conferences for the past twenty years looking at how to integrate ethics across all disciplines at the undergraduate and graduate levels. In fact, there appears to be a burgeoning effort to develop and implement programs that integrate ethics across a variety of different disciplines.[42] The key is to provide opportunities for students to reflect upon virtue ethics within their field and apply what they have learned from ethics courses. This can facilitate the development of an appreciation of the intrinsic value of virtuous behavior, something that is learned over time through repeated reflection, interaction, and examples. The hope is to transform ethics/virtue training from a hurdle one must clear into a default manner of thinking about and viewing the various complex situations one encounters in science. Having ethics/virtue training as part of the curriculum from high school onward would help foster this type of environment.

This leads into the second major issue that needs to be addressed if scientific virtue-based RCR training is to be effective: the financial model of twenty-first century academic science. While one may agree that certain virtuous behaviors are essential for the practice and advancement of science, when one's livelihood is on the line, one's moral calculus has a tendency to become much more malleable. Translating ethical decisions into the hyper-competitive world of modern science is fraught with compromise. Some of this pressure could be alleviated if different models of financial compensation and funding were explored. Many authors have proposed alterations to the grant funding system in order to address this issue. Some have advocated for a random allocation of awards to applicants who meet a certain scientific threshold.[43] Others have advocated for everything from simplified applications systems, to equal funding of eligible scientists, to a peer-voting system to allow for researchers to increase their relative share of grant funding.[44] Beyond changes to the grant system, others have

files/youth_ethics_series_curriculum.pdf; R. Peeler, "Children and the Development of Ethical Decision-Making," May 1, 2015, http://rockethics.psu.edu/this-is-the-rock/news/children-and-the-development-of-ethical-decision-making; James Arthur, Tom Harrison, Emily Burn, and Francisco Moller, "Schools of Virtue: Character Education in Three Birmingham Schools" (Birmingham, UK: Jubilee Center, 2017), https://www.jubileecentre.ac.uk/userfiles/jubileecentre/pdf/Research Reports/SchoolsOfVirtueResearchReport.pdf; M. Scott Niederjohn, Kim Nygard, and William C. Wood, "Teaching Ethics to High School Students: Virtue Meets Economics," *Social Education* 72.2 (2009): 76–8.

41. Niederjohn, Nygard, and Wood, "Teaching Ethics to High School Students: Virtue Meets Economics," 76–8.

42. Elaine E. Englehardt and Michael S. Pritchard, eds., *Ethics Across the Curriculum—Pedagogical Perspectives* (Basel, Switzerland: Springer, 2018).

43. Ferric C. Fang and Arturo Casadevall, "Research Funding: The Case for a Modified Lottery," *mBio* 7.2 (2016): e00422–16.

44. Johan Bollen, David Crandall, Damian Junk, Ying Ding, and Katy Borner, "From Funding Agencies to Scientific Agency: Collective Allocation of Science Funding as an Alternative to Peer Review," *EMBO Reports* 15.2 (2014): 131–33; John P.A. Ioannidis, "Fund People Not Projects," *Nature Reviews Immunology* 477 (2011): 529–31.

advocated for changes to the academic hiring system through the creation of additional permanent staff research positions rather than trapping individuals in low pay/long-term post-doc positions.[45]

While these ideas have their merits, they do not address one of the biggest financial issues associated with biomedical research, the need for faculty members to garner "soft money" (that is, grants) to sustain their salary. Currently, a significant portion of a researcher's salary at large research institutions is funded by grants, rather than by the institution. This precarious situation leaves scientists dependent upon grant funding, not only to support their research, but to even draw a full paycheck. As Paula Stephan pointed out in her book *How Economics Shapes Science*, universities "lease the facilities to faculty in [exchange for] indirect costs on grants and buyout of salary. In many instances, faculty 'pay' for the opportunity of working at the university, receiving no guarantee of income if they fail to bring in a grant. Those who land funding staff their labs with students enrolled in their department's graduate program, or with postdocs."[46] The students and postdocs are often paid out of the same grant so that all are dependent on the PI's continued success in the grant system.[47]

While an abrupt transition off the soft-money model would likely be too disruptive, a gradual transition toward the model that prevails in the humanities, where institutions are responsible for faculty salaries and soft money provides, instead, time and resources for research would have numerous benefits. First, it would allow more grants to be funded, as salaries reflect a significant component of most NIH grants. Second, it would give faculty a measure of financial stability. The major funding institutions, such as NIH and NSF, would have to champion this transition, as it runs counter to the research output metric that fuels the rankings of R1 universities. However, given that these government agencies largely hold the purse strings, they have some ability to incentivize universities to migrate in this direction.

Because this new model would likely reduce the number of faculty positions at research universities, other measures, such as limiting the number of graduate students or providing supplemental training, would have to be put in place in order to help reset the already distorted scientific labor market.[48] The most promising option would be to prepare, in a more deliberate fashion, the current glut of biomedical Ph.Ds for alternative careers in fields such as research administration, science policy, regulatory affairs, industry R&D, and science writing/advocacy. More formal training collaborations between industry, government, and academia would aid in the transitioning of Ph.Ds from the academy into government or industry lab settings, settings that operate under different conceptual orientations and implement more rigid laboratory practices than most academic labs. For example, designing Ph.D tracks that specifically prepare scientists for industry with good laboratory practice, good manufacturing practice, and business training would be of benefit to both industry and the current crop of graduate students. Unfortunately, while there has been much talk regarding modifying graduate education to foster academia/industry/governmental collaborations, there is no general consensus on

45. Muhammad Z. Ahmed, "Opinion: The Postdoc Crisis," *The Scientist*, January 4, 2016, https://www.the-scientist.com/opinion/opinion-the-postdoc-crisis-34259.

46. Paula Stephan, *How Economics Shapes Science* (Cambridge, MA: Harvard University Press, 2012).

47. Beryl Lieff Benderly, "Academia's Crooked Money Trail," *Science*, January 6, 2012, https://www.sciencemag.org/careers/2012/01/academias-crooked-money-trail.

48. Alberts, Kirschner, Tilghman, and Varmus, "Rescuing US Biomedical Research From Its Systemic Flaws," 5773–77.

how best to do this in practice, particularly given that each entity is driven by its own distinct interests.[49]

Given the challenges, none of these proposed changes would be easy to implement and all would face significant institutional resistance. Yet despite these hurdles alternative models need to be considered because the current funding pressures for academic scientists have become so pervasive and onerous that the virtues of objectivity, patience, skepticism, and meticulousness are very difficult to implement in practice, regardless of the level of one's internal motivation.

In conclusion, the implementation of the virtues associated with good scientific practice have always been challenging, given the human component of the scientific endeavor. However, the hypercompetitive environment that academic scientists face in the twenty-first century, coupled with the influence of corporate money, has created a situation where new solutions are needed to help foster scientific integrity. Given that the risks associated with unethical behavior appear low relative to the perceived benefits individual scientists can acquire in terms of money and career advancement, there is a need to develop an internal motivation for scientists to act virtuously, even when it may compromise one's professional advancement. Specific scientific virtue ethics training programs that incorporate real-world mentors should be considered, as they can foster the requisite internal rationale for virtuous behavior among young scientists. For this to be maximally effective, however, there is a need to expose students to virtue-based ethics long before graduate school and to explore different financial models that lessen the pressure on practicing scientists to act in a manner contrary to the scientific virtues.

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49. Beryl Lieff Benderly, "Fraying Ties among Academia, Industry, and Government Hurt Scientists and Science," *Science*, December 6, 2017, https://www.sciencemag.org/careers/2017/12/fraying-ties-among-academia-industry-and-government-hurt-scientists-and-science?r3f_986=https://www.google.com/.

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CHAPTER 10.

SCIENTIFIC PRACTICE, WONDER, AND AWE

KRISTJÁN KRISTJÁNSSON

Introduction

A good lecture begins with cogent arguments and ends with a compelling conclusion. Right? Probably that is right, as a rule of thumb, but in this lecture I break the rule by starting with the two following conclusions that I happen to endorse:[1]

> (a) Scientific practice can, and should ideally, cultivate moral virtues in its practitioners (in addition to more obvious intellectual virtues such as wonder), most specifically the moral virtue of awe.[2]
>
> (b) Science education can, and ideally should, inspire in students love of transcendent ideals, such as truth, and introduce them to morally relevant awe experiences when such ideals are fathomed. This is true for both budding scientists and budding interested laypeople: future friends rather than foes of scientific inquiry (and, believe me, science needs more friends in a post-truth world).

I propose to spend the rest of this lecture arguing for, and elaborating upon, those two conclusions. I will also explain, however, why they are radical and will remain controversial, even after my best efforts to support them.

None of the required argumentative spadework can be done satisfactorily in forty-five minutes. You will have to make do, therefore, with a series of observations and a few detours, resembling a typical British train journey, which rarely heads straight from place A to place B. I hope you will find the considerations I offer relevant to the reasonableness of the two conclusions or, at worst, quirky enough to be mildly interesting and worthy of further thought.

1. This paper was organized and written as a public lecture, and should be understood in that context.

2. If you prefer to call awe a "virtuous emotion" rather than a full-blown virtue, I do not mind; I have done so myself. Notably, in either conceptualization, it is morally virtuous. See Kristján Kristjánsson, *Virtuous Emotions*, (Oxford: Oxford University Press, 2018), chapter 8.

A Taxonomy of Virtues and Some Intellectual History in Capsule Form

It is something of a commonplace nowadays to divide human character virtues into four categories: *intellectual* virtues such as critical thinking and creativity, *moral* virtues such as honesty and compassion, *civic* virtues such as volunteering and social justice, and *performance* virtues such as self-confidence and grit.[3] It is also almost a platitude to claim that scientific practice is, at once, inspired by and inspires intellectual virtue. If someone argued, for example, that standard scientific inquiry is not driven by, and does not cultivate, critical thinking, one would find that argument as *empirically* implausible as an argument about running not building endurance—even perhaps teetering at the brink of violating a *conceptual* truth about the nature of scientific inquiry as such.

As there is no need to rehearse (in *Fawlty Towers* language) "the bleeding obvious" here, I can turn straight to the more interesting thesis: namely, that scientific practice is somehow intimately linked to the cultivation of *moral* virtue. This was a thesis that was, more or less, taken for granted during medieval times and the early Enlightenment period,[4] even to the point of not requiring a specific rationale. The underlying assumptions here often boiled down to considerations that would not cut much ice nowadays: the essential coherence of human beings' divine destiny on earth and how, if they perform their function well in the image of God, their virtuous activities will all fall into line and be mutually supportive. Frequent references were also made at the time to the "unity-of-virtue thesis," espoused by ancient philosophers such as Aristotle. However, Aristotle's thesis did not actually encompass the whole virtue repertoire; it was specifically about the essential unity of the moral virtues, guided by the bespoke intellectual means-end virtue of *phronesis*.[5] There is no hint in Aristotle of a unity thesis binding together, say, performance virtues such as grit and moral virtues such as compassion. And apart from the specific intellectual virtue of *phronesis*, which happens to serve the moral virtues, no claims are made about an essential bond between other intellectual virtues and the moral ones.

Alasdair MacIntyre, who in his famous book *After Virtue* tried to retrieve time-honoured ideas about excellent human practices, suggested linkages that would have tallied well with medieval sentiments, seeing the moral virtues of justice, courage, and honesty as conducive to the preservation, development, and flourishing of *all* successful human practices (including intellectual ones), and as essential for the acquisition of the internal goods making up such practices.[6] However, recent situationist findings in psychology have shown how context-dependent the functioning of moral virtues can be. Even if were true, for example, that a scientist could not be successful *qua* scientist in her lab without being able to display moral virtues of justice and honesty in her dealings with colleagues, conference organizers and journal editors, and in her collection and analysis of data, we have every reason to be scep-

3. See, e.g., Jubilee Centre for Character and Virtues, *A Framework for Character Education in Schools* (Birmingham: Jubilee Centre for Character and Virtues, 2017), http://www.jubileecentre.ac.uk/userfiles/jubileecentre/pdf/character-education/Framework for Character Education.pdf.

4. See, e.g., Matthew L. Jones, *The Good Life in the Scientific Revolution: Descartes, Pascal, Leibniz, and the Cultivation of Virtue* (Chicago: University of Chicago Press, 2006).

5. Even in that narrow form, many contemporary Aristotelians would contest this thesis. See my discussion in Kristján Kristjánsson, *Virtues and Vices in Positive Psychology* (Cambridge: Cambridge University Press, 2013), chapter 7.

6. See Alasdair MacIntyre, *After Virtue* (London: Duckworth, 1981). For a detailed discussion, see Arik Segey, "Does Classic School Curriculum Contribute to Morality? Integrating School Curriculum with Moral and Intellectual Education," *Educational Philosophy and Theory* 49.1 (2017): 89–98.

tical of the claim that these virtues would necessarily carry over into her general moral performance.[7] Indeed, the very idea of some sort of intrinsic (or even merely extrinsic) link between the intellectual virtues of scientific inquiry and the context-dependent moral virtues that may need to go with them, on the one hand, and the general moral character of scientific practitioners, on the other, will jar with modern sensitivities. At the risk of excessive simplification, let me single out three reasons for this scepticism:

> (a) The general collapse of the medieval teleological worldview, so vividly depicted in MacIntyre's *After Virtue*. Empiricism, later developing into positivism, set in, with its slavish obedience to Hume's two laws about the essential distinction between both facts and values and between descriptions and prescriptions—and subsequently, with Weber's *Wertfreiheit* thesis, objects of any unprejudiced social scientific inquiry were also quarantined against any admixture of normativity.[8] This new idea of science as detached inquiry, free from normative assumptions, of course left little room for the notion of moral cultivation as inherent in scientific inquiry.
>
> (b) While the image of the scientist as an "evil genius" was rampant in romantic nineteenth century literature, as we entered the twentieth century, examples of actual immoral scientific practice began to proliferate. The science behind eugenics, torture, the tobacco industry, weapons of mass destruction and, dare I mention, almost the whole field of the psychology of advertising are cases in point. The idea of some sort of an association between scientific inquiry and the growth of moral virtues seemed to have lost all traction and market value.
>
> (c) As the twentieth century progressed, science did take a moral turn, but not one which sought to retrieve ideals about the intrinsic moral benefits of sound scientific practice on its practitioners. Rather than rekindling aspirations for moral excellence, science sought to set minimal standards of what counted as acceptable practice from a narrowly understood "ethical"—rather than a more broadly understood "moral"—point of view. We entered the complex labyrinth of rules and codes, ethical reviews, and ethical committees: the realm of soulless deontological formalisms backed up by carrots and sticks.[9]

Some recent work in professional ethics signals a backlash against the tyranny of thin ethical codes.[10] More generally speaking, the upsurge of virtue ethics—mostly of neo-Aristotelian provenance—in moral philosophy has retrieved the whole language of virtue and character as crucial to human association and human practices. It does not sound outlandish or archaic any more to talk about the virtues of the good professional or the good practitioner, although those virtues would more often be understood in intellectual or epistemic, rather than moral, terms. Nevertheless, it would seem futile in the current climate to attempt to resurrect the medieval idea of the *inherently* morally formative value of scientific practice. It has taken such a knock—empirically as much, or more so, than philosophically—that it must count as beyond redemption. This is why at the outset I was careful to formulate

7. On the difference between honesty as an epistemic and moral virtue, see

8. I review this history in more detail in Kristjánsson, *Virtues and Vices in Positive Psychology*, 4.

9. For an analysis of this trend and a critique of it as anti-professional and demotivating, see Barry Schwartz and Kenneth Sharpe, *Practical Wisdom: The Right Way to Do the Right Thing* (New York: Riverhead Books, 2010).

10. See an argument and various references in Jubilee Centre for Character and Virtues, *Statement on Character, Virtue and Practical Wisdom in Professional Practice* (Birmingham, UK: Jubilee Centre for Character and Virtues, 2016), http://www.jubileecentre.ac.uk/userfiles/jubileecentre/pdf/Statement_Character_Virtue_Practical_Wisdom_Professional_Practice.pdf.

my two "conclusions" in aspirational rather than descriptive terms. I suggested what scientific practice and science education "can" and "should" ideally do for those who pursue them, not what such activities need necessarily do, even in their more idealised instantiations.

In the remainder of this lecture I propose to argue for the aspiration that scientific practice and science education cultivate a certain morally virtuous trait in practitioners and students: namely that of *awe*. However, as a necessary stepping stone to this argument I need to say quite a bit first about an intellectual virtue that carries a certain relation to awe, yet falls short of it: namely, *wonder*. It would be less cumbersome and controversial to argue for the thesis that science aspires to the cultivation of wonder. Indeed, in support of that weaker version of my thesis, I could helpfully enlist Aristotle as my ally. In arguing for the stronger thesis about awe as a moral virtue I need to acknowledge, however—as much as this pains me as a self-styled neo-Aristotelian—that Aristotle plays the role of the pantomime villain rather than that of the savior. In other words, one of the reasons why the thesis that I argue for will appear strong, even to the point of sounding positively implausible, is that it does not have any Aristotelian virtue ethical ammunition to back it up.

Wonder

Aristotle argued that all academic inquiry starts with wonder; his mentor Plato had already made similar points through his mouthpiece Socrates. Einstein later echoed those claims and added to them by claiming that the scientist who can no longer experience wonder "is as good as dead, a snuffed-out candle."[11] Concerned that some scientifically oriented people have indeed fallen prey to such a disenchantment, Caspar Henderson has recently published an inspiring book, entitled *A New Map of Wonders*.[12] Henderson takes us on a rollercoaster ride through some of the wonders that science has discovered, arguing that these should, if all is well, excite wonder in us. Just consider some of its topics—light, life, the heart, the brain, selfhood, our world as a whole—and you can just imagine, even if you have not read the book, the stories of how encounters with those phenomena have enraptured scientists and blown them away as new and astounding truths have been unveiled. Admittedly, in what Thomas Kuhn used to call "normal science," one may envisage days of non-uplifting drudgery in the lab. But at least during times of great discoveries, of Kuhnian "revolutionary science," it is difficult to imagine the spirit of the scientist not "firing on all cylinders."[13]

Henderson defines wonder (citing Martyn Evans and Philip Fisher) as "an attitude of altered, compellingly intensified attention towards something that we immediately acknowledge as important" and crave to understand—where this "something" is "a feature of the middle distance of explanation, outside the ordinary" but "short of the irrational or unsolvable."[14] While these descriptions do not amount to a philosophically rigorous specification, they do capture something essential about wonder. Wonder encapsulates human beings' most intense form of *curiosity* about the world in which we live and all its to-be-revealed enigmas. Just consider David Attenborough following the elegant movements of some sea animals that has never been captured on film before—and envisage the shine in his eyes. Wonder elicits heightened *awareness* of what is going on before our eyes, but at the same time a lessened self-focus. We forget ourselves and even the very passing of time as we lose ourselves in what

11. Cited in Anders Schinkel, "The Educational Importance of Deep Wonder," *Journal of Philosophy of Education* 51.2 (2017): 538.

12. Caspar Henderson, *A New Map of Wonders: A Journey in Search of Modern Marvels* (London: Granta Books, 2017).

13. Ibid., 24. See also Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962).

14. Henderson, *A New Map of Wonders*, 4, 7.

Csikszentmihalyi defined as a state of *flow*.[15] Then, as our mind "fires on all cylinders," we activate states of forceful (but not forced) *contemplation* where we try to untangle the relevant mystery, believing that it bears untangling. Finally, we experience *pleasure*, not as an immediately felt, self-conscious state but as a retrospectively identifiable satisfaction through unimpeded activities.

Wonder is an *intellectual* virtue in two distinct but interrelated senses. It (a) arouses the intellect and (b) directs it towards objects that are seen as intellectually understandable and decipherable, at least in principle if not always in immediate practice. It is crucially important to distinguish this virtue from that of awe, as I argue further in the following section. To be sure, *wonder* often seems to function as a gentle and low-level relative of awe (and its common precursor), with awe, then, best being described as intensification of wonder; and it is difficult to determine exactly at what point wonder shades into awe proper. A careful study of lay uses of the words "awe" and "wonder" may hold the key here.[16] It indicates that whereas "wonder" is associated with curiosity in trying to understand the world and contemplate its workings, awe is more related to observing it existentially—reflected in greater use of perception words.

Incidentally, this distinction between lay uses of the two concepts corresponds substantially to a specification suggested by Martha Nussbaum,[17] according to which wonder focuses on the value of the object, and is most likely to issue in contemplation but, contra awe, without self-reflexivity (i.e. with the subject "being minimally aware, if at all," of the object's "relationship to her own plans"). Nussbaum explains this non-self-reflexivity in terms of wonder being "non-*eudaimonistic*." I am not very happy with that term. I would argue that it would indeed impact negatively upon the *eudaimonia* of the scientist—or the scientifically minded layperson—if they did not, at some juncture in the exploratory process, experience wonder as a compound emotion, drawing upon and intensifying their attention, curiosity, and contemplation. However, Nussbaum is right in that wonder may be experienced independent of, and without impacting, our personal projects or our existential awareness. In that sense it is non-*eudaimonistic*. It is not about *us* as psycho-moral agents, either about how we evaluate ourselves or how we act. In other words, wonder is *not* a moral virtue situated in the ethical sphere of human association and appraisal.

Recently two conceptual analyses of *wonder* have appeared, conducted by philosophers. Kevin P. Tobia provides an exhaustive list of the necessary and sufficient conditions for experiencing wonder.[18] Much of his rhetoric seems to indicate a strong affinity between wonder and awe, as he also connects experiences of wonder to a sense of mystery and immensity. Yet he specifically singles out two distinctions between awe and wonder, one having to do with wonder being positively valenced while experiences of awe can be entirely negatively valenced, the other based on the observation that, unlike wonder, awe does not require interest in the object.[19] I doubt that experiences of awe can be entirely negative, even if they may sometimes be slightly terrifying.[20] Moreover, although wonder and awe

15. Mihaly Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (New York: Harper Perennial, 1990).

16. Kathleen E. Darbor, et al, "Experiencing Versus Contemplating: Language Use During Descriptions of Awe and Wonder," *Cognition and Emotion* 30.6 (2016): 1188–96.

17. Martha C. Nussbaum, *Upheavals of Thought: The Intelligence of Emotions* (Cambridge: Cambridge University Press, 2001), 54.

18. Kevin P. Tobia, "Wonder and Value," *Res Philosophica* 92.4 (2015): 959–84.

19. Ibid., 962n4.

20. Etymology seldom gets us very far in conceptual analysis. Nevertheless, it is instructive to note that the word "awe" is thought to be derived from the Old Norse word "*agi*" (terror, dread), a word which exists in contemporary Icelandic in permutations such as "*ægi-*

can be placed differently on the valence spectrum, I would follow Aristotle in seeing emotions being set apart by their cognitive consorts rather than their valence.[21] Tobia is right, however, in that (as opposed to wonder) awe does not require *interest* in the experienced object, if by "interest" he means "enduring intellectual interest." It suffices that the object of awe captivates us momentarily and puts us into a spin.

Somewhat differently from Tobia, Sophia Vasalou warns against too tight conceptual characterisations of, and distinctions between, awe and wonder.[22] She proposes "loosening the tenacity" of "taxonomic grids" in the emotional sphere, mollifying their "steely unity."[23] While acknowledging that awe is thicker in "the depth of feeling" than wonder, she sees both emotions as "tied to a mastery of language that is inherently pluralistic."[24] I agree that ordinary language does not always distinguish clearly between wonder and awe, and that the feelings accompanying the two may often shade into one another. Indeed, Henderson's popular book, on science as a journey towards marvels of wonder, often seems to apply the terms "wonder" and "awe" interchangeably. Yet to unpack and justify the conclusions with which this lecture began, on the ideal (aspirational) links between scientific practice and moral virtue, I need to trim the ragged edges of ordinary language somewhat; for whereas wonder is not, awe is, a *morally* virtuous emotion. What I have said so far does not yet support my strong conclusions at the outset; I need to delve deeper into the nature of awe.

Awe

In my recent book*, Virtuous Emotions*, I teased out the conceptual components of awe in the following way:

1. The *subject* of awe is the person experiencing it.
2. The *feeling* of awe is intense and predominantly pleasant although it may be slightly tainted with a sense of impending terror.
3. The *perception* eliciting it can be visual, olfactory, auditory, and tactile.
4. The *intentional object* of awe is the cognised contact with a truly great ideal that is mystifying or even ineffable in transcending ordinary human experiences. This experience is perceived to have increased existential awareness and connected the subject to a greater whole.
5. The *target* of awe is constituted by the ideals of the famous Platonic triad of truth, beauty, and goodness. Depending on whether the target is truth, beauty, or goodness, awe presents itself as the more specific emotions of *intellectual elevation* (for truth), *moral elevation* (for goodness), or *aesthetic elevation/ecstasy* (for beauty). Awe can thus be seen as a term for a general emotional cluster.

legur" (terrifying). Over the centuries, however, the center of gravity in "awe" moved from the terrifying to the fantastic, probably hand in hand with a decreased fear of supernatural powers. Yet a slight hint of underlying terror may still remain in the term in some locutions, which makes awe less than exclusively "positive" an emotion in terms of valence. See Kristjánsson, *Virtuous Emotions*, 8.

21. Kristjánsson, *Virtuous Emotions*, develops this further.

22. Sophia Vasalou, *Wonder: A Grammar* (Albany: State University of New York Press, 2015).

23. Ibid., 26.

24. Ibid., 32–33.

6. The characteristic *goal-directed activity* of awe is that of continuing to experience the emotion or experiencing it again, preferably more profoundly. Awe does not, however, present itself with a distinct *behavioral pattern*, apart (possibly) from a common facial expression of blissful surprise.

I presented these as *necessary and sufficient conditions* for an experience of awe to take place. This formulation does not mean that I consider the concept of awe to be specifiable with mathematical precision. Awe, like all emotion concepts, is open-textured and has vague boundaries. This vagueness is not, however, a result of the unavailability of relevant necessary conditions; it is rather a result of those conditions themselves being vague. For example, it is impossible to define with any mathematical precision the exact dividing line between mere wonder at a remarkable natural phenomenon, like the rainbow, and awe at a unique appearance of a rainbow which is somehow connected to a heightened existential awareness.

Yet lack of mathematical precision does not indicate lack of a conceptual boundary. The essential uniqueness of awe lies in its constituting an essentially *self-reflexive* experience. More specifically, awe is a self-reflexive emotion in the sense that it represents a relationship between the intentional object and features of the self, although it is not "self-conscious" in the strong sense of being representationally just *about* the self (like pride or shame). Awe prompts us to self-consciously reflect upon ourselves, for example by re-evaluating our status in the universe. It is thus, in a sense, *Janus-faced*: it turns outwardly towards its target but inwardly towards ourselves and it forces us to consider ourselves against the horizon of a more immense external reality—even to the point of making us transcend the boundary between the internal and the external. Being self-*reflexive* and even self-*transcending* does not mean, however, that experiences of awe need to be self-*comparative*; I resent the recent trend of connecting awe conceptually or empirically to humility, for example.[25]

Another argument that I made in *Virtuous Emotions*, and only have time to articulate dogmatically here, is that awe can be seen as a virtuous emotion in an Aristotelian sense. It may seem strained at first to try to accommodate an emotional awe-trait within the famous Aristotelian architectonic of a quantitative and qualitative golden mean, but it is still worth a shot. For example, with respect to the quantitative mean, it is obviously not good to be in a state of constant rapture; that sort of *aestheticism on steroids* would count as the excess-extreme of awe. The deficiency-extreme would be constituted, however, by the *insipid philistinism* of those incapable of experiencing awe towards the right objects when the occasion calls for it. To be in a qualitative mean, awe would obviously also have to be felt for the right reasons, in the right manner, for the right length of time, and so on. In order to justify awe as virtuous, we will need to show that it speaks to an intrinsic human need whose satisfaction is constitutive of human flourishing. I have indeed argued that awe satisfies this condition by responding to an inter-human urge for self-transcendence: not only self-transcendence in a *horizontal* sense, where we connect intimately to other people, but in a *vertical* sense where we come into close contact, and even merge our minds, with high-brow ideals. Notice that when I talk about awe as a "virtuous" emotion, I mean "virtuous" in a moral, not just an intellectual sense. In informing our existential awareness of our status in the great chain of things, our self-evaluations and our self-conceptions of ourselves as moral agents at work in the world, awe does more than just guide the self away from

25. I argue strongly against that common claim in *Virtuous Emotions*, chapter 8, and explain how it may have emerged through a skewed methodology of psychological self-reporting. For a more mainstream psychological take on awe and its psycho-social components and correlates, see Dacher Keltner and Jonathan Haidt, "Approaching Awe, a Moral, Spiritual and Aesthetic Emotion," *Cognition and Emotion* 17.2 (2003): 297–314.

itself, in a flow-like way—like wonder—towards external ideals. Rather, it touches the core of our own *moral selfhood*. The above claim that the *target* of awe is constituted by the ideals of truth, beauty and goodness does not mean, however, that awe always touches the core of our moral selfhood in the correct, virtuous way. As I noted above, awe does have a common excessive form of what I called "aestheticism on steroids." A disposition to such experiences is a morally relevant disposition but not a virtuous one. Moreover, people may easily mistake the proper targets of awe, just as we can feel truly proud of something which is not a proper object of pride.

Despite all his claims about the contemplative life being the best life for human beings and his reminders about how wonder is the springboard of all academic inquiries, Aristotle was no friend of awe. On his great escape route away from Plato's idealism, Aristotle seems to have become destitute of any sense of the ineffable, fearful of ecstatic wow-experiences, and limited in his view of the potential targets of morally relevant emotions: as comprising only other people (like compassion), ourselves (like pride), or external events (like fear), but not abstract ideals (like truth, beauty, and goodness). I consider these omissions to put severe constrictions on Aristotle's conception of human flourishing.[26] Be that as it may, perhaps because of the continued influence of Plato and of gnostic philosophies, ideas about the essentially moral and self-transcending or ecstatic nature of deep scientific inquiry remained very much part of the Western mind set until the eighteenth century.[27] It was not until the Enlightenment that awe experiences—as part of or inspired by scientific practice—came to be seen as threats to the newly emerging ideal of the rational, industrious, autonomous, and controlled self, with awe being relegated to the status of a mere irrational excess of wonder,[28] and with wonder itself being domesticated and normalised through a process towards a fetishization of the mundane.[29]

Much as I admire Henderson's rehabilitation of wonder into the world of scientific practice in his recent book, it does not quite reach the level of re-enchantment that I would recommend. I wish there were a little bit more of the rapture of another recent book in Henderson's work. Jules Evans's *The Art of Losing Control* is an unapologetic plea for the retrieval of ecstatic experiences across the whole spectrum of the human condition, and although he does not apply his argument to scientific practice in particular, it is easy to see how such implications could be elicited.[30] Evans may seem at times to come perilously close to sanctioning experiments in living that are potentially dangerous, such as dabbling with psychedelic drugs (albeit in "measured" ways), but I understand his more radical claims as deliberate antidotes to the post-Enlightenment fetishization of the mundane.

Anders Schinkel—who has recently received a John Templeton Foundation grant to study wonder—also tries to move beyond the disenchantment of ordinary wonder by postulating a concept of "deep wonder," which goes beyond wonder as mere dispassionate curiosity and retains some of awe's contours of mysteriousness and bewilderment.[31] Schinkel notes the relevance of this concept for science education. I am not sure whether there really is conceptual space for a notion of "deep wonder"

26. Kristján Kristjánsson, "Flourishing as the Aim of Education: Towards an Extended, 'Enchanted' Aristotelian Account," *Oxford Review of Education* 42.6 (2016): 707–20.

27. Jones, *The Good Life in the Scientific Revolution*.

28. See, for example, Jules Evans, *The Art of Losing Control: A Philosopher's Search for Ecstatic Experience* (Edinburgh: Canongate, 2017), especially xvi, 197.

29. See Charles Taylor, *A Secular Age* (Cambridge, MA: Harvard University Press, 2007), 308.

30. Evans, *The Art of Losing Control*.

31. Schinkel, "The Educational Importance of Deep Wonder."

between ordinary wonder and awe proper;[32] and even if there is, Schinkel's new concept falls short of capturing the self-reflexive existential awareness that I would like to see inform the education and practice of science.

Some Educational Implications and Concluding Remarks

A few years ago, when watching a Horizon documentary on the BBC about the concept of infinity, I felt as if I had entered a magic kingdom. Covering topics such as those of possible parallel worlds, the mystery of the singularity of a black hole, and the prospects of an endless array of universes, this documentary truly enthralled me. I felt intellectually elevated, spirited up to a transcendent reality where I existed as an ineluctable part of a great chain of being. I recorded the programme and have watched it again and again, each time reliving some of the emotion of the first viewing but never taken again to the same experiential heights.[33] This is the sort of moment that I would like as many students of science as possible to experience—and I would hope that such moments can be part and parcel of scientific practice also.

My argument in this lecture has been elliptical in many ways, drawing cursorily on previous writings and offering abundant helpings of not-that-well-argued-for articulations of my faith in a deep-seated human urge for self-transcendent and self-reflexive experiences that awe can, but mere wonder cannot, furnish. Lurking in the background are more deep-seated assumptions, which cannot be argued here, about human flourishing as an essentially moral enterprise and about all good education as being morally informed. I rue the way in which the classic school curriculum, including most notably education in so-called STEM subjects, has become untethered from any moral or existential concerns.

Eminent educational philosopher John White has written an engaging book on a revolution in schooling towards a paradigm of human flourishing.[34] Yet even White is hesitant to expand the standard conception of flourishing to include awe. Indeed, he devotes a whole chapter to demonstrating that all the "depth" we need in order to live well can be achieved within an explicitly mundane view of flourishing.[35] Revelling, so to speak, in disenchantedness, his main foils are anything spiritual and otherworldly. The danger is that White throws the baby out with the bathwater. Not to see anything irreducibly awe-inspiring in the workings of the universe—the singularity of a black hole; the possibility of endless parallel worlds—involves, in my view, a concession to philistinism, although White himself is clearly anything but a philistine, with his constant reminders to schools to expose children to art and culture.[36]

White sounds warning signals about taking children down the will o' the wisp road towards awe. He worries that, given children's penchant for the supernatural and otherworldly, feeding them material on transcendence will nourish that urge and lead them further away from finding this-worldly answers to life's greatest questions. They should be introduced to "wonder" but not to "awe" proper, as the latter has indelible religious connotations.[37] However, I have argued elsewhere that an acknowl-

32. Conceptual parsimony is typically seen to be in the service of economy and clarity. Recall here also Ockham's razor.

33. For this and some other personal experiences of awe, see Kristjánsson, *Virtuous Emotions*, chapter 8.

34. John White, *Exploring Well-Being in Schools: A Guide to Making Children's Lives More Fulfilling* (London: Routledge, 2011).

35. Ibid., chapter 12.

36. See Kristjánsson, "Flourishing as the Aim of Education," and *Virtuous Emotions*, chapter 8.

37. White, *Exploring Well-Being in Schools*, 98.

edgement of transcendence does not necessarily carry any such connotations.[38] Moreover, on the view of awe that I have been proposing in this lecture (a view which admittedly goes well beyond that of the historic Aristotle and gestures back to Plato on the love of the transcendent), we should allow, even encourage, children to peek under the arms of their educators—not least in science education—and catch a glimpse of the sunlight that exists outside the "cave" of mundane human experiences. Notably, Kieran Egan makes a distinction between wonder and awe, like White (with wonder focusing on the rationally graspable, but awe on the mysteries of existence), but he argues that it is the role of teachers to stimulate *both* emotions in students, and that they should do so by introducing each new topic with a focus on its exotic and unfamiliar aspects.[39]

White himself suggests that time should be carved out of the school day to enable students to pursue their particular passions.[40] I would go much further and suggest, explicitly, that teachers should expose students to experiences where they are most likely to come into contact with the ideals of truth, beauty, and goodness. Legends, fairy tales, and folk stories will provide an important initial resource in this regard, but as I have argued in this lecture, science education should ideally provide ample opportunities for awe experiences also. Enchantment is something that, I believe, can be taught through deliberative strategies in the science classroom. Complicating matters is, however, the necessary individualisation of virtue education. What triggers (virtuous) awe in one student may trigger non-virtuous awe in another, or even no awe at all. Cultivating awe in the science classroom thus requires considerable educational *phronesis* by teachers, geared towards the predispositions of the relevant individual students.

How far have I come in justifying the two "conclusions" with which this lecture started? I leave that to you, the audience, to judge. Much will depend, I presume, on the extent to which your general axiological commitments and your views of the nature of human flourishing coincide with mine. I hope I have at least been able to unpack what those conclusions mean, in practical terms, and to indicate a way in which a full argument for them could be elaborated. From an educational point of view, what I have been arguing for may not seem terribly radical in its essence. It is simply a rehearsal of the time-honoured view that all good education should help students see the world anew. What is radical, however, and will remain controversial, is the claim that this cannot be done through the elicitation of mere wonder as an intellectual virtue, and that even education in the apparently down-to-earth subject matter of the natural sciences should aim higher than that. Seeing the world anew is not only about seeing external reality anew—this flower, that galaxy—but about seeing ourselves anew in light of and as part of that reality, allowing ourselves to get lost in rapture as we grapple with the existential and moral ramifications of our being in the world.

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38. Kristjánsson, "Flourishing as the Aim of Education."

39. Kieran Egan, "Wonder, Awe and Teaching Techniques," in *Wonder-Full Education: The Centrality of Wonder in Teaching and Learning*, edited by Kieran Egan, Annabella I. Cant, and Gillian Judson (London: Routledge, 2014), 149–61.

40. White, *Exploring Well-Being in Schools*, 104.

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CHAPTER 11.

RECLAIMING AWE FOR THE RIGHT THINGS

DARCIA NARVAEZ

Knowledge is fostered by curiosity. Wisdom is fostered by awe.

–Abraham Joshua Heschel

Thank you, Kristján,[1] for your enlightening, informative, and rich paper, "Scientific Practice, Wonder, and Awe." I was *awed* by your analyses, integration, and mental wanderings. But I *wonder* about some things that may extend the excellent work you have done. I agree that *wonder* is more about curiosity, the explicit mind, and heightened focus. One can get into a state of concentration when trying to solve a problem, like many of us absent-minded professors do. I think a key characteristic of *awe* is absorption into something greater than the self, losing the ego to a greater or higher power, a mysterious sense of connection, even engulfment. It's a relational experience, which I think is the core of its morality. But, as I'll explain later, *it matters what you lose yourself to*.

In my practice of evolutionary developmental moral psychology, I concern myself with baselines for human development and parameters for flourishing. I want to bring ideas down to earth and understand what they mean for everyday life. I maintain that purpose here.

Focusing on science: though Aristotle noted that knowledge begins in wonder, some say that science is about transforming mysteries to problems—transforming the ineffable to something understandable.[2] Might this orientation to science be about transforming awe to wonder? Would this mean that such science actually undermines awe but supports wonder? But then, once everything is categorized, what is left to wonder about? The always-seeking orientation of someone like Arthur Eddington[3] counters this, but such an orientation does not seem widespread today.

Your paper made me wonder about where we find awe today.

1. This essay was an oral response to "Scientific Practice, Wonder, and Awe," Kristján Kristjánsson's keynote address, also printed in this volume.
2. Carolyn Merchant, *Reinventing Eden: The Fate of Nature in Western Culture* (New York: Routledge, 2003) and *The Death of Nature: Women, Ecology, and the Scientific Revolution* (New York: HarperOne, 1980/1990).
3. Matthew Stanley, *Practical Mystic: Religion, Science, and A. S. Eddington* (Chicago: University of Chicago Press, 2007); also see Stanley's essay in this volume.

In interviews that were conducted by Tim Reilly[4] for the "Developing Virtue in the Practice of Science" project, we found that when scientists talk about "awe experiences," they refer to a certain kind of awe that almost merges with intellectual wonder—awe toward an elegant theory or toward data that support a theory. It is not a relational awe but an emotionally-detached, objectifying awe. It makes me wonder if we need to expand types of awe.

If we take up the three types of awe you mentioned—truth, goodness, and beauty—the first seems less universal. "Truth awe" seems apparent primarily among scholars—that is, us—we intellectualizers, we ivory tower residents, inheritors of the ancient Greek emphasis on rationality. A problem of our age is that it is hard to establish what truth means. Truth in accord with what reality? The industrialized or neoliberal view?[5] Or the longstanding, sustainable Indigenous (First Nation) view?[6] As populaces have moved into a so-called post-truth era, perhaps we need to look at the awe of *un*truth. As Hannah Arendt[7] pointed out, the totalitarian mindset finds inspiration in the consistency of a narrative, not in its truth. And we see this on display in Trump's United States. His base, for whom he governs, doesn't mind his hundreds of lies weekly because they *seem* right. They are "truthy,"[8] and his followers seem entranced by his performance art, his lying boldly, bullshitting, and gaslighting.[9]

A second type, "awe of beauty," appears to be universal among traditional societies all around the world. But experiences of awe take place typically in groups, in community, in daily ensemble singing, dancing or music making[10]—largely kinesthetic experiences, something westerners might experience only relatively rarely in spectator sport or dance clubs or choral ensembles. (We found the latter, notably, in our interviews of musicians.)[11]

I also wonder about the third type of awe, "goodness," and how it might appear within moral hierarchical systems like slavery and apartheid. I am thinking here of the elevation experienced by white communities in the United States who lynched black citizens well into the twentieth century.[12] These communities made photographic postcards of themselves, standing proudly next to their vile deeds. We then need to ask, moral elevation of what kind? The egoistic morality of protectionism and hierarchy as shown by the lynchers? According to most religious and spiritual systems, moral elevation has

4. Timothy Reilly and Darcia Narvaez, "Virtue in Practice Interview Protocols," unpublished data.
5. See David Harvey, *A Brief History of Neoliberalism* (New York: Oxford University Press, 2005).
6. See Four Arrows and Darcia Narvaez, "Reclaiming our Indigenous Worldview: A More Authentic Baseline for Social/Ecological Justice Work in Education," in *Working for Social Justice Inside and Outside the Classroom: A Community of Teachers, Researchers, and Activists*, edited by Nancy E. McCrary and E. Wayne Ross (New York: Peter Lang, 2015), 93–112.
7. Hannah Arendt, *The Origins of Totalitarianism* (New York: Harcourt, Brace and Jovanovich, 1973).
8. "Truthiness" is a term coined by the comedian Stephen Colbert to describe the subjective feeling of a claim's rightness, regardless of its objective truth. For a tally of President Trump's lies in his first two years, see Glenn Kessler, Salvador Rizzo, and Meg Kelly, "President Trump Made 8,158 False or Misleading Claims in his First Two Years," *Washington Post*, February 17, 2019, https://www.washingtonpost.com/politics/2019/01/21/president-trump-made-false-or-misleading-claims-his-first-two-years/?utm_term=.010a73c1f068.
9. Paul Rosenberg, "Lies, Bulls**t and Gaslighting: A Field Guide to Trump's Reality-Warping Mendacity," *Salon*, February 24, 2019, https://www.salon.com/2019/02/24/lies-bullst-and-gaslighting-a-field-guide-to-trumps-reality-warping-mendacity/.
10. See, e.g., Victor Turner, *On the Edge of the Bush: Anthropology as Experience* (Tucson: University of Arizona Press, 1985).
11. Reilly and Narvaez, "Virtue in Practice Interview Protocols."
12. See Douglas A. Blackmon, *Slavery by Another Name: The Re-Enslavement of Black People in America from the Civil War to World War II* (New York: Doubleday, 2008).

more to do with an oceanic feeling of commonweal and connection to a Common Self, rather than self-aggrandizement, a demonstration through violence of one's moral superiority to another.[13]

This makes me wonder whether we need to add at least a fourth type of awe that may intersect with moral awe, or perhaps stands alone. The awe of *power* might be militaristic or ideological, or the result of trophy hunting a lion or giraffe, as in recent news.[14] Humans have the capacity to downshift to this primitive state.[15] This kind of awe might be what drives chants of "lock her up," of "throw them [immigrants] out," the flow of power over another, my group over yours, as occurred in the Rwanda massacre[16] and seems to inebriate Trump's United States.

Then there is *technological* awe. We've shifted the species-typical experience of awe from experiences in the natural world to awe for technology. Thomas Berry pointed out that technology has been luring us toward a "wonder world" for decades, if not centuries, but if we look around, we have ended up with a "waste world": toxically polluted and largely empty of the biodiversity and complex beauty that existed before colonialism, capitalism, and corporatism.[17] Still, inattentive to the consequences, we continue to be entranced by the latest technology.

So I think we need to ask whether there are better and worse kinds of awe—leading to more or less flourishing. Particularities matter. Intellectual awe of truth: What truth or whose truth in a post-truth era? Awe of what kind of morality—that of the white supremacists, or of the inclusivists? In science—which science? A power science whose awe come from power over nature, from a successful analysis, successful extraction, method, or outcome?

I appreciate the call to allow ourselves to fall into rapture. But it seems to me that awe requires the capacity to perceive and feel *in relation*. Awe does not individualize but *communalizes*—helps us feel connected. Noble laureate Barbara McClintock discussed "feeling for" the organism.[18] This type of awe relates to holistic functioning, attributed usually to right-brain functioning (versus focused attention, which is typical of the left hemisphere).[19] Holistic attention maintains an awareness of the dynamic, relational whole. Such an orientation is more apparent in first-nation societies around the world.[20] How does one get to that kind of awe? Our life experiences must prepare us. It turns out that the right hemisphere is scheduled to develop more rapidly in the first years of life, under species-typical care.[21] Right-hemisphere governed processing includes empathy, relational connection, and

13. Darcia Narvaez, *Neurobiology and the Development of Human Morality: Evolution, Culture and Wisdom* (New York: W.W. Norton, 2014).

14. Matthew Diebel, "American Woman Pictured Posing with Dead 'Rare' Giraffe She Shot in South Africa Sparks Outrage," *USA Today*, July 2, 2018, https://www.usatoday.com/story/news/world/2018/07/02/trophy-hunting-outrage-after-american-woman-kills-rare-giraffe/750376002/.

15. Narvaez, *Neurobiology and the Development of Human Morality*.

16. See Roméo Dallaire, *Shake Hands with the Devil: The Failure of Humanity in Rwanda* (New York: Carroll & Graf, 2003).

17. Thomas Berry, *The Dream of the Earth* (San Francisco, CA: Sierra Club Books, 1988).

18. Evelyn Fox Keller, *A Feeling for the Organism: The Life and Work of Barbara McClintock* (New York: Times, 1984).

19. Narvaez, *Neurobiology and the Development of Human Morality*. See also an extensive review of research comparing right and left hemisphere capacities in Iain McGilchrist, *The Master and His Emissary: The Divided Brain and the Making of the Western World* (New Haven, CT: Yale University Press, 2009).

20. See Phillip Descola, *Beyond Nature and Culture*, translated by Janet Lloyd (Chicago: University of Chicago Press, 2013); Alexander R. Luria, *Cognitive Development: Its Cultural and Social Foundations*, translated by Martin Lopez Morillas and Lynn Solataroff (Cambridge, MA: Harvard University Press, 1976).

21. Allan N. Schore, "Effects of a Secure Attachment Relationship on Right Brain Development, Affect Regulation, and Infant Mental

self-transcendence—which are fostered by humanity's evolved nest.[22] But species-*atypical* child raising is normative now in advanced societies, dominated by forces pressing against nurturing, such as patriarchy, the European Enlightenment philosophy of mechanism and separation, and a focus on money-making. Under this regime babies are coerced into isolation, artificial food, and silenced distress. Occurring at a time of rapid brain development in the first years of life, these experiences consequently undermine capacities for connected self-transcendence and many other capacities that are initially right-lateralized, or governed by the right hemisphere.[23]

The undermining of holistic and relational attention is further accomplished with culture and language, influencing the type of processing a person learns to bring to a situation.[24] East Asians raise their children to be attentive to the feelings of others and to fitting in, whereas westerners tend to focus children's attention on objects and agency. Western languages emphasize nouns, whereas indigenous and east-Asian languages are based on verbs and the interrelation of dynamic entities (for example, "tree being"). East-Asian societies have historically emphasized ethical and harmonious relationships and adjustment to situations rather than self-promotion and control, as in the west. These differences may have something to do with the lack of curiosity in terms of "knowledge for knowledge's sake" in traditional east-Asian societies, where curiosity is used for pragmatic ends and with attention to community effects.

Western science may have emerged from a combination of underdevelopment of the implicit systems initially governed by right-hemisphere development in early life; language and culture that emphasize detachment from relationships through objectification and a reliance on narrow intellect; and a detachment from intergenerational and cross-species consequences.[25] Experimental studies of left and right hemisphere functioning show that the left hemisphere narrows vision, categorizes, and seeks control, believing itself to be all-important—do these sound like the characteristics of western science and the seat of wonder? In contrast, the right hemisphere, implicitly guiding behavior when well-developed, takes in the dynamism of experience, perceiving and responding to interrelations—the seat of awe?[26]

Without full development of holistic attention capacities, perhaps one is relegated to only wonder. The undergraduate students in my classes typically come to situations with focused attention—the categorizing mindset, the mindset that gets caught in artificial boundaries and categories. But unless one is discussing human-made objects, no individual is the same as any other individual: no snowflake, no tree, no flower petal, no human body or human brain. Observational science tells us this, but maybe literature does it better, and maybe immersion in wild nature (an experience widely missing today) does even better. The lack of deep consistent experience in nature leads to Nature

Health," *Infant Mental Health Journal* 22.1-2 (2001): 7–66; Darcia Narvaez, Jaak Panksepp, Allan N. Schore, and Tracy Gleason, eds., *Evolution, Early Experience and Human Development: From Research to Practice and Policy* (New York: Oxford University Press, 2013).

22. Narvaez, *Neurobiology and the Development of Human Morality*; Darcia Narvaez, ed., *Basic Needs, Wellbeing and Morality: Fulfilling Human Potential* (New York: Palgrave MacMillan, 2018).

23. Narvaez, *Neurobiology and the Development of Human Morality*.

24. Richard E. Nisbett, *The Geography of Thought: How Asians and Westerners Think Differently...and Why* (New York: Free Press, 2003).

25. Narvaez, *Neurobiology and the Development of Human Morality*.

26. Rather than listing all the sources here, see the extensive review of research studies in McGilchrist, *The Master and His Emissary*. Also see Jill Bolke Taylor, *My Stroke of Insight* (New York: Viking, 2008).

Deficit Disorder,[27] which my students display on arriving in class (pre- and post-course surveys indicate that our class decreases that disorder as we focus on increasing nature connection). We work hard to help them relearn the open relational mindset and a docility toward nature as part of an Indigenous approach to science.[28] This requires learning to develop and attend to intuition and connectedness. In my classes we aim for awe instead of only wonder.

We live in a time of planetary devastation not only from global warming and our approach to a "hothouse earth," but from the eradication of species, the tens of thousands of chemicals taking over the rivers and oceans and floating in our bloodstreams, and the resulting massive toxicity in land, water, air, and our bodies.[29] Do we need awe to help us alter the destructive ways of the dominant culture? Can awe help us mitigate the climate crisis? Perhaps. If we could only turn off all the lights and once again see the Milky Way when we step out of the door at night, as was possible until about 150 years ago. If we could only see around us redwood trees the height of the length of a football field, with layers of ecosystems at different heights.[30] If we could reawaken our sense of connectedness to All and re-adopt a partnership orientation with earth entities rather than a dominator orientation, we might be able to turn things around.[31]

Perhaps the capacity for the right kind of awe does rely on humility. As Richard Powers writes in his science-rich novel *The Overstory*:

> *People aren't the apex species they think they are*. Other creatures—bigger, smaller, slower, faster, older, younger, more powerful—call the shots, make the air, and eat sunlight. Without them, *nothing.*[32]

A deep respect for and awe of nature is part of our ancestral Indigenous heritage, a heritage that the recent dominant worldview seems to have impaired.[33] Ohiyesa (Charles Alesander Eastman) describes how he showed a group of Lakota chiefs the wonders of the civilization that had taken over their lands with a tour of Washington, DC. After a visit to the Corcoran Art Gallery, he quotes one of the chiefs as saying: "Such is the strange philosophy of the white man! He hews down the forest that has stood for centuries in its pride and grandeur, tears up the bosom of Mother Earth, and causes the silvery watercourses to waste and vanish away. He ruthlessly disfigures God's own pictures and monuments,

27. Richard Louv, *Last Child in the Woods: Saving our Children from Nature Deficit Disorder* (New York: Workman, 2005).

28. Greg Cajete, *Native Science: Natural Laws of Interdependence* (Santa Fe, NM: Clear Light, 2000).

29. Intergovernmental Panel on Climate Change, *Climate Change 2013: The Physical Science Basis*, Working Group I Contribution to the IPCC 5th Assessment Report–Changes to the Underlying Scientific/Technical Assessment (IPCC-XXVI/Doc. 4) (Geneva, Switzerland: United Nations, 2013); Elizabeth Kolbert, *The sixth Extinction: An Unnatural History* (New York: Henry Holt, 2014); Leonardo Trasande, *Sicker, Fatter, Poorer: The Urgent Threat of Hormone-Disrupting Chemicals to Our Health and Future...and What We Can Do About It* (New York: Houghton Mifflin Harcourt, 2019); Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Synthesis* (Washington, DC: Island Press, 2005); Will Steffen, et al., "Trajectories of the Earth System in the Anthropocene," *Proceedings of the National Academy of Sciences* 115.33 (2018): 8252–59; Richard C. Thompson, Charles J. Moore, Frederick S. vom Saal, and Shanna H. Swan, "Plastics, the Environment and Human Health" *Philosophical Transactions of the Royal Society B* 364 (2009): 1971–2166.

30. Richard Powers, *The Overstory* (New York: W.W. Norton, 2018).

31. Riane Eisler, "Societal Contexts for Family Relations: Development, Violence and Stress," in *Contexts for Young Child Flourishing: Evolution, Family and Society*, edited by Darcia Narvaez, Julie Braungart-Rieker, Laura Miller-Graff, Lee Gettler, and Paul Hastings (New York: Oxford University Press, 2016), 61–78.

32. Powers, *The Overstory,* 285. Emphasis in original.

33. Narvaez, *Neurobiology and the Development of Human Morality*.

and then daubs a flat surface with many colors, and praises his work as a masterpiece!"[34] As Sam Keen has written: "One way to define modernity is to trace the process by which nature has been desacralized and God has moved indoors."[35] Clearly, the divorce from nature connection has contributed to the destruction of the other-than-human world.[36]

Maybe science education should make sure to take students back outside. Maybe we should temper wonder with awe, although not awe of power or awe of technology. Perhaps the most fundamental orientation to cultivate in students is awe of nature, a re-enchantment with the source of our lives, the earth. Maybe Mother Earth is the ultimate center of truth, goodness and beauty—the forms of awe identified by ancient Greeks but also First Nation societies.[37] Gratitude toward the natural systems on which our lives depend—soil, sun, water, insects, animals, plants—a central mindset among First Nation societies, may help us realign ourselves, our science, and all our endeavors around the laws, complexities and sensitivities of natural systems—before it is too late.

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34. Kent Nerburn, ed., *The Soul of an Indian and Other Writings from Ohiyesa (Charles Alexander Eastman)* (Novato, CA: New World Library, 2001), 16–17.
35. Sam Keen, *Hymns to an Unknown God* (New York: Bantam, 1994), 27.
36. William Berry, *It All Turns on Affection: The Jefferson Lecture & Other Essays* (Berkeley, CA: Counterpoint, 2013).
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PART IV.

FRAMEWORKS FOR PRACTICING SCIENTIFIC VIRTUES

CHAPTER 12.

CARING TO ASK: A NEW PICTURE OF INQUISITIVENESS

JORDAN DROIRA

In recent years, Anglo-American philosophy has increasingly mapped the contours of epistemic injustice. This type of moral and epistemic wrong—that is, wronging agents in their capacity as knowers—is pervasive wherever social power interacts with economies of knowledge, and science is no exception. As such, the scientist concerned with human flourishing must face the question: *what does virtuous scientific inquiry look like, not just generally, but in light of the dangers surrounding epistemic injustice?*

In this paper, I sketch one plausible answer.[1] I argue that scientists ought to cultivate "care-inquisitiveness," a virtue whereby an agent is characteristically motivated to engage sincerely in good questioning stemming from one's care for others. I reach my conclusion in four parts. In the first section, I motivate my project by presenting the dangers of epistemic injustice generally but also in science—particularly, that of testimonial injustice. In the second, I show a lacuna in conceptual resources, particularly in the distinction between (a) fulfilling one's *responsibility* with respect to the normativity of testimony and (b) the loftier goal of reaching *virtue* in testimony. In the third, I begin filling the conceptual gap by appealing to Vrinda Dalmiya's intellectual virtue of care and Lani Watson's intellectual virtue of inquisitiveness, highlighting the distinctively investigative aspect of science as well as testimonial injustice's interpersonal dimension. In the fourth, I propose a hybrid view of Dalmiya and Watson's proposals, characterizing virtuous activity in science as exercising "care-inquisitiveness." Finally, I conclude that this new paradigm of "caring to ask" enriches the way we look at research generally, since it views the good as primarily attractive.

Epistemic Injustice in Science

In this section, I will briefly outline the general concept of epistemic injustice, then focus on one in particular—namely, testimonial injustice. My goal here is to show one particular form of epistemic injustice and its relevance to scientific practice. Miranda Fricker has made a notable recent contribu-

1. The conceptual problem I raise (section 2) is that "testimonial justice" reduces, by and large, to harm-avoidance. I suspect that other forms of epistemic injustice (e.g., hermeneutical injustice) suffer from the same problem, though a deeper discussion of this issue is beyond the scope of this paper.

tion to the general topic of epistemic injustice.[2] While this, broadly speaking, is framed as "wronging an agent in her capacity as a knower," Fricker distinguishes at least two ways in which this may take place: testimonial justice and hermeneutic injustice. Roughly, the former occurs when a hearer attributes less credibility to a speaker than she is owed; the latter occurs when an agent lacks the ability to understand a key aspect of her lived experience, due to the fact that conceptual resources for her community have been undercut by systemic oppression.

For an example of testimonial injustice, Fricker turns to the scene from *To Kill a Mockingbird* in which the jury withholds the credibility owed to Tom Robinson because of their anti-black prejudice. To illuminate hermeneutic injustice, Fricker cites women experiencing sexual harassment while not yet possessing the term "sexual harassment."[3] Testimonial injustice wrongs agents in their capacity to know, since giving and receiving testimony is a large part of our epistemic lives. On the other hand, hermeneutic injustice wrongs knowers in their ability to self-understand and relate lived experiences to others, since the creation of conceptual resources often prioritize already privileged social groups and overlook oppressed ones. Indeed, part of Fricker's goal is to elucidate the dually ethical *and* epistemic dimensions of oppressive systems.

As such, these two frameworks—testimonial injustice and hermeneutic injustice—contribute immensely to our ability to map our epistemic responsibilities. However, these concepts have also fueled further conversation within analytic philosophy, including in the growing taxonomy of epistemic wrongs. For example, Gaile Polhaus Jr. takes the concept of hermeneutical injustice—something which Fricker characterizes as primarily systemic rather than culprit-based—and extends it to situations where dominantly-situated knowers refuse to acknowledge and employ terms already created by marginalized communities.[4] She calls this "willful hermeneutical ignorance."[5] Again, what makes this an epistemic injustice is that it harms agents as knowers. However, other terms, such as "participant-based injustice" and "trust injustice," have also been proposed to map formerly obscured situations, denoting increasingly nuanced aspects of epistemic harm. There is even work that examines how the study of epistemic injustice may itself perpetuate epistemic injustice in some key ways.[6] The

2. Miranda Fricker, *Epistemic Injustice: Power and the Ethics of Knowing* (New York: Oxford University Press, 2009).

3. Ibid., 150. The implication here is that the work of women such as Carmita Dickenson and Susan Brownmiller filled this conceptual lacuna by proposing a fitting and then new term. Fricker quotes Brownmiller: "The 'this' they were going to break the silence about had no name. 'Eight of us were sitting in an office of Human Affairs,' Sauvigne remembers, 'brainstorming about what we were going to write on the posters for our speak-out. We were referring to it as 'sexual intimidation,' 'sexual coercion,' 'sexual exploitation on the job.' None of those terms seemed right. We wanted something that embraced a whole range of subtle and unsubtle persistent behaviors. Somebody came up with 'harassment.' *Sexual harassment!* Instantly we agreed. That's what it was" (emphasis in original).

4. Gaile Pohlhaus, Jr., "Relational Knowledge and Epistemic Injustice: Toward a Theory of Willful Hermeneutical Ignorance," *Hypatia* 27.4 (2012): 715–35.

5. Ibid., 15.

6. Iann James Kidd, Jose Medina, and Gaile Pohlhaus, Jr. outline this worry in their introduction to *The Routledge Handbook of Epistemic Injustice* (London: Routledge, 2017), as Pohlhaus "…offers four different lenses for examining the varieties of epistemic injustice and relations among epistemic injustices. Because our knowledge practices, including those that map concepts, orient epistemic attention simultaneously toward some and away from other aspects of the world, [Pohlhaus Jr.] cautions against using only one lens (or even one set of lenses) for thinking about epistemic injustices." For more explicit cases of epistemic opression perpetuated through its own study see, for example, Kristie Dotson, "A Cautionary Tale: On Limiting Epistemic Oppression," *Frontiers: A Journal of Women's Studies* 33.1 (2012): 24–47. Moreover, the perpetuation of epistemic injustice perpetuation through its own study may also occur within other intellectual traditions which study the same phenomenon, though by a different framework; see, for example, Mariana Ortega's criticism of the citation politics within U.S. academic work in decolonial philosophy ("Decolonial Woes and Practices of Un-Knowing," *The Journal of Speculative Philosophy* 31.3 (2017): 504–16).

general idea here is that analytic philosophy's understanding of epistemic injustice is valuable but also unfinished and still-budding—partly evidenced by this paper and the connections I attempt to show with scientific inquiry and virtue epistemology.

Now that I've briefly reviewed the general concept of epistemic injustice, I'd like to dig a bit deeper into the nature of one particular type of epistemic injustice—namely, testimonial justice. Fricker describes testimonial injustice as a negative trait, whereby a speaker experiences "a credibility deficit owing to identity prejudice in the hearer."[7] In other words, if a hearer's identity prejudice causes her to discount the testimony of a speaker, she has committed a testimonial injustice. Fricker explains that this kind of injustice need not be conscious; in fact, we perpetrate it by failing to reflectively and critically engage our own prejudices so as to neutralize them. Conversely, a stable disposition to neutralize one's identity prejudices, causing one to fully recognize one's speakers as knowers, amounts to the "virtue of being testimonially just."

Importantly, Fricker frames both testimonial injustice and testimonial justice in the context of responsibilist virtue epistemology.[8] As such, the virtue of testimonial justice is conceptualized as a "global trait."[9] In other words, testimonial justice qua intellectual character virtue ought not to manifest merely in a single subset of an agent's life (e.g., neutralizing identity prejudices *only* when they speak to their family); the virtue should manifest in a variety of situations. They will be testimonially just when they converse with their friends, when they serve on a jury, when they teach a class, etc. And, most relevant, the testimonially just agent will act accordingly when they engage in scientific inquiry.

Testimonial justice, then, plays an important role in scientific inquiry, since it focuses on all the ways testimony and credibility attribution towards speakers contributes to the production of scientific knowledge.[10] For example, the background assumptions scientists carry into an inquiry play an important causal role in the research projects—assumptions which we usually imbibe (or fail to imbibe) from the testimony of others.[11] These assumptions can range but are not limited to implicit biases with respect to: who "looks like" a competent scientist, who should be prioritized with respect to research aims, who is expendable with respect to a research project's cost, what kind of research methodologies are "legitimate science" and which ones belong in an assumed lesser "anthropological studies." Allowing implicit biases with respect to gender, race, disability, and so on to sneak into our lives generally also means that they threaten to implicate scientists in testimonial justice. Such vulnerabilities demonstrate how and why egregious abuse of, e.g., the poor and racial minorities, have taken place: science, to be good, must fully acknowledge the agents involved as contributors of knowledge. Neutralizing credibility deficits due to identity prejudices, then, is of clear importance to the scientist concerned with virtue.

7. Fricker, *Epistemic Injustice*, 28.
8. Linda Zagzebski, *Virtues of the Mind: An Inquiry into the Nature of Virtue and the Foundations of Knowledge* (Cambridge: Cambridge University Press, 1996).
9. Nancy Snow, *Virtue as Social Intelligence: An Empirically Grounded Theory* (London: Routledge, 2010).
10. Heidi Grasswick, "Epistemic Injustice in Science," in *The Routledge Handbook of Epistemic Injustice*, 314–23.
11. Ibid.

Responsibility or Excellence?

At this point, one might be convinced that Fricker's virtue of testimonial justice is indeed necessary for a flourishing scientific life. At the very least, the converse seems obviously true: testimonial injustice in science would clearly inhibit human flourishing. However, as important as testimonial justice is, there is good reason to think it is not a genuine virtue. As I will argue in this section, how we characterize neutralizing our identity prejudices is important, especially if it is more of a responsibility than a virtue. The upshot, if testimonial injustice is a mere responsibility, is not that it isn't worth pursuing; it's that we have no robust normative rubric for *excellence* in relation to avoiding testimonial injustice. I explain this first by appealing to the distinction between right action and virtuous action, and second by applying Wayne Riggs's analysis on the deeply deontic nature of testimonial injustice. As I will show, an analysis of full-fledged virtue in relation to testimonial injustice requires further conceptualization.

Linda Zagzebski characterizes intellectual virtues as a subcategory of moral virtues. As such, they share the same overall structure: both are dispositions of emotions as well as dispositions of reliable success in their characteristic ends. However, virtues, on this responsibilist account, are also moral excellences. More specifically, whereas deontic concepts of duty entail merely escaping blame, character virtues aim for the praiseworthy.[12] This conceptual distinction may be illustrated by an example. When students take an exam, the grading rubric may be one of two types. The first type is pass/fail; the second is a gradient from a "A+" to a "low F." A deontic model, which defines right action in terms of "avoiding the wrong," is more akin to the pass/fail distinction of grading; an aretaic model, which aims for moral excellence, is more akin to the "A+" to "low F" spectrum of grading. One advantage of virtue theoretic rubrics is that their primary focus is mapping the contours of "A+ living," not just merely a "passing" behavior.

This is especially important when we examine the culpability for testimonial injustice, as Wayne Riggs does.[13] By a careful exegesis of Fricker's text, Riggs highlights that it is not clear *when* we are culpable for testimonial injustice; moreover, it's not clear exactly for *what* the agent is culpable. Of course, a failure to neutralize one's identity prejudices is an obvious part of the problem, but Fricker's examples seem to yield conflicting judgments as to when we are culpable. For example, though Fricker defines testimonial injustice as occurring whenever a speaker experiences a "credibility deficit owing to the identity prejudice of the hearer," there is an exception made for Herbert Greenleaf, a character in *The Talented Mr. Ripley*.[14] Even though Herbert disbelieves the testimony of Marge Sherwood, Fricker proposes that this is a "non-culpable" instance of testimonial injustice.[15]

As Riggs comments, it's difficult to understand exactly what a "non-culpable injustice" may amount to. On the one hand, Herbert Greenleaf's culpability may be diminished on account of "the critical consciousness of gender" being beyond his reach.[16] Perhaps, this view goes, Greenleaf's behavior would become *culpably* unjust should he have greater opportunity to understand his social situatedness as

12. Zagzebski, *Virtues of the Mind*.

13. Wayne Riggs, "Culpability for Epistemic Injustice: Deontic or Aretetic?," *Social Epistemology* 26.2 (2012): 149–62.

14. Fricker, *Epistemic Injustice*.

15. For those who are unfamiliar with this part of the story, Marge possesses knowledge as to the identity of her husband's killer. Herbert fails to attribute her due credibility with a wave of the hand: "Marge, there's female intuition, and then there's facts."

16. Riggs, "Culpability for Epistemic Injustice."

a man in a male-dominated society and, even then, fail to correct for his biases. On the other hand, Greenleaf clearly attributed less credibility than his speaker was owed. Riggs solves the conflicting intuitions regarding culpability by recasting the "vice of testimonial injustice," plainly and simply, as a form of negligence. In other words, agents are testimonially unjust only when (a) it is reasonable to expect the agent in question to correct their credibility judgements and (b) it is reasonable to expect the agent in question to recognize the harms that would result from a failure to do so.[17]

However, this analysis is deeply deontic in nature. In other words, if Riggs is right, testimonial injustice simply amounts to avoiding harm: it is a type of negligence related to one's identity prejudices. Testimonial justice, then, amounts to doing one's duty and not being negligent. This provides a more satisfactory answer as to when and why agents are culpable. But the price tag on this amendment is forfeiting the notion of testimonial justice as an intellectual character virtue. Since Fricker defines testimonial justice as "not being testimonially unjust," the virtue language used for prejudice-neutralization is misleading. Testimonial justice amounts only to fulfilling one's responsibility.

Riggs' analysis is especially illuminating when we turn back to see how epistemic injustice has played in science.[18] As Grasswick explains, science has been misused to oppress marginalized social groups along such axes as race, class, gender.[19] A specific example of this is the Tuskegee syphilis experiment, which denied black men treatment for syphilis—despite the fact that penicillin was available and recognized as the standard medical response—merely to track the progression of the disease.[20] Surely, testimonial injustice was part of what led to the harms. And as such, the scientists involved were culpable in their negligence according to the two features above: their prejudices prevented them from fully recognizing racial minorities as knowers, and this led to the preventable harms to which the test subjects were subjected.

Above and Beyond Harm-Avoidance: Possible Candidates

This raises a further question: what does it mean for the scientist to act *virtuously* in relation to testimonial injustice? Simply put, virtue theorists must show us exactly what the "A+" looks like, whereas Fricker's "testimonial justice" only shows us what a "passing grade" is. A comprehensive answer is likely too much for a single paper, but I would like to briefly sketch a picture which may at least help fill out the missing parts of our normative rubric. The first part of this section simply explains my overall strategy—appealing to non-*sui generis* character virtues which have *prima facie* relevance to testimonial injustice. I then appeal to an intellectual character virtue specifically relevant to scientists qua researchers, and finally appeal to an intellectual character virtue dealing specifically with the interpersonal dimension of testimonial injustice. My overall goal, then, is to lay the foundation for a genuinely virtue-based rubric concerning testimonial injustice, one which not only avoids harm, but reaches excellence.

17. Ibid.

18. I mention epistemic justice generally, since testimonial injustice is surely not the *only* means by which these science-sponsored harms have taken place; testimonial smothering, testimonial quieting, trust injustice, hermeneutical injustice, etc.—these are all jointly the means by which these harms are perpetuated, when we talk about the history of marginalized groups in relation to science. However, I think that Riggs' argument applies equally well to several of these other types of epistemic injustice as well: these are importantly connected to the foreseeable and preventable harms agents fail to prevent.

19. Grasswick, "Epistemic Injustice in Science."

20. Susan Reverby, *Examining Tuskegee: The Infamous Syphilis Study and Its Legacy* (Chapel Hill: University of North Carolina Press, 2009).

As mentioned, my goal is to provide a normative account that goes above and beyond the harms intrinsic to testimonial injustice. As such, one plausible strategy is to appeal to another intellectual character virtue, such as open-mindedness.[21] On this augmented rubric regarding testimonial injustice, a *wrong* act is avoided by correcting one's prejudices to avoid harm, but a *virtuous* act is reached by exercising open-mindedness. Such is Jack Kwong's contention, when he explains how open-mindedness plays an important normative role in accounting for the goodness and badness of testimonial injustice (along with other "culprit-based" forms of epistemic injustice, for that matter). Thus, we receive the full "A+ to low F" spectrum of evaluation characteristic of virtue ethics, since it also allows us to evaluate acts with greater specificity. Building off his addendum, excellence means exercising the virtue of open-mindedness; being continent with respect to open-mindedness ranks a bit lower; incontinence with respect to open-mindedness (thus allowing prejudices to diminish credibility attributions) ranks a bit lower; and, finally, vicious close-mindedness with respect to others' standpoints is the most morally blameworthy. This "A+ to low F" gradience in normative evaluation is a characteristic advantage of virtue-based rubrics, and Kwong's style of thought is what I seek to emulate here.

As helpful as open-mindedness is in relation to testimonial injustice, this normativity-mapping is not finished. For one thing, Kwong himself suggests that there must be other intellectual character virtues doing the explanatory work.[22] Another issue, however, has to do with the uniqueness of scientists qua investigators. It is not enough for a scientist to be open-minded; a characteristic feature of the scientist is that she *actively seeks* cognitive goods. And though open-mindedness is intuitively important for a scientist's success, the fact that the scientist goes above and beyond this—initiating research projects and seeing them through to the end—suggests, at least on *prima facie* grounds, another virtue.

Lani Watson provides us with a plausible candidate for this additional virtue: the character virtue of inquisitiveness.[23] On her view, the inquisitive agent is characteristically motivated to engage in sincerely good questioning. Here, good questioning always ends at improving epistemic standing, or in Zagzebski's language, "bringing the agent into closer cognitive contact with reality."[24] Such a virtue is partly a matter of perception—i.e., being able to properly ingest the data from the world around her—and partly a matter of question construction—i.e., getting to the "heart" of a particular matter.

We can find an illustration of this virtue in a classroom setting. Imagine an ethics course where the subject matter is utilitarian ethical theories. The student who creates a relevant, sincere, and well-formulated question succeeds in a virtuous act of inquisitiveness. If the question is about what the instructor had for lunch, it fails to reach virtue because of its irrelevance; if the student asks a question merely to impress the instructor (perhaps for a letter of recommendation), the question fails to reach virtue because of its poor motivation; if the question is too confusing in its wording, then it fails to reach virtue because of its formulation. Thus, Watson's conception of inquisitiveness entails excellence in all these criteria of questioning, making the person who characteristically engages in this kind of behavior the possessor of this intellectual character virtue.

So, in at least one sense, the virtuous scientist must concern herself with the virtue of inquisitive-

21. Jack Kwong, "Epistemic Injustice and Open-Mindedness," *Hypatia* 30.2 (2015): 337–51.

22. Ibid.

23. Lani Watson, "What is Inquisitiveness?," *American Philosophical Quarterly* 52.3 (2015): 273–87.

24. Ibid.; Zagzebski, *Virtues of the Mind*.

ness—particularly as she is a researcher.[25] But there is another facet we must account for as well: virtue, in relation to testimonial injustice, deals with agents' relationships to others. That is, inquisitiveness (and open-mindedness, for that matter) has little to say about how to relate to other people *qua* people. In the epistemic sense, they do not tell us what cognitive goods, or even what kinds of cognitive goods, we should prioritize.

Here's another way to frame this problem: inquisitiveness is a virtue which, by and large, a calloused person could exercise.[26] Imagine a scientist who is deeply concerned with figuring out how the human body works and uses human test subjects in her research projects. Such a scientist may be characteristically motivated to ask sincere, relevant, and well-formulated questions. But she may prioritize her curiosities about biology over and above the well-being of the test subjects. That is, her pursuit of cognitive goods needs to be evaluated alongside the criteria of her relationship to others. Appealing to inquisitiveness alone, it is unclear why there is *a specific subset of questions* she ought to consider. Once we isolate this desideratum of scientific inquiry—i.e., how well we relate to others—it stands to reason we should isolate what virtue looks like in particularly in this regard.

A plausible candidate for this is the intellectual character virtue of care, as conceived by Vrinda Dalmiya in her 2002 article "Why Should a Knower Care."[27] Dalmiya first acknowledges that care is intuitively conceived as a moral virtue, and so develops a version of care that is consistent with Linda Zagzebski's model of responsibilist character virtues—i.e., a characteristic disposition of emotions and behavior. However, Dalmiya argues further that care is an *intellectual* character virtue. Her reasoning is that it brings us, in Zagzebski's words, "into closer cognitive contact with reality."

In Dalmiya's view, care (as a moral virtue) is rooted in empathy for the person cared-for, a kind of empathy manifested in the simulation of the cared-for's subjective experience. Moreover, there must be a displacement of interest from the care-giver's experience, favoring that of the person cared-for. This displacement of interest is important because even psychopaths may understand the subjective experiences of their victims; sincerely valuing the other's experience is what makes a moral difference. Care is also characterized as a golden mean between caring too much and caring too little. This kind of care is tempered by feedback from the person cared-for, such that the virtuous caregiver values the cared-for's experience to the right degree. As such, the person who characteristically engages in this type of behavior is virtuously caring.

However, care (as an intellectual virtue) also plays an important role in reorienting the knower's perspective of what is epistemically valuable and what is not. Knowledge-seeking tempered by care is focused not only on true belief collection—but also on whose beliefs they are. The caring knower is cognizant of the complex relationship between herself and her community. As Dalmiya writes, virtuous care-knowing "involves taking a broader look at those who are affected by our attitudes and

25. Watson, "What is Inquisitiveness?" Another way to frame my appeal to inquisitiveness is to recall the work of Phillipa Foot. Her neo-Aristotelian theory asks us to consider the "natural goodness" of a creature—and though scientists are members of the human species, we may also ask what about the characteristic features of the scientific life. Plausibly, inquisitiveness is a central feature in the scientific life and so deserves a place on the normative rubric we seek.

26. This possibility assumes that the "unity of the virtues" thesis is incorrect. Of course, if possession of one virtue entails the possession of all others, then this counterexample would not hold. At the very least, what I aim to show here is that our normative rubric thus far—even with both open-mindedness *and* inquisitiveness—fails to explain the goodness and badness that manifests in the characteristically interpersonal aspects of testimonial injustice.

27. Vrinda Dalmiya, "Why Should a Knower Care?," *Hypatia* 17.1 (2002): 34–52.

by our knowing and at the reasons for our interest in them in the first place."[28] As such, ignoring the expectations of others in our relationships in knowledge-seeking constitutes not only an ethical failure, but an epistemic one. Put simply, virtuous care-knowing points epistemic agents towards the appropriate cognitive goals—based on the particularities of her relationships, not least those of her community.

What's important for our analysis is that care, qua intellectual character virtue, plays an important role in our normative rubric—particularly in the pursuit of the right cognitive goods. Thinking back to our callous yet inquisitive scientist, we can now evaluate her badness and goodness in a virtue-normative framework, since the scientist falls short particularly because her inquisitiveness isn't aimed at the right target. And most importantly, Dalmiya's account gives us a principled understanding of what excellence in this respect would be: valuing not just true nor interesting beliefs, but the subjective-experience of another, constitutes virtuous care.

Again, my overall strategy is to invoke the normative power of other intellectual character virtues when it comes to accounting for what we originally called "testimonial justice." Since Fricker's conception of testimonial injustice seems to amount to merely avoiding harms, it should be augmented with other virtues to provide a fuller picture, one which maps virtues *qua* excellences. As it concerns virtuous scientific inquiry, my first candidate is inquisitiveness, since scientists are characteristically in the business of seeking knowledge and understanding the world. However, my second candidate is the intellectual character virtue of care, since testimonial justice is fundamentally other-regarding. Together, these virtues lay the groundwork for my next section, where I argue that the two virtues are complementary in at least one important sense, helping refine the picture of what virtuous activity—in relation to testimonial injustice—looks like.

Pin-Pointing the "A+": Care-Inquisitiveness

Now that I've laid the foundation for a virtue theoretic addendum to Fricker's rubric, I can refine my target. As explained earlier, the two virtues of inquisitiveness and care seem importantly relevant to the scientist concerned with testimonial injustice. In what follows, I will first show how the two virtues intersect in at least one important way; then, I will show how the exercise of this virtue adequately accounts for the excellence which goes above and beyond specifically testimonial harm; I conclude this section by demonstrating the value of this normative re-structuring.

When thinking about the virtue of inquisitiveness, it's worth digging deeper with respect to what constitutes a valuable question. In other words, there is a matter of "significance, worthiness, and relevance" that a particular question may bring an agent's epistemic standing. As mentioned earlier, a question about what an instructor may have eaten for lunch, if asked during a lecture on utilitarianism, does not count as good questioning because it does not seem to meet the worthwhileness aspect of question-asking. However, our intuition regarding what counts as a "good question" in a classroom setting is partially dependent on the aims of the class. When it comes to good questioning more generally, and especially in science where more open-ended inquiry is not only possible but encouraged, the matter of "significance, worthiness, and relevance," requires further clarification.

28. Ibid.

Roberts and Woods delve into this topic in their work on regulative epistemology.[29] Namely, they highlight that cognitive goods can be "worthy" in more than one sense: some are worthy because of the role they play in human flourishing (e.g., medical discoveries); others are worthy even if they have no practical application (e.g., the age of the universe); others can even be fictional and worth studying (e.g., the mythology of J.R.R. Tolkien's literature). However, I submit that the value of other-related cognitive goods finds a parsimonious explanation in the virtue of care. In the virtue-responsibilist language of Zagzebski, certain cognitive goods are valuable because a caring agent would characteristically seek them. Adding care to Watson's normative rubric has two main advantages.

First, the hybridization of inquisitiveness and care produces a normative standard that is excellence-aimed *independently of avoiding harms*. In other words, it is a genuinely virtue-theoretic and not a mere deontological norm dressed in virtue language. The inquisitive agent who acts from care does so in a way that is "A+" material in a way that is not explanatorily dependent on avoiding negligence. Second, the care-inquisitive agent *will also neutralize her credibility deficits as to avoid harm*, though she will go above and beyond that expectation as well. Since this agent's goals are such that she excellently seeks the cognitive goods which prioritize the wellbeing of others, prejudice neutralization is entailed by the exercise of this virtue.[30] After all, caring about the well-being of those around us is partly constituted by critically assessing and avoiding the ways we may harm them.[31]

It's helpful to provide an exemplar of care-inquisitiveness, for which I turn to my mother. About two years ago, my grandmother (my mother's mother) was diagnosed with an aggressive type of cancer. In light of this news, my mother quickly began personal research into the subject, consulting the appropriate experts on the subjects (family members who practiced medicine, local oncologists, and others). She researched the type of cancer itself, learning about possible side effects of treatment and what different timelines looked like, what kind of diet is best for chemotherapy patients, and so on. In a word, she was sincerely motivated to improve her epistemic standing by engaging in good questioning. According to typical Western cultural and philosophical intuitions, such behavior is clearly within the bounds of care (she would also engage in caring practices which were not distinctively epistemic—e.g., comforting my grandmother, praying with her, etc.) However, what's important to notice for my purposes is that my mother's cognitive goals were not led by a *general* thirst for knowledge and other cognitive goods. Her admirable inquiry was led by her prioritization of the cared-for's subjective experience. In other words, she asked because she cared.

Another way to conceptualize this virtue is to imagine a Venn diagram: in one circle, you find all the acts which count as genuine acts of inquisitiveness; in the other, you find all the acts which count as genuine acts of virtuous care. Where the circles overlap, you find care-inquisitiveness—wherein an agent is genuinely motivated to engage in good questioning not because of her general interest in cognitive goods but because of her care for others. This image of inquisitiveness recognizes the variety

29. Robert Roberts and Jay Wood, *Intellectual Virtues: An Essay in Regulative Epistemology* (Oxford: Clarendon Press, 2007).

30. My account's success is partly dependent on the notion that care, as a virtue, entails caring for people broadly speaking. If the agent only cares for her immediate family members (and is not expected to care beyond this circle), then my proposed normative rubric won't be much help. A full treatment of this objection is beyond the scope of this paper. However, I submit that scientists have a *prima facie* duty to care for their communities. Pre-theoretic intuitions about the moral wrongness inherent in unjust experimentation on minorities, for instance, are rooted in the vice of callousness. And if this intuitive judgement is correct, care is the corresponding trait we should appeal to when explaining moral goodness.

31. Dalmiya, "Why Should a Knower Care?"

in value when it comes to improve epistemic standing—some questions may be valuable since they seek deep truths about the world, others may have instrumental value—but an important subset are valuable simply because they are what a caring agent would seek.

I believe this provides a much better target for scientific virtue as it relates to testimonial injustice. In other words, we now have a clearer picture of excellence as it relates to science, oppression, and testimonial harms. According to my rubric, testimonial injustice occurs with incontinent and vicious character—i.e., when scientists may know they are incontinent with respect to care-inquisitiveness or have a corresponding vice (e.g., callousness).[32] Credibility-reducing identity prejudices will never or seldom be undone unless we self-interrogate with the right motivation and skill. But we now have a more robust rubric for when agents do indeed neutralize identity-prejudices in their hearing: they may characteristically engage in sincerely good questioning, prioritizing the subset of cognitive goods which deal with the well-being of others. Simply put, we have a clearer picture as to how they may reach virtue.

Conclusion

My sketch of virtue in relation to testimonial injustice is, I hope, a small but constructive step in fully mapping the normative terrain of scientific inquiry. In my first section, I highlighted the problem that testimonial injustice plays in science; in the second, I showed that testimonial justice is not a genuine responsibilist virtue, as it amounts to mere harm-avoidance; in the third, I began constructing a virtue-normative response to this lacuna by appealing to the virtues of inquisitiveness and care; finally, I showed how the two virtues may overlap in a single type of activity—care-inquisitiveness. Such a rubric goes over and above the deontic roots of testimonial injustice and brings us closer to understanding what human flourishing looks like.

Though this argument may appear to be a mere philosopher's quibble, the way we conceptualize goodness in with respect to prejudice, responsibility, harm, and virtue is fundamentally important to the way we practice science. It matters to the same degree that "being a violinist" goes above and beyond merely avoiding the sour notes; doing so would severely impair a violinist's growth, since the target is ill-conceived. Instead, conceptualizing violin-playing as reaching for *virtuosity* is far preferable. Thus, we may ask, how should the scientist conceptualize her practice in relation to testimonial injustice: a matter of avoiding harms or reaching for excellence? Virtuosity, in this case, means caring to ask.

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32. Here, one might highlight that many scientists may not see callousness as a vice with respect to scientific inquiry. The idea here is that callousness may actually be something epistemically desirable in research—taking the form of, say, impartiality. I think this is an important point. However, I think that the two concepts remain conceptually distinct: being callous denotes the kind of behavior that we described earlier—of pursing research at the expense of harm caused to other people. Conversely, impartiality denotes a kind of justice with respect to inquiry. If so, then it may highlight the need for a higher-order virtue, such as *phronesis* (roughly, practical wisdom), to adjudicate how and when to be caring rather than impartial—or vice versa. I thank Darcia Narvaez for raising this point in her comments.

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CHAPTER 13.

MAPPING THE LANGUAGE OF HOPE WITHIN EMPIRICAL RESEARCH ONTO VIRTUE THEORY

MICHELLE A. MARVIN

Many dispositions are colloquially referred to as virtues in today's Western society, yet few have inspired as much recent debate over their formal inclusion within a virtue ethics framework as hope. Intuitively, hope is a positive character disposition with potential instrumental value; however, scholars disagree both over how to define hope and whether the cultivation of hope leads to a morally virtuous life. Scholars who favor hope as a moral virtue, such as Luc Bovens and Adam Kadlac,[1] claim that hope's virtuous quality exists in its productive capacity to promote human wellbeing. Scholars who deny hope the status of a moral virtue, such as Christopher A. Bobier and Barbro Fröding,[2] ground their arguments in traditional definitions of virtue, contending that hope is not an intrinsically good disposition of character. This essay argues that the debate is currently irresolvable because contemporary virtue ethics does not give sufficient attention to the diversity of linguistic expressions associated with hope in various empirical research programs.

While maintaining a neutral position about whether hope is a virtue, this essay brings hope language from twentieth and twenty-first-century medical research into dialogue with virtue ethics in order to show that medical cases of hope cannot currently be used to substantiate claims about whether hope is a virtue. Although philosophers sometimes use a terminally ill individual's hope as evidence for or against the claim that hope is a virtue, this essay argues that such evidence is insufficiently qualified to support an argument in either direction. As demonstrated by the qualitative empirical research in medical scientific literature, such as patient surveys and interviews, hope language contains a multiplicity of meanings including expectation and optimism. The purpose of this essay is to provide examples of these meanings within the medicalized language of hope in order to argue that virtue ethicists should give greater attention to the nuance with which hope language is imbued.

I begin by reviewing current positions in the philosophical debate over hope as a moral virtue in order to demonstrate how specific interpretations of hope language play a role in determining whether

1. Luc Bovens, "The Value of Hope," *Philosophy and Phenomenological Research* 59.3 (1999): 667–81; Adam Kadlac, "The Virtue of Hope," *Ethical Theory and Moral Practice* 18 (2015): 337–54.

2. Christopher A. Bobier, "Why Hope is Not a Moral Virtue: Aquinas's Insight," *Ratio* 31.2 (2018): 214–32; Barbro Fröding, "Hope as a Virtue in an Aristotelian Context," *Philosophy, Psychology, & Psychiatry* 19.3 (2012): 183–96.

hope should be included in a virtue ethics framework. Next, given that virtue ethics frequently refers to medical cases of hope, I review the historical landscape that led medical and philosophical communities of the mid-twentieth century to concurrently take up an ethical interest in hope. Finally, as a case study, I analyze the way hope language is used by four terminally ill patients as documented in psychiatrist Elisabeth Kübler-Ross's seminal work *On Death and Dying.*[3] This essay reveals the ways in which hope language is used to express expectation and optimism, dispositions toward the future that are ambiguous in a virtue ethics framework. The conclusion summarizes the challenges that hope language presents for a virtue ethics framework.

The Current Philosophical Debate over Hope as a Moral Virtue

Several virtue ethicists, such as Philippa Foot, Luc Bovens, and Adam Kadlac, argue for the inclusion of hope in a list of moral virtues.[4] In 1978, Foot included hope in a list of virtues in her article "On Virtues and Vices."[5] Situating virtue ethics firmly on the foundations of classical traditions, Foot argues that "… it is best when considering the virtues and vices to go back to Aristotle and Aquinas."[6] Foot interprets virtues as correctives for the development of human character, whereby virtues resist or correct certain temptations and guide a person towards the good life.[7] In her framework, just as courage resists the temptation of cowardice and temperance resists the temptation of pleasure, so hope resists the temptation of despair.[8] Additionally, Foot provides cases where collectively the three virtues of temperance, courage, and hope are necessary to preserve a person's life.[9] By contrasting hope with despair and describing hope's life-preserving capacity, Foot's framework serves as a model for contemporary arguments that favor hope as a moral virtue in both philosophical and medical-scientific literature.

Following Foot's hope and despair dichotomy, philosopher Luc Bovens adopts an Aristotelian lens for his approach to hope within virtue ethics. His 1999 essay "The Value of Hope" laments the notable dearth of attention given to hope as a virtue within philosophical literature.[10] Bovens claims that "hope seems to obey Aristotle's doctrine of the mean. To live one's life well one should not hope too much and not hope too little."[11] This stress on finding hope a mean, or an average between two extremes, frames Bovens's understanding of hope in terms of an Aristotelian virtue. Using dramatized hope from *The Shawshank Redemption* as a case study, Bovens argues that hope's virtue exists as the mean of intrinsic, instrumental benefits.[12] When given a variety of future trajectories, Bovens argues that hope enables the realization of desired outcomes, reduces a focus on possible losses, and incites

3. Elisabeth Kübler-Ross, *On Death and Dying: What the Dying have to Teach Doctors, Nurses, Clergy, and Their Own Families*, 40th anniversary edition (London: Routledge, 2009).
4. Philippa Foot, "Virtues and Vices," in *Virtues and Vices and Other Essays in Moral Philosophy* (Berkeley, CA: University of California Press, 1978), 1–18; Bovens, "The Value of Hope"; Kadlac, "The Virtue of Hope."
5. Foot, "Virtues and Vices."
6. Ibid., 1.
7. Ibid., 8.
8. Ibid., 9.
9. Ibid., 13.
10. Bovens, "The Value of Hope," 669.
11. Ibid.
12. Ibid., 673–78.

new, more realistic hopes.[13] If a person is given guidelines and assistance in cultivating hope, Bovens claims that hope can have an instrumental value that strikes a balance between overconfidence and despair. Balancing hope in order to optimize an individual's wellbeing is a theme from Bovens's work that continues to be addressed in scholarship across the disciplines.

Recent research in favor of hope as a virtue builds upon Bovens's emphasis on hope's intrinsic and instrumental value. Specifically, philosopher Adam Kadlac argues that hope's value is not based on the goodness of its object or its alignment with future realities. Rather, Kadlac contends that hope is virtuous when it promotes a realistic perspective of the future, tempers confidence and avoids pessimism, promotes an attitude of courage, and advances solidarity with others.[14] In situations where hope fails to produce these benefits, Kadlac suggests that hope is tainted by other vices or underdeveloped virtues.[15] For example, if an individual hopes for a particular future but lacks the prudence to recognize that hope deters participation in meaningful activities while awaiting the future, then the virtue of hope is diminished by underdeveloped prudence. For Kadlac, the value that hope provides for guiding an individual's life towards moral ends justifies his position that hope, itself, is a moral virtue.

Despite these perspectives that advocate hope's inclusion in a virtue ethics framework, other scholars oppose hope's status as a moral virtue. Philosopher Barbro Fröding argues that Aristotle often describes hope negatively, especially in cases where hope "…[causes] agents to feel inappropriately confident and trigger vicious self-delusion."[16] In an Aristotelian virtue ethics, overconfidence is linked with excess courage that can lead to imprudent decision-making and harmful consequences. Fröding notes that it is not clear within the Aristotelian account whether hope is "something intrinsically valuable [or] perhaps even necessary to the leading of a good life."[17] Contra Bovens and Kadlac, Fröding contends that an Aristotelian concept of human flourishing holds that virtues are not instrumental in themselves; rather, acting virtuously leads to the realization of flourishing. For Fröding, "agents must develop a deep understanding of a set of virtues. If they are successful in this, they will be able to think, feel, choose, and act in a certain manner that is conducive to their happiness."[18] Thus Fröding suggests that hope may be a component of a virtue, but it does not meet the Aristotelian definition of virtue. Although it is not necessary that contemporary virtue ethics uphold Aristotelian standards, Fröding believes that the current debate over hope appeals to Aristotelian criteria in ways that fail to provide support for the case of hope as a moral virtue.

In further opposition to hope as a moral virtue, philosopher Christopher A. Bobier uses Aquinas's distinction between hope as a passion and hope as a theological virtue to argue that scholars "…have moved too quickly from observing hope's value to positing it as a moral virtue."[19] Bobier uses Aquinas's definition of hope as a passion to argue that the objects of human hopeful desires can be both moral and immoral. While a person may hope for something that is morally good, hope may also

13. Ibid., 670–73.

14. Kadlac, "The Virtue of Hope," 338.

15. Ibid., 351.

16. Fröding, "Hope as a Virtue in an Aristotelian Context," 184.

17. Ibid.

18. Ibid.,

19. Bobier, "Why Hope is Not a Moral Virtue," 232.

be directed towards that which is immoral. Because hope is intrinsically neither good nor evil, other moral virtues, such as prudence, can combine with the passion of hope to support rational moral decision-making. Aquinas does not assign hope to the set of moral virtues, yet he does allow for a specific kind of hope to be understood as a theological virtue. This kind of hope is "… a divinely implanted disposition of the will, or intellectual appetite, to depend on God."[20] Given this definition, Bobier argues that hope as a passion situates an individual towards future outcomes in the world, whereas hope as a theological virtue orients the individual towards hope in God. In this framework, Bobier leaves no room for the possibility of hope as a moral virtue.

While the philosophical community argues over whether or not hope is a virtue, the medical-scientific community assumes that hope has an ethical value that is important for patient well-being. Hope is frequently used to gauge patient disposition and coping capacity, yet qualitative research from medical-scientific scholarship reveals that hope language is fraught with obscurity. Such ambiguity naturally occurs in an interview setting, but this ambiguity has gone largely unaccounted for by virtue ethics scholarship. The multiplicity of meanings in hope language reported in qualitative studies from the medical-scientific community may underlie some of the difficulty that is contributing to determining whether or not hope is a virtue.

The Mid-Twentieth Century: Virtue Ethics and Medical Hope

The tendency for philosophers to use medical cases as evidence of embodied virtues is a practice as old as Greek virtue ethics itself and continues to persist in virtue ethics scholarship on hope today. The twentieth-century interest in hope as a moral virtue is particularly associated with medical cases of hope, although this is not surprising given the development of new medical treatments and cures that allowed for hope in the face of previously devastating diagnoses.[21] The twentieth-century surge of renewed attention in virtue ethics initiated by G. E. M. Anscombe's 1958 article "Modern Moral Philosophy" also coincided with shifts in the philosophy of medical practice, particularly in areas of physician-patient ethics.[22]

As Anscombe began to question the foundations on which secular moral philosophy could prescribe moral obligations, the medical community began to question its own moral responsibility regarding patient diagnoses. In 1951, the Journal of the American Medical Association described how only ten years prior, a cancer diagnosis was "…almost unmentionable between patient and diagnostician, and most persons did not wish to know or expect to be told of such diagnoses."[23] As patients became more acquainted with cancer prognoses and the possibilities of survival, their physicians required additional guidance as to when, and how, terminal diagnoses should be discussed. The American Medical Association acknowledged that physicians were under tremendous pressure to maintain a patient's hope, yet it asserted that it was "important to forestall the possibility of raising false hopes…" while

20. Ibid., 221. Bobier is drawing upon Thomas Aquinas's response to whether hope is a virtue in *Summa Theologiae* II. II. 17. 1.

21. In particular, the development of chemotherapy treatments beginning the 1940s radically changed survival outcomes for patients with cancer diagnoses.

22. G. E. M. Anscombe, "Modern Moral Philosophy," *Philosophy* 33.124 (1958): 1–19.

23. Nathan S. Kline and Julius Sobin, "The Psychological Management of Cancer Cases," *Journal of the American Medical Association* 146.17 (1951): 1547.

providing the patient with "immediate reassurance…so that [the patient] will feel that everything is not hopeless."[24]

The ability to balance and maintain hope became a moral standard for whether or not a physician should reveal the diagnosis of a terminal illness to a patient. This emphasis on finding a balance of hope in order to promote a patient's individual flourishing indicates a shift in the practice of medical ethics away from a physician's moral sense of right and wrong and toward an ethics of patient flourishing. While the changing medical ethics landscape of the 1950s corresponded with Anscombe's transformative vision of moral philosophy, the language of hope within medical research had yet to begin accounting for the multiple meanings that patients could attribute to hope itself.

After the shift towards an ethics of patient flourishing, an emphasis on hope arose in medical-scientific literature on terminal illness. In the 1960s at Billings Hospital of the University of Chicago, psychiatrist Elisabeth Kübler-Ross began to conduct interviews with terminally ill hospital patients about their experience with the dying process. In her seminal 1969 book, *On Death and Dying,* Kübler-Ross reached the same conclusion as the American Medical Association: patients demonstrate the greatest confidence in doctors who balance hope. She writes that "[patients] appreciated it when hope was offered in spite of bad news. This does not mean that doctors have to tell them a lie; it merely means that we share with them the hope that something unforeseen may happen, that they may have a remission, that they will live longer than is expected."[25] Without the option for hope, Kübler-Ross argues, patients decline into despair and give up the fight for life. In one case, a patient stated that his cancer diagnosis

…was more of a blow than it might be because [the doctor] gave me no hope… But after I got [to the hospital] and found out that there was some hope for my condition and that my condition wasn't hopeless, then I found out that I had done the wrong thing…and that if I had only known it at the time I would be in top-notch shape right now.[26]

Upon interpreting this interview, in which the patient further revealed many personal losses including the death of his daughter, Kübler-Ross states that "what grieved him most, however, was the loss of hope."[27] While this vignette appears to exemplify Kübler-Ross's argument on the need for balancing patient hope, a closer look at the way hope is used to mean several different sentiments will provide greater insight into the complexity of locating hope within a medical context.

The Complexity of Hope Language in Elisabeth Kübler-Ross's *On Death and Dying*

In order to appreciate the multiplicity of meanings in hope language within medical-scientific research, I will examine four interviews with terminally ill patients in Kübler-Ross's book *On Death and Dying.* I chose this particular work because Kübler-Ross makes the claim that "…no matter the stage of illness or coping mechanism used, all our patients maintained some form of hope until the last moment."[28] Kübler-Ross's research focuses on the patient experience of the dying process, and

24. Ibid., 1548.

25. Kübler-Ross, *On Death and Dying*, 113.

26. Ibid., 74.

27. Ibid., 88.

28. Ibid., 214.

it is through her elaboration of this process that hope becomes a prominent theme. Through this work, Kübler-Ross influenced the following five decades of medical-scientific research on terminally ill patients; thus her presentation and interpretation of hope language is an important starting point for understanding the multiplicity of meaning in the language of hope.

According to Kübler-Ross, patient hope finds expression in many desires, including the possibility of new medical discoveries, a new drug or serum, a miracle from God, a mistaken X-ray reading, the realization that a pathological slide belongs to another patient, a natural remission, and so forth. From Kübler-Ross's perspective, each of these articulated possibilities reveals that many patients hope toward the same goal: physical survival. However, expressions of hope contain different relations with personal agency, expectation, optimism, grounding within reality, and time to possible fulfilment. The remainder of this essay will focus exclusively on the relationship between hope, expectation, and optimism within Kübler-Ross's patient interviews in conjunction with current scholarship on expectation and optimism in order to demonstrate the degree to which hope may be distinct from these terms.

Throughout Kübler-Ross's work, the word "expectation" is rarely used, especially in relation to patient prospects for future outcomes. According to a 2009 review of hope and expectation in medical literature over the last forty years, expectation is best defined as "…cognitions about future events and experiences [that] derive from subjective assessment of probability that range from the unlikely but possible to the virtually certain."[29] Using this definition of expectation that bases future outcomes on probabilistic reasoning, a 2016 psychiatric study with chronically ill individuals found that patients are more often willing to voice desires for the future in terms of hope than to describe actual expectations.[30] The authors of the study posit that because all forecasted probabilities have the chance of an unfavorable outcome, patients prefer not to hold expectations at all. High expectations leave a patient open to traumatic disappointment and low expectations have a culturally superstitious association with negatively influencing outcomes; therefore expectations are a risky investment.[31] However, patients feel less vulnerable to outcome possibilities when they frame future desires in terms of hope, since hope language allows for the expression of improbable desires.[32] Therefore, hope can disguise a patient's actual expectations with a preference for more desirable outcomes.

Research comparing medical hope with expectation demonstrates that hope is most frequently driven by preferences for future outcomes, whereas expectations are driven by a sense of probability.[33] A patient's preference for hopeful outcomes is often based on personal experiences or the stories told by others, rather than the probabilistic, calculated facts given by statistics.[34] This tendency for patients to use the language of hope in a way that veils expectations is evident in Kübler-Ross's interview transcripts. For example, a woman with a terminal cancer diagnosis named Mrs. A becomes distraught over the knowledge that radiation will result in her sterility. Mrs. A expresses a firm desire to have children, despite her growing cancerous malignancy. Initially, her hopeful preference for having chil-

29. Karen K. Leung, James L. Silvius, Nicholas Pimlott, William Dalziel, and Neil Drummond, "Why Health Expectations and Hopes are Different: The Development of a Conceptual Model," *Health Expectations* 12.4 (2009): 348.

30. Emery R. Eaves, Mark Nichter, and Cheryl Ritenbaugh, "Ways of Hoping: Navigating the Paradox of Hope and Despair in Chronic Pain," *Culture, Medicine, and Psychiatry* 40 (2016): 42.

31. Ibid., 50.

32. Ibid.

33. Leung, et al, "Why Health Expectations and Hopes are Different," 348.

34. Ibid., 347–60.

dren and overcoming her malignancy without treatment results in her resistance to medical consultation. However, her preferential perspective eventually yields to probability: Mrs. A chooses to forsake the possibility of bearing children and undergoes radiation treatment, "hoping that this treatment might cure the malignancy."[35] In this statement, Mrs. A's hope represents expectation: a subjective assessment of the probability that her malignancy will not resolve without treatment, as the doctors have stated. While Mrs. A never uses the word expectation, she expects that her medical treatment will be successful and no longer holds the preferential hope that she will bear children. Although Kübler-Ross does not distinguish between hope and expectation when interpreting this interview, this close review of her case suggests that a subtle shift in future prospection has taken place in her interviewee.

A second case study demonstrates the use of hope language to disguise expectation. In the transcript of an interview with a farmer named Mr. Y who had never previously been to the city or the hospital, Kübler-Ross describes the distressed state of a hopeful and frantic man who was waiting for news about his terminally-ill wife's recovery. Even though Mr. Y was very uncomfortable in the city hospital setting, Kübler-Ross writes that "…the big hospital bore the promise of extending [his wife's] life and he, the old man from the farm, was willing to venture into such a place for the glimpse of hope that it had offered."[36] Mr. Y's "glimpse of hope" was more than an uncertain longing for his wife's survival. His hope was invested in the "promise of extending [his wife's] life," indicating that he had high expectations that his investment in the unusual place and hospital culture would result in the benefit of his wife's survival. Mr. Y's hope had shifted from a preference of nurturing his wife back to health on his farm, to a subjective assessment of the probability that her terminal illness would not find relief without the resources of the city hospital. As in the interview with Mrs. A, this case demonstrates that a shift in the meaning of hope had taken place for Mr. Y, even though the language of hope remained the same.

As with the term expectation, there are occasions when optimism would be a better descriptor for the patient's intentions than hope, and yet the patients in Kübler-Ross's interviews do not use the word optimism. A 2013 psychological study suggests that hope is distinguishable from optimism because hope requires both personal agency and pathways towards favorable outcomes, whereas optimism requires only a generalized positive outlook on the future.[37] These criteria suffice to demonstrate that there are distinctions between hope and optimism that patients intend to express even when they only use the word hope. For example, in Kübler-Ross's interview with a woman named Mrs. C, the patient states that "nobody knows how long this can still last. I surely have always held onto hope, but this is the lowest I have ever been. The doctors have not revealed anything to me."[38] Even though Mrs. C is in her lowest affectual state, her desire to live is framed in an attitude of general optimism rather than an expression of specific pathways towards success such as cures or treatments. She claims that she has "always held on to hope," yet her hope is not linked with any particular method of recovery nor with her own action towards the goal of survival; therefore her hope is an indiscriminate optimism towards the future.

35. Kübler-Ross, *On Death and Dying*, 27.

36. Ibid., 135.

37. Gene M. Alarcon, Nathan A. Bowling, and Steven Khazon, "Great Expectations: A Meta-Analytic Examination of Optimism and Hope," *Personality and Individual Differences* 54 (2013): 822.

38. Kübler-Ross, *On Death and Dying*, 176.

Similarly, Kübler-Ross questions a patient named Mr. H about what motivates him to continue living, despite his terminal condition. Mr. H responds by stating: "well, it's a kind of blind hope more than anything else."[39] Mr. H's hope is "blind" in the sense that he does not foresee a path towards ensuring his survival, nor a role that he can play that would result in a favorable health outcome. His hope, therefore, is also an expression of generalized optimism. In these two cases, each patient uses the word hope to describe experiences of optimism, though Kübler-Ross interprets these accounts as expressions of hope. As demonstrated in these case studies, research on expectation and optimism from the fields of medical science is just beginning to provide tools for analyzing and interpreting the multiplicity of meaning that lies beneath the language of hope in medical contexts.

Conclusion

As shown by these four cases, expectation and optimism separately play dominant roles in what patients mean when they use the word hope to the degree that expectation and optimism may be distinct from hope, though still called hope within qualitative research. Although I cited specific psychiatric and psychological studies acknowledging distinctions between hope, expectation, and optimism, the majority of scholarship conflates these terms or uses the terms ambiguously. While arguments for the inclusion of hope within a virtue ethics framework assert that hope obeys an Aristotelian mean, it is unclear whether expectations may adhere to an Aristotelian mean, whether optimism is distinct from hope's extreme of overconfidence, and whether hope can be uniquely defined apart from optimism or expectation. In the philosophical debate over whether or not hope is a moral virtue, the degree to which expectation and optimism may themselves be considered virtuous, or assist in the virtuous life, requires further deliberation. By examining the subtleties in hope language, this essay has argued for virtue ethics to give greater attention to the diversity of linguistic expressions associated with hope in empirical research programs.

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39. Ibid., 81.

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CHAPTER 14.

VIRTUE IDEALS AND THE SCIENTIFIC RESEARCHER: MORALITY, WISDOM, AND CLIMATE

TIMOTHY S. REILLY AND DARCIA NARVAEZ

There is increasing interest in the role of virtues in the development of scientists and in the practice of science, visible in scholarship on virtue epistemology,[1] epistemic cognition,[2] and intellectual and scientific virtue.[3] However, little research has tied this burgeoning interest into a more comprehensive psychological consideration of scientific character in light of virtue theory.

This paper begins to address this gap, presenting preliminary results from a survey of scientists' conceptions of virtue and correlating them with personality traits relevant to virtue and character. We explored the relationship between conceptions of virtue and aspects of morality and ethics. Virtue, as defined in this paper, refers to an excellent disposition that allows individuals to achieve the ends relevant to their practices. A disposition refers to a tendency to act in certain ways in relevant situations, especially with regard to a practice domain.[4] As such, we adopt the lenses of personality and moral psychology in order to examine participant perceptions of virtue in science. Virtue is differentiated from character in that virtues are particular ideal qualities while character is the realization of such qualities in an individual. Thus, a person of "high" character is closer to the ideal of virtue than a person of "low" character.

Virtue and Moral Behavior

Recent research on virtues as traits has converged on a tripartite model of virtue: intellectual virtue, intrapersonal/self-regulatory virtue (e.g., self-control), and caring/interpersonal virtue.[5] But rather

1. Jason S. Baehr, *The Inquiring Mind: On Intellectual Virtues and Virtue Epistemology* (New York: Oxford University Press, 2011).
2. For example, Clark A. Chinn, Ronald W. Rinehart and Luke A. Buckland, "Epistemic Cognition and Evaluating Information: Applying the AIR Model Of Epistemic Cognition," in *Processing Inaccurate Information: Theoretical and Applied Perspectives from Cognitive Science and the Educational Sciences*, edited by David Rapp and Jason Braasch (Cambridge, MA: MIT Press, 2014), 425–53.
3. Daniel J. Hicks and Thomas A. Stapleford, "The Virtues of Scientific Practice: Macintyre, Virtue Ethics, and the Historiography of Science," *Isis* 107.3 (2016): 449–72; Robert C. Roberts and W. Jay Wood, *Intellectual Virtues: An Essay in Regulative Epistemology* (New York: Oxford University Press, 2007).
4. For example, Melissa Sommerfeld Gresalfi, "Taking Up Opportunities to Learn: Constructing Dispositions in Mathematics Classrooms," *The Journal of the Learning Sciences* 18.3 (2009): 327–69.
5. Robert E. McGrath, Michael J. Greenberg, and Ashley Hall-Simmonds, "Scarecrow, Tin Woodsman, and Cowardly Lion: The Three-

than discussing virtue at the abstract level of the decontextualized person, the present project explores virtue in practice, including *intellectual* virtue. However, in our prior work[6] we found that the caring aspect of virtue is, with scientists, perhaps better conceptualized as *relational* virtue, and that *self-regulatory* virtue, stemming from conversation with ethicists, may be better considered as *role-related* virtue. In addition, we assessed virtues in two ways, as general ideals for scientists (*domain ideals*) and as *personal ideals*. In sum, we examined three types of virtue (intellectual, relational, role-related) in two ways, according to the respondent's ideals for self (personal ideals) and for the domain of science (domain ideals).

Scholars studying virtue and character are interested in the relevance of virtue traits to other aspects of moral and optimal functioning. Here we focused on (1) moral reasoning, (2) moral identity, (3) wisdom, (4) workplace climate, and (5) moral behavior. Each of these topics has received substantial attention, though these aspects of moral functioning have rarely been considered in concert with virtue ideals.

Beginning with the 1983 work of Kohlberg and his colleagues,[7] moral reasoning has been central to moral psychology for decades, though research suggests that in many cases it has only limited correspondence with moral behavior.[8] Despite its limitations, moral reasoning is associated with intellectual virtue, given its highly reflective cognitive nature. The Defining Issues Test (DIT)[9] has become a standard approach to assessing moral judgment development generally and its relation to performance in various domains. The DIT documents conceptions of fairness that develop toward greater inclusiveness with maturation and intense and diverse social experience.[10]

Moral identity, the centrality of moral concerns to the self-concept, helps bridge the gap between moral reasoning and action.[11] Moral identity is closely related to social perception, such as the chronic

Factor Model of Virtue," *The Journal of Positive Psychology* 13.4 (2017): 373–92; Darcia Narvaez, "Triune Ethics: The Neurobiological Roots of Our Multiple Moralities," *New Ideas in Psychology* 26 (2008): 95–119; Darcia Narvaez, *Neurobiology and the Development of Human Morality: Evolution, Culture and Wisdom* (New York: W.W. Norton, 2014); Daeum Park, Eli Tsukayama, Geoffrey P. Goodwin, Sarah Patrick, and Angela L. Duckworth, "A Tripartite Taxonomy of Character: Evidence for Intrapersonal, Interpersonal, and Intellectual Competencies In Children," *Contemporary Educational Psychology* 48 (2017): 16–27; Willibald Ruch, "Character Strengths and Positive Outcomes in Different Life Domains," paper presented at the Fifth World Congress on Positive Psychology, Montreal, QC, Canada, 2017.

6. Timothy Reilly and Darcia Narvaez, "Virtue and the Scientific Researcher: Understanding the Personality and Character of Scientists," poster presented at the American Educational Research Association, New York, NY, 2018.
7. Lawrence Kohlberg, Charles Levine and Alexandra Hewer, "Moral Stages: A Current Formulation and a Response to Critics," *Contributions to Human Development* 10 (1983): 174.
8. Daniel K. Lapsley, "Moral Stage Theory," in *Handbook of Moral Development,* edited by Melanie Killen and Judith Smetana (Mahwah, NJ: Erlbaum, 2006), 37–66; Lawrence J. Walker, Jeremy A. Frimer, and William L. Dunlop, "Varieties of Moral Personality: Beyond the Banality of Heroism." *Journal of Personality* 78.3 (2010): 907–42.
9. James R. Rest and Darcia Narvaez, *Guide for Defining Issues Test-2* (Minneapolis: University of Minnesota Center for the Study of Ethical Development, 1998).
10. Darcia Narvaez and Patrick L. Hill, "The Relation of Multicultural Experiences to Moral Judgment and Mindsets," *Journal of Diversity in Higher Education* 3.1 (2010): 43–55; James R. Rest, Darcia Narvaez, Muriel Bebeau, and Stephen Thoma, *Postconventional Moral Thinking: A Neo-Kohlbergian Approach* (Mahwah, NJ: Erlbaum, 1999).
11. Augusto Blasi, "Bridging Moral Cognition and Moral Action: A Critical Review of the Literature," *Psychological Bulletin* 88 (1980): 1–45.

accessibility of constructs that guide behavior,[12] as well as to moral action.[13] Individuals with a strong moral identity are more likely to see situations in moral terms and to be strongly motivated to act in moral ways in these situations. Because moral identity concerns social values, we expect it to be most closely related to caring/interpersonal virtue ideals.

Wisdom has been a topic of research for some time, with varying conceptions emerging in the literature. We focus here on practical wisdom, adopting a definition that includes six components: (1) decision making, (2) emotional regulation, (3) pro-social orientation, (4) insight, (5) tolerance for divergent values, and (6) decisiveness.[14] We expected practical wisdom, while overlapping with intellectual and interpersonal virtue, to be most strongly associated with role-related virtue.

It is also important to consider the role of context when considering virtue because different situations call for different virtue expression. We focused our attention on three reliable aspects of ethical climate that have particular relevance to the practice of science: (1) self-interest (members of the lab are primarily interested in work for self-advancement), (2) team interest (members of the lab are interested in the good of the lab as a whole), and (3) public interest (members of the lab are interested in what is good for the field and the public).[15]

We also examined moral behavior. Whereas intellectual virtue, as commonly understood, may not relate directly to moral behavioral outcomes, intrapersonal and interpersonal virtue are presumed to be related to behavior. Two common measures of moral behavior in work contexts like that of laboratory science are organizational citizenship behavior (OCB), morally praiseworthy behavior in the organizational context, and counterproductive work behavior (CWB), which captures morally culpable behavior in the work context.[16] Using a psychological model of character, prior studies of these constructs demonstrated that greater character leads to more OCB and less CWB.[17] In addition, ethical climate moderates OCB, with a stronger ethical climate predicting more OCB.[18]

The Present Study

The aim of this study was to explore the nature of virtue ideals among scientists and relate those con-

12. John A. Bargh, Wendy J. Lombardi, and E. Tory Higgins, "Automaticity of Chronically Accessible Constructs in Person X Situation Effects on Person Perception: It's Just a Matter of Time," *Journal of Personality and Social Psychology* 55.4 (1988): 599–605; Darcia Narvaez, Daniel K. Lapsley, Scott Hagele, and Benjamin Lasky, "Moral Chronicity and Social Information Processing: Tests of a Social Cognitive Approach to the Moral Personality," *Journal of Research in Personality* 40.6 (2006): 966–85.
13. Karl Aquino and Americus Reed, "The Self-Importance of Moral Identity," *Journal of Personality and Social Psychology* 83.6 (2002):1423–40; Taya R. Cohen and A.T. Panter, "Character Traits in the Workplace," in *Character: New Directions from Philosophy, Psychology, and Theology,* edited by Christian B. Miller, R. Michael Furr, Angela Knobel, and William Fleeson (New York: Oxford University Press, 2015), 150–63.
14. Michael L. Thomas, Katherine J. Bangen, Barton W. Palmer, Averria S. Martin, Julie A. Avanzino, Colin A. Depp, Danielle Glorioso, Rebecca Daly, and Dilip V. Jeste, "A New Scale for Assessing Wisdom Based on Common Domains and a Neurobiological Model: The San Diego Wisdom Scale (SD-WISE)," *Journal of Psychiatric Research* 108 (2017): 40–47.
15. John B. Cullen, Bart Victor, and James W. Bronson, "The Ethical Climate Questionnaire: An Assessment of its Development and Validity," *Psychological Reports* 73.2 (1993): 667–74.
16. E.g., Cohen and Panter, "Character Traits in the Workplace"; Taya R. Cohen, A.T. Panter, Nazli Turan, Lily Morse and Yeonjeong Kim, "Moral Character in the Workplace," *Journal of Personality and Social Psychology* 107.5 (2014): 943–63.
17. Cohen and Panter, "Character Traits in the Workplace."
18. Yuhyung Shin, "CEO Ethical Leadership, Ethical Climate, Climate Strength, and Collective Organizational Citizenship Behavior," *Journal of Business Ethics* 108.3 (2012): 299–312.

ceptions to other measures of morality and behavior. We developed a survey measure of virtue ideals for the practice of science,[19] assessing personal ideals and ideals for the domain of science. Factor analysis indicated three factors: intellectual, relational and role-related. Here we compared scores on this measure to scores on a variety of trait measures considered to be relevant to scientific virtue. Several research questions were explored. Do ideal conceptions of virtue relate to personality traits that can be considered virtuous in science and, if so, how? Do ideal virtue scores predict respondents' self-reported moral behavior? Specific hypotheses were that (1) the intellectual virtue ideals would correspond most closely with scores on moral reasoning and wise insight, (2) role-related virtue ideals would correspond most closely with wise decisiveness and emotional regulation, and (3) relational virtue ideals would correspond most closely with communal imagination identity. We also predicted that (4) personal ideals would predict work behavior more strongly than domain ideals and that (5) personal ideals would predict work behavior over and above the effects of ethical climate.

Method

Participants and Procedure

A panel sample of 259 U.S. based laboratory scientists, recruited by Qualtrics, completed our survey. Roughly three-fifths of the scientists (n=156) worked in university settings and the rest in non-university settings (n=103). The sample was 64% male, ranging in age from 22 to 78 (M = 45.03, SD = 10.90). Participants reported being active in science for on average 21.4 years (SD=10.02); ethnicity was 51% white, 33% Asian American, and 16% other racial and ethnic backgrounds (combined percentage of African American, Native American, Hispanic/Latino, Immigrant, and Multiracial). Participants completed the survey online through Qualtrics survey software and were compensated monetarily for their time.

Measures

The Virtue Ideals in the Practice of Science (VIPS) measure was developed and validated by an interdisciplinary team of theologians, philosophers, science and technology studies scholars, and psychologists.[20] See Table 1 for a summary of the resulting constructs. The 30 items are administered in two ways, first with the following focus to elicit domain ideals for scientists generally (VIPS-DI): "How a good scientist *ideally* behaves within the laboratory." The same items are administered with a focus on personal ideals (VIPS-PI): "How I would *ideally* behave in my scientific work." Each item is presented with parenthetical descriptors, for example "Accountability (Holding others accountable to relevant norms and laws as appropriate)" and "Generosity (Voluntarily sharing time, resources, talents, or inventions)." The only direct mention of scientists and science is in the initial prompts for focus, and not in the items themselves. Prior analyses have indicated no significant effects of social desirability and ongoing analyses[21] indicate reliability and validity of these factors across multiple samples.

19. Reilly and Narvaez, "Virtue and the Scientific Researcher."

20. Ibid.

21. Timothy Reilly, Xiao Liu, and Darcia Narvaez, *Virtue in the Practice of Science: A Three Wave Validation Study* (manuscript in preparation, 2019).

Virtue in the Practice of Science Facets, Descriptions, and Associated Characteristics

Intellectual Virtue
Concern for and excellence in pursuing truth, primarily aligned with philosophical conceptions of the 'Practical Intellect'
Key Virtues: Creativity, Curiosity, Imagination, and Insight
Role Virtue
Align roughly with the Thomistic concept of justice.
Key Virtues: Responsibility, Accountability, Meticulousness, Objectivity
Relational Virtue
Concern for and excellence in pursuing beauty and the good
Key Virtues: Perspective Taking, Empathy, Generosity, Good Will, Love of Beauty

Table 1.

The survey also included personality and climate measures relevant to virtue and moral outcomes.

(1) For moral reasoning, we utilized a short form of the Defining Issues Test-2,[22] a measure of moral judgment development. The DIT is a multiple-choice measure where respondents rate and rank preferred types of moral reasoning (coded by personal interests, maintaining norms, or postconventional) in response to diverse hypothetical dilemmas. We used the most common score, the postconventional score.

(2) For moral identity, we used Triune Ethics Orientation Communal Imagination,[23] which asks respondents to "Please respond to your views of how you are in SOCIAL SITUATIONS" and presents a short list of words representing a particular mindset. For Communal Imagination, the terms are "humanitarian, neighborly, inclusive, broad-minded." The list of terms is followed by four statements regarding self-perception of those characteristics (e.g., "My friends think I have these characteristics;" "I strongly desire to be like this") that respondents rate on a Likert-type scale (1 = *strongly disagree*, 5 = *strongly agree*). Higher scores indicate greater affiliation with the ethical orientation.

(3) We used the San Diego Wisdom Scale (SD-WISE),[24] a Likert-type measure of wisdom with six subscales: (a) social advising (e.g., "I am good at perceiving how others are feeling"); (b) insight (e.g., "I avoid self-reflection"—reversed); (c) prosocial behavior (e.g., "I treat others the way I would like to be treated"); (d) tolerance for divergent values (tolerance; e.g., "I enjoy learning things about other cultures"); (e) decisiveness (e.g., "I usually make decisions in a timely fashion"); and (f) emotional regulation (e.g., "I have trouble thinking clearly when I am upset"—reversed).

(4) Climate measures were included to account for the influence of social context on pressures to act in prosocial and antisocial (roughly moral and immoral) ways. We measured workplace climate, specifically ethical climate, using adapted Ethical Climate subscales:[25] (a) self-interest ("In this lab peo-

22. Rest, Narvaez, Bebeau, and Thoma, *Postconventional Moral Thinking*.

23. Darcia Narvaez, Alexandra Thiel, Angela Kurth and Kallie Renfus, "Past Moral Action and Ethical Orientation," in *Embodied Morality: Protectionism, Engagement and Imagination,* edited by Darcia Narvaez (New York: Palgrave-Macmillan, 2016), 99–118.

24. Thomas, et al, "A New Scale for Assessing Wisdom Based on Common Domains and a Neurobiological Model."

25. Cullen, Victor, and Bronson, "The Ethical Climate Questionnaire."

ple are mostly out for themselves"), (b) team interest ("The most important concern is the good of all the people in the lab," and (c) public interest ("People in this lab have a strong sense of responsibility to the outside community.") We also measured perceptions of social support.[26]

(5) Moral behavior was assessed with organizational citizenship behavior (OCB),[27] a measure of prosocial behavior within an organizational (typically work) context, and with counterproductive work behavior (CWB),[28] a measure of antisocial behavior within the same kind of context. Prior work suggests that these measures can be treated as measures of moral behavior.[29]

Results

Descriptive Statistics and Correlations

Descriptive statistics, correlations and reliability statistics (Cronbach's alphas) for key variables were calculated including Virtue Ideals in the Practice of Science subscales: domain ideals (VIPS-DI) and personal ideals (VIPS-PI) and their three facets (intellectual, role, relational). Means, standard deviations, ranges, and alphas for measures are listed in Table 2. See Table 3 for correlations.

26. Gregory D. Zimet, et al, "The Multidimensional Scale of Perceived Social Support," *Journal of Personality Assessment* 52.1 (1988): 30–41.

27. Suzy Fox, et al, "The Deviant Citizen: Measuring Potential Positive Relations Between Counterproductive Work Behaviour and Organizational Citizenship Behavior," *Journal of Occupational and Organizational Psychology* 85.1 (2012): 199–220.

28. Paul E. Spector, et al, "The Dimensionality of Counterproductivity: Are All Counterproductive Behaviors Created Equal?," *Journal of Vocational Behavior* 68.3 (2006): 446–60.

29. Cohen and Panter, "Character Traits in the Workplace."

Measure Descriptives (Means and Standard Deviations) and Reliability Statistics (Cronbach's Alpha).

Variable	Long Variable Name	N	Mean	SD	Alpha
VIRTUE IDEALS IN PRACTICE OF SCIENCE (VIPS)					
Domain-Int	VIPS-Domain-Intellectual	259	4.47	0.43	0.83
Domain-Role	VIPS-Domain-Role	259	4.37	0.51	0.76
Domain-Rel	VIPS-Domain-Relational	259	3.82	0.62	0.82
Personal-Int	VIPS-Personal-Intellectual	259	4.5	0.47	0.76
Personal-Role	VIPS-Personal-Role	259	4.57	0.40	0.88
Personal-Rel	VIPS-Personal-Relational	259	4.10	0.62	0.89
ETHICAL CLIMATE					
Support	Social Support	259	5.66	0.98	0.93
Self	EC- Self Interest	259	3.75	1.23	0.79
Team	EC- Team Interest	259	4.64	1.06	0.86
Public	EC- Public Interest	259	4.93	0.99	0.76
MORALITY					
Reasoning	DIT Postconventional Reasoning	224	35.7	15.8	-
Communal	Communal Imagination Orientation	259	4.06	0.60	0.83
WORK BEHAVIOR					
Citizenship	Organizational Citizenship Behavior	259	2.96	0.69	0.88
Counterproductive	Counterproductive Work Behavior	259	1.40	0.54	0.87
WISDOM					
Advising	Wise-Advising	251	3.75	0.53	0.64
Decisive	Wise-Decisiveness	251	3.53	0.70	0.69
Emotion Reg	Wise- Emotion Regulation	251	3.41	0.64	0.66
Insight	Wise-Insight	251	3.85	0.60	0.70
Prosocial	Wise-Prosocial Orientation	251	4.06	0.64	0.74
Tolerance	Wise-Tolerance	251	4.05	0.58	0.80

Table 2.

Correlation Matrix

	Domain			Personal			Climate			Morality			Wisdom					Behavior	
Variable	Int	Role	Rel	Int	Role	Rel	Self	Team	Pub	SO	Com	Reas	Ad	Dec	EM	In	Pro	Tol	OCB	CWB
VIRTUE IDEALS IN PRACTICE OF SCIENCE (VIPS)																				
Domain-Int	-																			
Domain-Role	.72***	-																		
Domain-Rel	.59***	.63***	-																	
Personal-Int	.58***	.46***	.43***	-																
Personal-Role	.52***	.68***	.46***	.65***	-															
Personal-Rel	.46***	.44***	.47***	.58***	.61***	-														
ETHICAL CLIMATE																				
Self	-.11	-.09	.01	-.07	-.10	-.05	-													
Team	.19**	.14*	.17**	.20**	.17	.07	-.13**	-												
Public	.18**	.13*	.14***	.13**	.13**	.05*	-.13**	.59***	-											
Support	.17**	.13*	.17**	.14**	.25***	.23***	-.10**	.26***	.26***	-										
MORALITY																				
Communal	.23***	.24***	.27***	.24***	.25***	.13***	-.06	.10**	.21***	.25***	-									
Reasoning	.17*	.12	.06	.16*	.12	.02	-.19**	-.04	-.01	.11	.08	-								
WISDOM																				
Advising	.23***	.26**	.14*	.26**	.13**	.16**	-.14*	.10**	.19**	.28***	.16***	.06	-							
Decisiveness	.07	.06	.06	.03	.08	.03	.12	.03	.01	.14*	.08	.13	.36***	-						
Emotion Regulation	.11	.12	.08	.07	.13*	.08*	-.13*	.11	.19**	.25***	.21***	.03	.40***	.40***	-					
Insight	.31***	.33***	.16	.32***	.36***	.19***	.20***	.05	.05	.22***	.26***	.26***	.34***	.34***	.34***	-				
Prosocial	.31***	.26***	.12	.32***	.18***	.26***	.19***	.07	.10	.18***	.16***	.14*	.44***	.33***	.34***	.48***	-			
Tolerance	.30***	.24***	.23***	.28***	.16***	.17***	.11	.08	.06	.22***	.15***	.12	.31***	.17*	.19***	.18***	.39***	-		
BEHAVIOR																				
Citizenship	.15*	.12***	.09*	.17*	.11*	.12***	.05	.10	.07	.18**	.20***	.06	.26***	.10	.10	.11	.01	.18**	-	
Counterproductive	-.25***	-.19**	-.01	-.19***	-.16***	-.11*	-.25***	-.03	-.04	-.13	-.05	-.09	-.15*	-.25	-.11	-.13***	-.13**	-.26***	.36***	-

For VIPS ideals Int= Intellectual and Rel = Relational. For Ethical Climate, Self = Self-interest, Team = Team-Interest, and Public = Public-Interest. Support = Social Support, Communal = Communal Imagination Orientation, Reasoning = DIT Postconventional Score, Wisdom denotes subscales of the San Diego Wisdom Scale, Tolerance = Tolerance for Divergent Views, Citizenship = OCB, Organizational Citizenship Behavior, Counterproductive = CWB, Counterproductive Work Behavior.

* = p<.05, ** p<.01, *** p<.001

Table 3.

Virtue Ideals in the Practice of Science Regressions

Regression models were used to test the strength of unique variance accounted for by predictors when combined. The models were constructed on each subscale of the Virtue Ideals in the Practice of Science measure (VIPS-DI, VIPS-PI) by facet (intellectual, role, relational). Based on theory and

significant correlations, we set up three models to test across dependent variables. Model 1 included morality, specifically, communal imagination as the predictor (and included postconventional reasoning only for the intellectual virtue regression). Model 2 added wisdom (advising, insight, prosocial behavior, and tolerance), excluding decisiveness and emotion regulation given low correlations with the outcome variables (for relational virtue wisdom insight was excluded). The final model, Model 3, added age as a control variable to assess whether it accounted for significant variance beyond our hypothesized predictors. A regression was conducted for each dependent variable and these are presented as follows: intellectual virtue (personal, domain), role virtue (personal, domain), and relational virtue (personal, domain).

Intellectual virtue regressions are listed in Table 4. For *personal ideals*, Model 1 showed significant effects for post-conventional reasoning (β = .136, $p < .05$) and communal imagination (β = .198, $p < .01$). In Model 2 only wise insight (β = .202, $p < .01$) was a significant predictor. Age was not significantly predictive in Model 3, though wise insight (β = .205, $p < .01$) remained a significant predictor. Model 2 provided the best fit to the data (Adjusted $R2$ = .13, $F(6, 195) = 5.79$, $p < .001$). For *domain ideals*, Model 1 showed significant effects for only communal imagination (β = .207, $p < .01$). In Model 2 wise insight (β = .207, $p < .01$) and wise tolerance (β = .169, $p < .05$) were the significant predictors. Model 3 showed no significant effect of age, though wise insight (β = .209, $p < .01$) and wise tolerance (β = .170, $p < .05$) remained significant predictors. Model 2 also provided the best fit to the data for domain ideals of intellectual virtue (Adjusted $R2$ = .15, $F(6, 195) = 7.04$, $p < .001$).

Standardized Beta Coefficients and Model Fit Statistics for Regressions Predicting Intellectual Ideals (n=202)

	Personal Intellectual Ideals			Domain Intellectual Ideals		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Moral Reasoning	.136*	.076	.063	.128	.064	.057
Communal Imagination	.198**	.121	.116	.207**	.091	.088
Wisdom- Advising		-.100	-.094		-.059	-.056
Wisdom- Insight		.202**	.205**		.207**	.209**
Wisdom- Prosocial		.085	.073		.120	.114
Wisdom - Tolerance		.155	.157		.169*	.170*
Age			.111			.059
Adjusted R^2	.05	.13	.13	.05	.15	.15
ΔF		5.26***	2.79	6.50**	6.93***	0.79
F statistic	6.32**	5.79***	5.41***	6.5**	7.04***	6.14***

Notes: * = p<.05, ** p<.01, *** p<.001. All coefficients are standardized.

Table 4.

Regression results for role virtue are presented in Table 5. For *personal ideals*, Model 1 included only communal imagination (β = .198, $p < .01$). Model 2 added wisdom (advising, insight, prosocial behavior, and tolerance), with wise insight (β = .215, $p < .01$) and wise prosocial behavior (β = .282, $p < .001$) as significant predictors. Model 3 added age, though wise insight (β = .215, $p < .01$) and wise prosocial behavior (β = .286, $p < .001$) remained as the only significant predictors. Model 2 showed the best model fit (Adjusted $R2$ = .20, $F(5, 222) = 12.16$, $p < .001$). For *domain ideals*, Model 1 included communal imagination (β = .200, $p < .01$) as the sole predictor. Model 2 added wisdom (advising, insight,

prosocial behavior, and tolerance), with wise insight (β = .231, $p < .001$) the sole significant predictor. Model 3 added age, with wise insight (β = .231, p < .001) again as the sole significant predictor. Among the domain ideals models, Model 2 showed the best model fit (Adjusted *R2* = .11, $F(5, 222) = 6.81$, $p < .001$). These results indicate that wise insight and prosocial behavior explained the most variance in personal ideals-role virtue ratings, and that when wisdom scales were included as predictors, they took up the variance accounted for by communal imagination. Age provided no additional variance coverage. VIPS-PI role virtue was predicted more reliably than VIPS-DI role virtue by these variables (see Table 5 to compare adjusted *R2* and *F*).

Standardized Beta Coefficients and Model Fit Statistics for Regressions Predicting Role Ideals (n=228)

	Personal Role Ideals			Domain Role Ideals		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Communal Imagination	.198**	.065	.067	.200**	.090	.088
Wisdom-Advising		-.118	-.12		.036	.037
Wisdom-Insight		.215**	.215**		.231***	.231***
Wisdom-Prosocial		.282***	.286***		.130	.127
Wisdom - Tolerance		.097	.095		-.006	-.005
Age			-.033			.025
Adjusted R^2	.03	.20	.19	.04	.11	.11
ΔF	9.19**	12.44***	0.3	9.43**	5.95***	0.16
F Statistic	9.19**	12.16***	10.15***	9.43**	6.81***	5.68***

Notes: * = p<.05, ** p<.01, *** p<.001. All coefficients are standardized.

Table 5.

Regressions for relational virtue are listed in Table 6. For *personal ideals*, Model 1 included only communal imagination (β = .295, $p < .001$). Model 2 added wisdom (advising, prosocial behavior, and tolerance), with communal imagination remaining the sole significant predictor (β = .252, $p < .001$). Model 3 added age, with communal imagination remaining the sole significant predictor (β = .250, $p < .001$). Model 1 showed the best model fit (Adjusted *R2* = .08, $F(5, 222) = 21.62$, $p < .001$). For *domain ideals*, Model 1 included only communal imagination (β = .230, $p < .001$). Model 2 added wisdom (advising, prosocial behavior, and tolerance), but communal imagination was the only significant predictor (β = .200, $p < .01$). Model 3 added age, with communal imagination remaining the sole significant predictor (β = .197, $p < .05$). Model 1 showed the best fit for domain ideals (Adjusted *R2* = .05, $F(5, 222) = 12.61$, $p < .001$). Across models, communal imagination predicted relational virtue explained the most variance though VIPS-PI relational virtue was predicted more reliably than VIPS-DI (see Table 6 to compare adjusted *R*2 and *F*).

Standardized Beta Coefficients and Model Fit Statistics for Regressions Predicting Relational Ideals (n = 228)

	Personal Relational Ideals			Domain Relational Ideals		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Communal Imagination	.295***	.252***	.250***	.230***	.200**	.197*
Wisdom-Advising		-.046	-.044		.010	.012
Wisdom-Prosocial		.013	.007		-.063	-.069
Wisdom - Tolerance		.153	.155		.128	.129
Age			.046			.045
Adjusted R^2	.08	.11	.11	.05	.05	.04
ΔF	21.62***	1.68	0.53	12.61***	0.86	0.46
F statistic	21.62***	6.71***	5.46***	12.61***	3.79**	3.12**

Notes: * = p<.05, ** p<.01, *** p<.001. All coefficients are standardized.

Table 6.

Work Behavior Regression Models

We also conducted hierarchical regressions on work behavior with citizenship behavior (OCB) and counterproductive work behavior (CWB) as dependent variables. See Tables 7 and 8.

Regressions for citizenship behavior (OCB) using VIPS scales as predictors began with Model 1, which included only VIPS *personal ideals* (relational, role, and intellectual). Model 2 added climate (self-interest and social support). Other ethical climate measures were excluded due to small and statistically nonsignificant correlations with CWB. Model 3 included age. Not much of the variance was accounted for in any of the models of personal ideals, and no predictors were significant.

We conducted a second regression on OCB where *domain ideals* (relational, role, and intellectual) were included in Model 1; none were significant. Model 2 added climate (self-interest and social support); role virtue ($\beta = .200$, $p < .05$) and social support ($\beta = .140$, $p < .05$) explained a significant amount of variance. Model 3 added age but no further variance was explained. Model 2 for domain ideals showed the best model fit (Adjusted $R2 = .06$, $F(5, 230) = 3.99$, $p < .01$). See Table 7.

Standardized Beta Coefficients and Model Fit Statistics for Regressions Predicting Organizational Citizenship Behavior (n=236)

	Personal Ideals as Associated with Organizational Citizenship Behavior			Domain Ideals as Associated with Organizational Citizenship Behavior		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Relational Virtue	.161	.142	.141	.054	.030	.030
Role Virtue	.031	.014	.015	.189	.200*	.201*
Intellectual Virtue	.01	.031	.029	.001	-.003	-.005
Ethical Climate-Self Interest		.124	.126		.126	.128
Social Support		.128	.129		.140*	.140*
Age			.010			.012
Adjusted R^2	.02	.04	.04	.04	.06	.06
ΔF	2.82*	3.21*	0.02	4.12**	3.66*	0.03
F statistic	2.82*	3.01*	2.5*	4.12**	3.99**	3.32*

Notes: * = p<.05, ** p<.01, *** p<.001. All coefficients are standardized.

Table 7.

Regressions for counterproductive work behavior (CWB) are listed in Table 8. Model 1 used VIPS scales as predictors (relational, role, and intellectual). Model 2 included climate (self-interest and social support). Other ethical climate measures were excluded due to insignificant correlations with CWB. Model 3 included age. For *personal ideals*, in Model 1 both intellectual virtue (β = -.314, $p < .001$) and relational virtue (β = .189, $p < .05$) were significant predictors. In Model 2, which added climate, self-interest (β = .216, $p < .001$), intellectual virtue (β = -.275, $p < .001$), and relational virtue (β = .162, $p < .05$) accounted for a significant amount of variance. Age added no predictive power in Model 3. Model 2 had the best model fit (Adjusted $R2 = .14$, $F(5, 230) = 8.62$, $p < .001$).

Standardized Beta Coefficients and Model Fit Statistics for Regressions Predicting Counterproductive Work Behavior (n=230)

	Personal Ideals as Associated with Counterproductive Work Behavior			Domain Ideals as Associated with Counterproductive Work Behavior		
Variable	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Relational Virtue	.189*	.162*	.165*	.077	.046	.048
Role Virtue	-.134	-.156	-.161	.007	.021	.017
Intellectual Virtue	-.314***	-.275***	-.266**	-.280**	-.253**	-.244**
Ethical Climate - Self Interest		.210***	.203**		.238***	.224**
Social Support		.036	.033		.022	.018
Age			-.060			-.062
Adjusted R^2	.10	.14	.14	.04	.09	.09
ΔF	9.90***	6.07**	0.92	4.66**	7.06**	0.93
F statistic	9.90***	8.62***	7.34***	4.66**	5.77***	4.96***

Notes: * = p<.05, ** p<.01, *** p<.001. All coefficients are standardized.

Table 8.

For *domain ideals*, Model 1 used VIPS scales as predictors (relational, role, and intellectual) of CWB. Only intellectual virtue was a significant predictor (β = -.280, $p < .001$). Model 2 added climate (self-interest, social support) and self-interest (β = .238, $p < .001$) accounted for significant variance with intellectual virtue (β = -.253, $p < .01$) remaining significant. When age was added in Model 3, no additional variance was accounted for. Model 2 for domain ideals had the best model fit (Adjusted *R2* = .09, $F(5, 230) = 5.77$, $p < .001$). Domain-ideals for intellectual virtue and self-interested ethical climate accounted for a significant amount of variance in CWB. See Table 8.

Discussion

With a sample of scientists, we used a new measure, VIPS, which assesses virtue ideals and explored how ideal conceptions of virtue related to morality and behavior, using existing measures. Significant correlations between virtue ideals, personal and domain, and most measures were obtained. We conducted regression analyses, expecting that some of these relationships would prove more reliably predictive than others. The first hypothesis, that intellectual virtue would correspond with moral reasoning and wise insight, was supported, though wise tolerance for divergent values was also predictive of VIPS-DI intellectual virtue, and moral reasoning was not predictive in the best model. The prediction that role virtue would correspond most closely with decisiveness and emotional regulation was not supported. Instead, wise insight and (for VIPS-PI) prosocial behavior best predicted role virtue. Wise insight, as captured in the measure we used, corresponds largely with reflection and thoughtfulness, which may serve to mitigate problematic impulsiveness in fulfilling one's role and ensure rigor in one's thinking. Hypothesis 3, that relational virtue would correspond most closely with communal imagination, was supported.

Our second set of hypotheses concerned behavior. We found that virtue ideals ratings did in fact pre-

dict moral behavior, but that, with counterproductive work behavior (CWB), a measure of immoral behavior, personal ideals (VIPS-PI) were better predictors than domain ideals (VIPS-DI) when climate factors were taken into account. The hypothesis, that personal ideals would predict moral and immoral behavior more strongly than domain ideals, found partial support, as VIPS-PI did better predict lower levels of CWB. However, VIPS-PI did not predict citizenship behavior (OCB). Finally, we found support for our hypothesis that VIPS measures would predict CWB and OCB even when accounting for ethical climate, specifically intellectual virtue. We speculate that intellectual virtue endorsement reflects more intellectual advancement (since it was correlated with advanced moral reasoning). The fact that the variance explained by virtue ideals was small, especially for citizenship behavior, points to the complexities of moral behavior. Rest[30] explained the gap between moral reasoning and action with a four-process model where all processes must be enacted for moral behavior to ensue: perception and sensitivity to situation, judgment and decision making, motivation in the moment, and action skills (effectiveness and perseverance). Thus, having a set of ideals does not guarantee that one will or is able to act on them.

Taken as a whole, this study provides preliminary evidence for the usefulness of the two subscales of VIPS measures as assessments of virtue ideals in science. This sets the stage for future research that might extend their use to examine the relevance of the VIPS measures as they relate not just to moral behavior in the laboratory but other aspects of virtuous science, such as creativity, collaboration with international colleagues, ethical use of research materials, and treatment of research subjects, among other possibilities. Further, this study provides a starting point for the consideration of virtue in other practices, as the measure could be used in other domains, an important approach for grounding the study of virtue in particular contexts or domains.

Finally, the study provides evidence that consideration of *personal* scientific ideals may be important in understanding antisocial and unethical behavior in science, as such behavior constitutes counterproductive work behavior. This is to say that those who hold themselves to a higher personal standard are less likely to give themselves license to engage in misuse of an employer's equipment and funds, intentionally fail to follow through on project timelines, miss work without cause, and/or demean others in the workplace. The study results suggest that researchers move beyond separating intellectual virtue and moral virtue to instead recognizing the ways that moral and intellectual virtue may be intertwined in scientific practice.

The present study has important limitations to consider. First, there was considerable diversity among the roles and experiences of laboratory scientists surveyed. As such, while the measure demonstrated reliability in the present sample, it may be helpful for future research to target scientists in particular roles to examine whether these findings hold across roles or whether they might pertain only to particular roles. For example, perhaps the findings apply more to scientists who continue to work at a lab bench than to those who supervise others' research. Second, it was a self-report, cross-sectional study of volunteers. A random sampling of scientists would be preferable. In addition, most effects were quite small. Unmeasured but measurable factors may better account for much of the variation in VIPS scores and in reported work behavior. Future research could examine what additional

30. James R. Rest, "Morality," in *Cognitive Development,* edited by John Flavell and Ellen Markham, *Manual of Child Psychology*, Volume 3, edited by Paul Mussen (New York: Wiley, 1983), 556–629; Darcia Narvaez and James Rest, "The Four Components of Acting Morally," in *Moral Behavior and Moral Development: An Introduction*, edited by William Kurtines and Jacob Gewirtz (New York: McGraw-Hill, 1995), 385–400.

factors might be important. It would also be interesting to study how perceptions change across time and experience in a particular laboratory. The present study cannot tease out causality. Are virtue ideals causes of other outcomes and/or do (and which) contextual features support or undermine virtue ideals? Such questions may be the seeds for future longitudinal work.

Conclusion

The present study provides evidence for the validity of virtues-in-science measures, considered both as ideals for the domain of science and as personal ideals. These two facets related to ratings of virtue ideals that were consistently predicted by measures of moral reasoning, wisdom, and moral imagination. Further, the study demonstrates that virtue ideals predict moral behavior, specifically greater organizational citizenship behavior and lower counterproductive work behavior.

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CHAPTER 15.

SEMANTIC ANALYSIS OF MORAL VALUES IN SEMI-STRUCTURED INTERVIEWS

MARK GRAVES

Moral psychology investigates the development and functioning of human behavior and mental processing in moral contexts and serves as a good foundation for investigating human moral behavior. Moral psychologists draw upon methods and theories from social, developmental, cognitive, and other areas of psychology and frequently engage with the philosophical study of morality and ethical systems to develop empirical theories and models for human moral development, reasoning, and action.[1] One method in moral psychology, the semi-structured interview, attempts to elucidate aspects of a person's moral framework including goals, significant events and influences, and stated moral values. In the interview, the interviewer typically asks the interviewee about two dozen questions derived from psychological and moral theory, along with follow-up prompts as needed. The interviews are recorded and transcribed, yielding a semi-structured narrative response to the theory-driven questions. Analyzing the responses provides empirical evidence on the participant's moral framework within an open-ended theoretical context.

The present empirical study investigates how scientists and musicians characterize moral values in their respective fields and also serves as an example of how to analyze moral values using semantic analysis of semi-structured interviews. This study is part of a larger, ongoing investigation into the characterization of virtue among scientists and musicians.[2] Interview questions were based on the Good Work Interview Protocol and augmented with questions based upon virtue studies.[3] Questions included: What qualities do you think a good [field member] has? What inspired you to become a [field member]? Why did you get involved in [field] rather than something else?

1. Valerie Tiberius, *Moral Psychology: A Contemporary Introduction* (New York: Routledge, 2014); Darcia Narvaez and Daniel K. Lapsley, eds., *Personality, Identity, and Character: Explorations in Moral Psychology* (Cambridge: Cambridge University Press, 2009); Julia Annas, Darcia Narvaez, and Nancy E. Snow, eds., *Developing the Virtues: Integrating Perspectives* (New York: Oxford University Press, 2016).
2. Timothy Reilly and Darcia Narvaez, "Virtue and the Scientific Researcher: Understanding the Personality and Character of Scientists," poster presented at the American Educational Research Association, New York, NY, 2018; Timothy Reilly, Xiao Liu, and Darcia Narvaez, *Virtue in the Practice of Science: A Three Wave Validation Study*, manuscript in preparation, 2019.
3. Howard Gardner, Mikhail Csikszentmihalyi, and William Damon, *Good Work: When Excellence and Ethics Meet* (New York: Basic Books, 2001); Timothy Reilly and Darcia Narvaez, "Virtue in Practice Interview Protocols," unpublished report, University of Notre Dame, 2017; Timothy Reilly and Darcia Narvaez, "Practitioner Understanding of Excellence: Using Interviews to Understand Virtue," paper presented at a meeting of the Society for Qualitative Inquiry in Psychology, Pittsburgh, PA, 2018.

Transcribed interview texts can be analyzed manually or through computational methods. Manual coding techniques identify significant constructs in transcribed texts by having a trained person annotate passages with tags derived from psychological or moral theory. However, manual coding generally requires considerable effort and consensus among human coders, and may introduce inadvertent bias. Some techniques also tend to categorize short, extracted segments of texts and may miss global themes underlying the texts, including identity constructs and pervasive mental schemas. The effort needed and theoretical commitments required also preclude easy comparisons between methods or quick investigations of novel hypotheses.

Computational techniques developed within artificial intelligence can augment manual close-reading and characterization techniques by scoring the text based upon its similarity to theory-driven text descriptors. The automatic techniques seek to avoid idiosyncratic individual human biases by adopting theory-driven descriptor texts that make biases more visible and explicit. By automating text comparison, the software can quickly evaluate numerous probes over large quantities of text. Of course, the automatic method may miss subtleties in the narrative text that a trained human might identify, though those subtleties often create points of disagreement among human coders.

Latent Semantic Analysis

The computational method of latent semantic analysis (LSA) used in the present study scores the narrative interviews of scientists and musicians and compares the implicit presence of particular moral values in the text. LSA quantifies the extent to which a moral value occurs implicitly within the interview text by using a computational proxy for meaning to measure the semantic similarity between the theory-derived moral value descriptors and the transcribed interview text. We use statistical methods to compare average semantic similarity between interviews and moral value descriptors for both scientists and musicians, yielding a characterization of the groups' differences in implicit moral values.

Semantic analysis extracts meaning from text by transforming the text into a mathematical representation of its semantics. The mathematical representation of a text (such as a participant interview) is then compared with the representation of another text with known meaning (such as a theory-driven moral descriptor) yielding a measure of similarity between the texts. When the questions in the interview elicit mental constructs and schemas about the interviewee's moral values, belief structures, and dispositions, then the comparison between the interviews and the theory-driven moral descriptors can elucidate and measure those specified aspects of that person's moral framework.

Semantic analysis depends on an associationist and distributional theory of meaning. This is supported by recent philosophical investigations. While older understandings saw the meaning of a word as referring to a universal essence, Ludwig Wittgenstein argues that the meaning of a word lies in its use in language.[4] The linguist John Firth further clarifies that the meaning of a word depends on the words with which it is in frequent and habitual company.[5] More precisely, a word's meaning depends on the words with which it frequently collocates and how it relates to those frequently collocated words. Collocation refers to a word's occurrence near another word in a text. Thus the associations, or repeated collocations, between words define meaning. To model those associations, the mathe-

4. Ludwig Wittgenstein, *Philosophical Investigations I*, translated by G.E.M. Anscombe (Oxford: Blackwell, 1958), secs. 80, 109.

5. John Firth, "A Synopsis of Linguistic Theory 1930–1955," in *Studies in Linguistic Analysis*, edited by John R. Firth (Oxford: Oxford University Press, 1957), 1–32.

matical linguist Zellig Harris identified and developed the distributional hypothesis. Harris noticed that words with similar meaning have similar contexts, that is, they regularly collocate with the same words, and suggested that in a sufficiently large sample of language words with similar patterns of association would have similar meaning.[6] For example, "cat" and "dog" would often occur in text with many overlapping associated words, such as "petting," "feeding," and other words for activities of non-human companioning. Thus "cat" and "dog" have similar meanings, while differences in associated words, such as "climbing" or "fetching," differentiate the meaning between "cat" or "dog." This kind of analysis can model meaning in language as a distribution of associated contexts; LSA implements those distributional and associative aspects of meaning in a particular way.

To capture the distribution meaning in LSA, a distributional semantic space is created from a global cache of knowledge in English, in this case an 11-million-word collection of texts, novels, newspaper articles, and other documents from kindergarten through first year collegiate readers.[7] This collection of texts creates a generalized semantic space useful in a variety of domains. Construction of the space uses the linear algebra process of singular value decomposition to transform the documents into a 300-dimensional semantic space where vectors are assigned to texts as approximations of meaning. After the space is constructed, additional documents are mapped to the space to obtain a vector representation for their respective meanings. (A vector is a mathematical object with direction and magnitude/length.) As visualizing 300-dimensional space is obviously difficult, Figure 1 illustrates the mapping of moral descriptors and one of the participant interviews to the first two dimensions of the semantic space. In a semantic space, documents that are similar in meaning are mapped to similar locations. Each point in Figure 1 refers to a 2-dimensional vector (from the common origin point labeled "0.0") to the labeled location in the "meaning" space.[8]

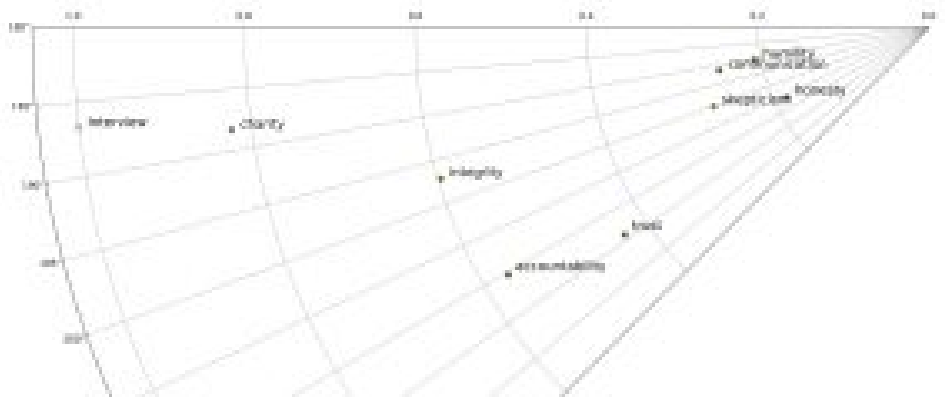

Figure 1. Plot of Example Interview and Eight Moral Descriptors in Two Dimensions

To determine association between words, LSA uses a "bag of words" transformation, so a document is defined as a collection of words along with the number of times those words occur in the text. For example, the sentence "You should tell the truth" is defined mathematically as having one occurrence

6. Zellig Harris, *Mathematical Structures of Language* (New York: Interscience, 1968).

7. Thomas K. Landauer et al., *Handbook of Latent Semantic Analysis* (Mahwah, NJ: Lawrence Erlbaum Associates, 2007), 69.

8. The magnitude (or length) of the vector measures the "loading" (or projection) of the vector onto that dimension of "meaning" space. Whether that value has any meaning separate from the overall semantics of the vector depends upon whether that dimension is semantically coherent in isolation, which is often not the case. In Figure 1, only a relevant portion of the two-dimensional graph (in polar coordinates) is shown.

of the word "you," one occurrence of the word "should," and so on. In practice, common words like "you" and "the" (called stopwords) do not contribute much to the overall meaning and are omitted from subsequent calculations. The sentence is thus represented as one occurrence each of "tell" and "truth." The association between words in a document, in this case "tell" and "truth," depends upon the context of the possible vocabulary words not used in the document. The sentence is therefore not only defined by the words occurring in it, but also by the words not appearing. If the vocabulary of the corpus has 5000 words, the sentence is represented as a 5000-dimension, bag-of-words vector with a value of one for the dimension for "truth," one for the entry for "tell," and zeros for all other words in the vocabulary. Some information is certainly lost in discarding syntactic relationships and some common words, and transformed short sentences often lack sufficient word associations to be effective for analysis. Generally, to provide greater precision texts of at least a paragraph or longer are used.

In addition, although it is possible to perform some analysis directly with the bag-of-words vectors, LSA transforms the lexical representation of associated words to the semantic space by mathematically projecting the bag-of-words vector representation of the document onto the previously constructed 300-dimension semantic space. The vectors capture dimensions of the distributional aspects of meaning, and thus transform the bag-of-words vector to a vector that incorporates each word's associative meaning in the distributional semantic space calculated from the larger sample of English text. The projection onto 300-dimension space results in words that are close in meaning being mapped to locations near each other, and thus the 300-dimension vector for the document represents the overall meaning of that document. The shift from word associations in the 5000-dimension bag-of-words representation to the more meaningful 300-dimension semantic space depends on the word associations of the corpus used to construct the semantic space and is also limited by its appropriateness as a representative sample of the language's semantics.

Similarity is calculated as the cosine of the angle between vectors with higher cosine values indicating greater similarity between texts, in this case pairwise similarity between each of the interview responses and the moral descriptors. The cosine similarity calculation measures the angle between the vectors representing participant text and descriptor documents and thus measures their similarity without being influenced by the number of words in the texts. In Figure 1, the angle between the vector for the example interview and the vector for "charity" is fairly small, so that interview would be scored high in similarity to the "charity" moral descriptor. The cosine similarity score ranges from -1 to 1 and is higher for identical texts (with most scores between 0 and 1). The average (mean) cosines for scientists and musicians are then compared.

Moral Descriptors

Because the meaning of the moral values depends on the text used to describe that value, some care is needed to define the moral descriptor texts. In this study, four descriptors came from the moral psychology literature, and we developed eight additional moral descriptors, described immediately below and listed in the Appendix. Using the previously published moral descriptors enables eventual comparison of the results of this study with other investigations using those descriptors. Developing eight novel moral descriptors not only focuses moral analysis on professional practices but also contributes additional constructs to the emerging study of moral psychology using semantic analysis techniques.

Reimer et al. developed four descriptors to examine moral mental schemas among humanitarian exemplars, that is, those who serve as excellent examples of humanitarian moral behavior.[9] Reimer et al. derived the descriptors—"religious," "just," "brave," and "caring"—from two prior studies of moral exemplarity. For the "religious" moral descriptor, Reimer et al. use the terms best describing religious exemplars from Lawrence Walker's empirical study that found distinguishing personality features among moral, religious, and spiritual exemplars.[10] In a subsequent empirical study, Walker and Hennig showed that the "moral" exemplarity Walker had previously investigated could not be captured by a single profile. Based on their studies and coordinated readings in moral philosophy, Walker and Hennig distinguished three main types of moral exemplarity and produced profiles of just, brave, and caring exemplars, framed in part by the philosophical work of Rawls, Miller, and Noddings, respectively.[11] Reimer et al. similarly use Walker and Henning's results to create moral text descriptors for just, brave, and caring exemplarity, which they combine with the religious descriptor for their broad study of moral traits. Because the moral and religious domains are often intertwined, we retained Reimer et al. religious descriptor in our moral text descriptors. These empirically derived text descriptors of religious, just, brave, and caring exemplarity are compared with the interview text to develop similarity scores between each descriptor and each of the scientist and musician interviews.

To develop more specific moral descriptors for the study of scientific and musical practice, a multistep process was undertaken. First, thirty-four virtue terms believed appropriate for the study were extracted from the literature of virtue ethics, epistemology, and moral psychology and were refined down to fourteen qualitative codes using grounded theory.[12] The qualitative codes were made available for manual coding of the interviews, but were also transformed into moral descriptors and probed against the interview texts. Although it would have been reasonable to stop and compare groups on the basis of those probes, we continued to refine the probes with the hope they could become useful beyond the present study.

The statistical method of factor analysis, commonly used in psychology research, was used to identify eight virtue descriptors that appeared to make independent contributions. They are "honesty," "integrity," "humility," "trust," "accountability," "skepticism," "communication," and "charity." Each sentence in each virtue descriptor was stepwise compared with all the virtue descriptors to remove sentences that failed to contribute to the descriptor of which it is a part (cosine < .3) or to overly contribute to the other descriptors (cosine > .3).[13] This aspect of LSA used for the moral descriptors is analogous to the interview LSA analysis, except that each sentence in the moral descriptor text is treated as an independent document, while for the interview analysis, each person's interview is treated as a document for processing. (See the Appendix for the resulting moral descriptor documents.)

9. Kevin S. Reimer et al., "Maturity Is Explicit: Self-Importance of Traits in Humanitarian Moral Identity," *The Journal of Positive Psychology* 7.1 (2012): 36–44.
10. Lawrence J. Walker, "The Perceived Personality of Moral Exemplars," *Journal of Moral Education* 28.2 (1999): 145–62.
11. Lawrence J. Walker and Karl H. Hennig, "Differing Conceptions of Moral Exemplarity: Just, Brave, and Caring," *Journal of Personality and Social Psychology* 86.4 (2004): 629.
12. Reilly and Narvaez, "Virtue in Practice Interview Protocols;" Barney Glaser and Anselm Strauss, *The Discovery of Grounded Theory: Strategies for Qualitative Research* (London: Transaction Publishers, 1967).
13. A cutoff of 0.3 was chosen based upon familiarity with the protocol in a variety of contexts and because similar cutoffs are frequently used for correlations and factor analysis, which have similar ranges and analogous distributions in psychology.

Participants

The present investigation draws upon an international interview study of laboratory scientists (n=27) and ensemble musicians (n=44) who each completed an approximately one-hour semi-structured interview.[14] The scientists ranged from undergraduate research assistants to tenured professors, and the musicians ranged from music directors to amateur instrumentalists. Both groups were recruited from the United States and the United Kingdom. The resulting interview transcripts averaged approximately 7500 words in length.

Results

For analysis, LSA was used to determine similarity scores (cosines) between each interview transcript and the twelve value descriptors. The statistical test MANOVA found significant differences for field and location but not gender or any interactions (field: $F(12,55)=29.01$, $p<.001$, Pillai's trace=.86; location: $F(12,55)=5.24$, $p<.001$, Pillai's trace=.53). Scientist interview text showed higher latent value for honesty and integrity, and musician interviews showed higher latent value for religious value (honesty: scientist cosine mean=.215, musician cosine mean=.146, $t(68)=11.608$, $p<.001$; integrity: scientist cosine mean=.301, musician cosine mean=.269, $t(68)=4.407$, $p<.001$; religious: scientist cosine mean=.201, musician cosine mean=.273, $t(68)=5.786$, $p<.001$). There were no significant differences for the other probes. Comparing transcript latent values across location did not find significant differences given adjustments used for multiple statistical tests.

Discussion

We defined moral values in terms of twelve moral descriptors with four moral descriptors coming from the literature and eight derived from grounded theory, with the grounded theory descriptors also reduced through a series of discussions and refined through their pairwise comparison using LSA. Measuring the semantic similarity between the meaning representations of theory-derived value descriptors and the transcribed interview responses, we then used statistical methods to compare participant groups and characterize the groups' differences in implicit moral values. MANOVA found significant differences by field, with scientist interview texts showing higher latent value for honesty and integrity, and musician interviews showing higher latent value for religious value. These findings suggest that honesty and integrity might play a central role in how scientists conceive their practice.

The higher cosine scores for scientists on honesty and integrity suggest that the interview texts for scientists included more implicit value set on honesty and integrity than it did for musicians. One might speculate that as values, honesty and integrity are simply more relevant to science than to music. If so, then other field-relevant values, perhaps especially skepticism, should also have higher value for scientists. However, that was not the case. The findings appear to indicate something about the moral practice of scientists and musicians rather than something intrinsic to the fields themselves.

Although many of the values examined in the study may contribute to scientific practices, honesty and integrity appear more present for scientists than musicians within an interview focused on what is important in being a "good" [field member]. A possible explanation is that honesty and integrity are more of a prerequisite to the practice of science than other examined values (as characterized by the text descriptors). One might become a better scientist if one were to have more skepticism or account-

14. Reilly and Narvaez, "Virtue in Practice Interview Protocols."

ability, but one could still be a fair scientist with only a modicum of these virtues. However, a dishonest scientist or a scientist who lacks integrity may miss something so fundamental to the practice of science that person might lose the right to identify as a scientist among their professional peers. As the interview questions are designed to evoke moral schemas related to the practice of science (or music), the differences may relate to deeper aspects of one's identity within one's practice.

The higher cosine scores for religious value in musicians, as compared to scientists, may indicate that religion plays a more central role in professional identity for this particular sample of musicians. The ensemble musicians interviewed perform religious music, a fact that may affect their scores. In addition, the scientists might deliberately try to separate any personal religious commitments from their professional practice.

These findings have several caveats. They are limited by the moral text descriptors used and the scope of practice-related moral identity covered by the interview questions. LSA has psychological plausibility but is nevertheless limited by the semantic space used as a foundation for its representation of meaning. The populations of scientists and musicians in this study may also be insufficiently representative to allow generalizations across these vocations. In addition, treating the entire interview as a monolithic text may obscure differences in responses to the particular questions asked.

However, the significance of the findings on honesty and integrity warrant further investigation. Among musicians, honesty may be less important because the performer can alter the composer's initial guidelines (for good reason), making the performer "dishonest" to the composer's intent. Future work will examine more closely how scientists and musicians differ on the importance of honesty and integrity for their respective practices.

Conclusion

LSA can extract implicit meaning from text and quantify the level that a moral value implicitly occurs within interviews of scientists and musicians about their practices. Comparisons between groups help elucidate differences in their moral values and underlying moral schemas. Using LSA to compare theory-driven moral descriptors with semi-structured interviews adds an additional method to help moral psychologists analyze human moral behavior. In addition, the method's broad applicability and automated processing of larger quantities of text may open up new avenues of investigation into human moral values, schemas, and behaviors.

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Appendix: Moral Descriptors

HONESTY

You should tell the truth. Be honest in all you do. Lying and fabrication are harmful. You should stick to the evidence. Be confident that what you say is true. Try not to deceive others. Provide accurate information.

INTEGRITY

He is motivated to do it for itself. Doing this is part of her identity. I am motivated to do it for its own sake. I appreciate her genuineness. I want to act with integrity. I have pure motivations. Pursue the goals and values of your sources. Resist temptation. No matter what happens do not compromise yourself. Do your work for the right reasons. Stay committed to your purpose. Do meaningful work. Do not do things for status.

HUMILITY

Recognize your mistakes. You have to be honest with yourself. Know your limits. Know your biases.

Recognize your flaws and weaknesses. Be aware of your strengths. You have to know what you can do. Be honest about your capabilities. Be honest about failures. Notice when you have overreached. Know when you made a mistake. Be self-critical. Be humble.

TRUST

You have to trust that others did what they say they did. I believe what they wrote. I trust the peer-review process. You need to trust others. I trust people that are knowledgeable. You have to trust their capabilities. I trust them to know what they are doing. I trust that they are honest. I trust the director to know what he is doing. You have to trust the writer. You have to trust the leader.

ACCOUNTABILITY

I often give feedback. I let someone know how they are doing. He auditions candidates. She screens applications. You point out mistakes. I give constructive criticism. I engage in justified critique. I let others know my expectations. I help new people learn the system. I guide others on the right way to behave. Some behaviors are not acceptable. Punish violators appropriately. Even leaders need to be accountable.

SKEPTICISM

You have to look at what they did. You have to look at the data. It is important to ask questions. Did they do this right? Is there something wrong with their reasoning? Does it sound right? Is there a better way to do it? Do the results justify conclusions? Be skeptical. Did they do something wrong? Do I see any mistakes?

COMMUNICATION

How you say something is important. You have to communicate in a way that others will understand. What you say should translate to your audience. You need to report clearly. Others should be able to recognize what you are communicating. Communicate things of value.

CHARITY

They do it to contribute to society. They want to make the world a better place. They are seeking to connect with others or with God. Help others flourish. Improve the wellbeing of others. Make the world a happy place. Make the world more peaceful. Be kind and helpful to others. Help humanity thrive. Contribute to your community.

JUST

I consider myself a just and fair person. I make good judgments by listening to all sides and being clear in my thinking. I usually feel truthful, honest, reasonable, and rational. In most circumstances, I am upright and true. I also try to have integrity in a way that is consistent. Many people consider me to be lawful, trustworthy, and honorable.

BRAVE

I consider myself a brave and courageous person. I stand up for my beliefs even when I must take a risk, make sacrifices, or face danger. I usually feel fearless, determined, strong-minded, strong-willed, and gutsy. In most circumstances, I am unafraid and daring. Many people consider me to be gallant, intrepid, and heroic.

CARING

I consider myself a compassionate and loving person. I care about others by helping and making time for them. I usually feel sympathetic, empathic, and concerned about the welfare of others. In most circumstances, I am kind, considerate, supportive, and nurturing. I also try to be comforting in a way that is genuine, and sincere. Many people consider me to be good-hearted.

RELIGIOUS

I consider myself a religious and faithful person with strong beliefs. I believe in a higher power and try to know and please God by going to church, praying a lot and worshiping a lot. I usually feel devout, committed, and dependent on God. I also try to be active in church life and read the Bible regularly. Many people consider me to be dedicated, devoted, and knowledgeable about religion.

CHAPTER 16.

VALUE IN VIRTUOUS COMMUNITY: INSIGHTS ABOUT VALUING THE SELF AND OTHER FROM COMPUTATIONAL COGNITIVE AND BRAIN SCIENCES

MICHAEL SPEZIO

The moral philosopher Robert C. Roberts suggests that the study of virtue needs the support of a virtuous community. In other words, to understand what virtue is and how it flows in practice, it helps to be in that flow oneself. How can one hope to recognize virtuous formation without entering it oneself, in hope, and in the company of others? I suggest that those seeking a deeper understanding of virtue more broadly, and virtue in the sciences in particular, would benefit from scientific inquiry into the cognitive affections and the affective cognitions of those committed to virtuous community, and of actions that are modeled after their practices. How do people with long-lived commitments in such communities value one another and themselves? How do they remember and describe their formation and transformation? How do they remember their past selves? How do they describe their hope for the future? How important are empathy, theory of mind, and humility in managing the daily challenges of life in community? Can computational models of cognitive and neural systems shed light on the transformations of mind and brain that happen? Drawing on work with communities of L'Arche in the US and in France, and with the community of Homeboy Industries in Los Angeles, this address relates computational models of mind and brain to narrative accounts of how the self and other are valued within communities dedicated to virtuous formation.

Keynote Video on YouTube: Search "Spezio Value in Virtuous Community"

Further Reading

Spezio, Michael. "Corrigibility and Trust in the Practices of Science." *Philosophy, Theology and the Sciences* 5.2 (2018): 265–80.

ABSTRACT In the context of crises in science, understanding what virtue in science is requires attention to virtue studies and virtue science themselves. Within and beyond the study of practices in laboratories and in scientific collaborations held up as exemplary or noted for being less so are core beliefs about what trust in science is or should be. Prevailing conceptions of trust in science and scientists are at the root of the crises in science. Virtue science and studies can help to identify the noxious tendencies of some conceptions of trust and suggest possible new

ways of thinking. This article reviews evidence for sciences in crisis before drawing on Bayesian thinking to propose ways of thinking about trust, reliability, and validity in relation to science. Corrigibility, rather than fallibility, is the defining feature of science, calling for a trust in the persons, systems, and institutions of science as ever error-probable-plus-corrigible.

Spezio, Michael. "Humility as Openness to Others: Interactive Humility in the Context of l'Arche." *Journal of Moral Education* 48.1 (2019): 27–46.

ABSTRACT: Exploring the concept of virtuous humility helps to highlight paths of human flourishing. Yet humility is difficult to study because it is often stereotyped as shame or self-abasement, it tends to defy uniform conceptualization across contexts and cultures, definitions are difficult to justify, and operationalizing humility challenges standard approaches in the social sciences. The present work develops a theory of interactive humility as openness to others (IHO) by foregrounding interaction and interpersonal context. IHO theory builds on a previously published theory of humility as the absence of the vices of pride and tests the new proposal against research done in conjunction with l'Arche communities. Conceptual networks from core l'Arche texts showed that openness ranks second among concepts most similar to humility (0.85), while humility ranks first for openness. These networks support the view that humility as openness in the context of l'Arche is primarily interactive and interpersonal, rather than intellectual.

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PART V.

THE FUTURE OF SCIENTIFIC VIRTUES

CHAPTER 17.

DOES THE DIGITALIZATION OF SCIENCE AFFECT SCIENTIFIC VIRTUES?

MARKUS CHRISTEN

Introduction: Scientific Virtues and Digitalization

The emergence of science and scientific thinking in modern Europe[1] has been accompanied by the development of a set of virtues that intend to characterize "good science" and "veritable scientists." Also denoted as "epistemic virtues,"[2] they are preached and practiced in order to know the world; "they are norms that are internalized and enforced by appeal to ethical values, as well as to pragmatic efficacy in securing knowledge."[3] Scientific virtues are not stable entities across time and not clearly separable from other kinds of virtues, which leads to the initial question in this essay: which scientific virtues should be of interest? For example, should we refer to "high-level virtues" such as a well-developed *phronêsis*, one of Aristotle's four cardinal virtues? Certainly, this virtue is also critical to practicing science; in order to produce sound scientific knowledge, scientists must be able to deliberate well about their work and the work of others.[4] However, *phronêsis* as virtue covers a broad spectrum of human activities and is thus beyond the scope of this short essay.

Instead, should we refer to a very fine-grained virtue ontology and focus on a broad set of virtue candidates? Darcia Narvaez, Timothy Reilly, and colleagues created an impressive list of virtues (broadly construed)[5] relevant for scientific inquiry, including caution (showing appropriate caution with respect to various contingencies), collegiality (working with and for colleagues), foresight (planning ahead and foreseeing possibilities), imagination (visualizing or conceptualizing abstract entities), open-mindedness (being receptive to new ideas or information, especially that which goes against conventional wisdom), and recognition (appreciating and valuing the contribution of others to your work). Certainly, all those virtues refer to important demands for science (and for other types of human collaborative endeavors)—but assessing such a long list would again exceed the aims of this short essay.

1. Paolo Rossi, *Die Geburt der Modernen Wissenschaft in Europa* (München: Beck-Verlag, 1997).
2. Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007).
3. Ibid., 40.
4. Jiin-Yu Chen, "Virtue and the Scientist: Using Virtue Ethics to Examine Science's Ethical and Moral Challenges," *Science and Engineering Ethics* 21 (2015): 75–94.
5. Personal communication during the "Developing Virtues in the Practice of Science" project.

Instead, I suggest focusing on six scientific virtues proposed by Pennock and O'Rourke[6] and emerging from Pennock's "Scientific Virtues Project." These virtues directly refer to the basic scientific goal of discovering empirical truths about the natural world. Pursuing this goal requires distinctive traits that a scientist should cultivate; because of science's special aims, *curiosity* and *intellectual honesty* are the primary scientific virtues. Other virtues play important related roles. Pennock and O'Rourke mention *skepticism* and *objectivity* as important scientific virtues. Moreover, as repeatable empirical testing is not easy, especially when one must quantify results, *perseverance* and *meticulousness* are valuable qualities for scientists.

As the aim of this essay is to assess the impact of changing scientific practices on scientific virtues due to technological developments, my second question is: What influences the practice of science? This is obviously a broadly discussed theme both within the history of science and the philosophy of science on the nature and the causes of scientific change. Answering this question requires a reference to both macro-scale sociological factors (work pioneered by scholars such as Joseph Ben-David[7]) as well as micro-level, that is, the concrete work of scientists in experimental systems (see for example the work of Hans-Jörg Rheinberger.)[8] The ongoing digital transformation likely impacts both the macro- and micro-scale of scientific activity, as the second section will outline. Based on this short general sketch of the nature of the current digital transformation, the third section will speculate on the possible impact of the use of digital tools on these six virtues. A short conclusion outlines potential positive and negative uses of new digital tools in the scientific practice with reference to the cultivation of scientific virtues.

Digitalization: The Next Wave Driven by Machine Learning

Using digital tools in science is certainly not a new phenomenon. Beginning from the theoretical and practical foundation of modern computation in the 1930s and 1940s, computers became an indispensable tool for many scientific disciplines; they enabled "big science" and allowed for the emergence of new fields that strongly relied on computer simulations.[9] On the broader societal level, the application of information technology is not new, and resulting phenomena such as the automation of production processes are well-studied.[10] However, the key differences between today's digital transformation and the previous use of computer technology result from the combination of advances in the field of machine learning (ML), enormously increased data availability, and greatly increased computing power. ML-generated artificial intelligence (AI) systems increasingly solve problems where traditional computer programs fail. In contrast to explicitly written programs, new types of AI systems (so-called deep learning algorithms) are trained by being exposed to a multitude of examples and rewarded for making the right decisions. Their learning imitates human learning to some degree, although the latter includes emotional engagement and purpose. Within a few years, these advances have enabled AI systems to achieve impressive success in demanding and ambiguous tasks such as

6. Robert T. Pennock and Michael O'Rourke, "Developing a Scientific Virtue-Based Approach to Science Ethics Training," *Science and Engineering Ethics* 23 (2017): 243–62.
7. Joseph Ben-David, *Scientific Growth: Essays on the Social Organization and Ethos of Science* (Berkeley: University of California Press, 1991).
8. Hans-Jörg Rheinberger, *Toward a History of Epistemic Things* (Stanford, CA: Stanford University Press, 1997).
9. Markus Christen, Nikola Biller-Andorno, Berit Bringedal, Kevin Grimes, Julina Savulescu and Henrik Walter, "Ethical Challenges of Simulation-Driven Big Neuroscience," *AJOB Neuroscience* 7.1 (2016): 5–17.
10. Klaus Henning and Maike Süthoff, eds., *Mensch und Automatisierung: Eine Bestandesaufnahme* (Opladen: Westdeutscher Verlag, 1990).

image recognition, translation, radiological image analysis, and gaming. They not only compete with human abilities, but also sometimes even surpass them. These techniques are improving rapidly and lead to applications that were previously reserved only for people, such as driving vehicles or diagnosing illnesses. AI thus becomes an enabling technology for an enormous range of applications.

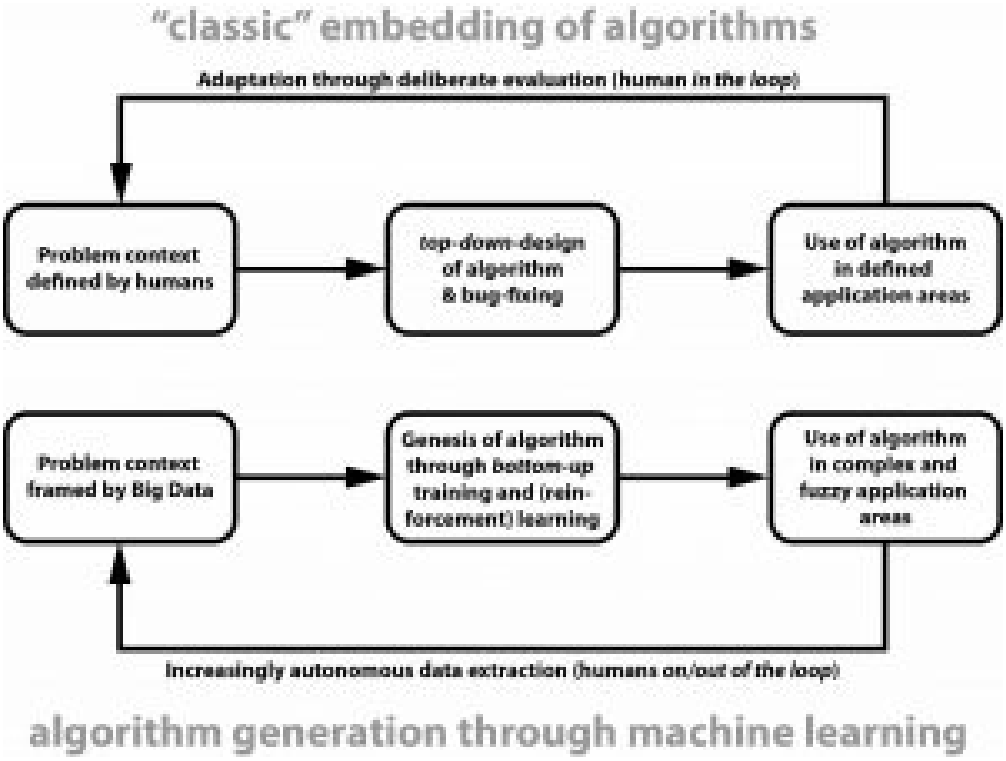

Figure 1. Sketching the changing societal embedding of algorithms

The associated change is profound because the way algorithms are embedded in social systems is fundamentally changing, as Figure 1 illustrates. Until recently, people have explicitly defined the algorithmically manageable problems, created the necessary programs top-down, and applied the algorithms in clearly distinguishable areas. But now, large amounts of diverse data form the (often only incompletely understood) basis of the problem context, machine learning generates the problem-solving algorithm, which is then used in increasingly heterogenic and blurred application areas, whereby the applications act increasingly autonomously and exchange information with each other. Thus, the "feedback" between concrete problem solving by means of an algorithm in a defined area of application and the resulting adaptation of the definition of the problem is increasingly happening with limited or even without human control. The result is a gradual shift from decision support through algorithms to the automation of decisions in areas relevant to life, such as lending, mobility, legal examinations, or access to resources. Therefore, the public discussion about the application of AI is often dominated by dystopian future scenarios.[11]

Artificial intelligence is a branch of computer science that deals with the automation of intelligent behavior using concepts from other disciplines such as neuroscience and cognitive science. Since the concept of intelligence itself is relatively diverse, there is no clear scientific definition of AI. The origins of AI go back to the 1950s, and this initial phase was marked by almost limitless expectations about the capability of computers. This attitude was regularly criticized, and the high expecta-

11. For an overview see https://en.wikipedia.org/wiki/Existential_risk_from_artificial_general_intelligence.

tions raised by "old AI" have so far not been fulfilled. However, current technical innovations have changed this assessment to a certain degree. Machine learning has become the basic technology for self-driving cars, robot assistants, and the automation of non-trivial social, administrative, and economic processes. Technological progress, the training of qualified practitioners, and competitive pressure are accelerating the spread of AI.

Accordingly, various discourses have developed in recent years. These are briefly described below because they provide orientation points for assessing the potential impact of AI and Big Data on scientific practice:

The black box problem: In contrast to "classic" computer algorithms, the new ML technologies—especially the so-called deep neural networks—use different programming techniques. Instead of clear software structures, which are at least comprehensible in principle for the programmer, a neural network is provided by the programmer, but its connectivity and weighting of the connections change over an enormous number of training cycles (an image recognition algorithm is trained with millions of images, for example). In the end, even the developers do not know how the algorithm comes to the solution, because such ML models are equations that have no obvious physical or logical basis. Therefore, certain AI algorithms appear as "black boxes," a significant limitation for practical applications of AI, provided there is an expectation that one understands how a system comes to a decision.[12] When using AI for automated translation, the problem is probably irrelevant, especially since determining the quality of a translation is simple, but if the system is to decide on a customer's creditworthiness, for example, both customers and users need to know what criteria the system uses to make its decisions.

The bias problem: As Figure 1 illustrates, (big) data is the central resource for AI algorithms; this is particularly true in the case of deep learning. Depending on the type of decision problem, however, one-sidedness or biases can be hidden in the data, which then shape the behavior of the algorithm.[13] A well-known example is that the Google search for "professional hair" returns mostly images of white women, while the search for "unprofessional hair" shows primarily black women. This classification reflects the bias hidden in the data. AI systems can even be manipulated and thus abused by means of inappropriate learning data. In March 2016, a Microsoft experiment that ran a Twitter account using artificial intelligence failed. The fictitious AI teenager began to tweet increasingly racist and misogynistic statements after being deliberately influenced by a group of Twitter users. The bias problem is relevant because the user is unlikely to be able to identify hidden one-sidedness in training data sets consisting of a million units.

The fairness problem: Important questions arise not only with regard to the data, but also with regard to the algorithms themselves, because these contain implicit normative assumptions and are thus value-laden. Important parameters are defined by the developers and configured intentionally or unintentionally by the users in such a way that certain values and interests are privileged over others. This is relevant if AI systems are used, for example, to assess criminals. The problem of the fairness of algorithms is complex, because given legal norms must be translated into a "language" that computer

12. Frank Pasquale, *The Black Box Society: The Secret Algorithms That Control Money and Information* (Cambridge, MA: Harvard University Press, 2015).

13. Aylin Caliskan, Joanna J. Bryson, and Arvind Narayanan, "Semantics Derived Automatically from Language Corpora Contain Human-like Biases," *Science* 356 (2017): 183–86.

programs can understand. For example, algorithms can be constructed in such a way that they systematically ignore certain data characteristics (for example, information on gender or social status), but this often influences the accuracy of the algorithm.[14] Other intuitions of fairness can be "algorithmically packaged" in such a way that, for example, the proportion of classification errors of the first and second order (X is falsely assigned or falsely not assigned to group Y) may not be differentiated across discrimination-relevant groups.[15] However, mathematical considerations show that certain ethically equally justifiable demands on algorithms (for example, regarding accuracy and fairness) cannot be met simultaneously.[16] Thus, the designers are forced to make moral choices when creating algorithms.

The problem of trust: In view of the problems described above, a paradoxical finding of psychological research is that people apparently tend to trust the results of automated decision-making too much. This manifests a basic problem of ML models that reveal correlation when it cannot be known whether or not they reveal causation. There is a risk that decisions depending on these models will be made with an illusion of security, even though they are only based on alleged connections that are not causally secure. A study from Stanford, for example, shows that participants rated the discriminatory employment recommendation of an algorithm as better and more neutral than the same recommendation made by a human.[17] However, the reverse problem (algorithm aversion) is also known: Studies show, for example, that evidence-based algorithms predict the future of certain types of problems more accurately than human forecasters do. But when people have to decide whether to use a human prognosticator or a statistical algorithm, they often choose the former—even when they see that the latter exceeds human capability.[18] This is apparently because people lose confidence in algorithmic procedures faster than in human forecasters. These studies point to a complex problem of trust when people increasingly rely on automated decisions: there is evidence of both too much and too little trust. This may indicate that a social practice for dealing with automated decisions has yet to be established.

Economic effects: The economic consequences of digital change clearly occupy the largest place in social discourse—and AI has a key role here in view of the enormously broad application potential. In contrast to previous automation pushes, activities that previously seemed to be reserved for people can now potentially be replaced. Some studies have predicted that up to 50 percent of all occupations could be automated in the next twenty years[19] and even highly qualified work will not be spared. Even though the extent of job losses is highly controversial[20] and the potential for creating new jobs

14. Moritz Hardt, Eric Price, and Nathan Srebro, "Equality of Opportunity in Supervised Learning" (2016), https://arxiv.org/abs/1610.02413.

15. Richard Berk, Hoda Heidari, Shahin Jabbari, Matthew Joseph, Michael Kearns, Jamie Morgenstern, Seth Neel, and Aaron Roth, "A Convex Framework for Fair Regression" (2017), https://arxiv.org/abs/1706.02409v1.

16. Jon Kleinberg, Sendhil Mullainathan, and Manish Raghavan, "Inherent Trade-Offs in the Fair Determination of Risk Scores" (2016), https://arxiv.org/abs/1609.05807v2.

17. Arthur Jago, "Technology and (in)discrimination," paper presented at Psychology of Technology Conference, Berkeley, CA, 2017, available at https://www.psychoftech.org/2017-schedule.

18. Berkeley J. Dietvorst, Joseph P. Simmons, and Cade Massey, "Algorithm Aversion: People Erroneously Avoid Algorithms After Seeing Them Err," *Journal of Experimental Psychology: General* 144.1 (2015): 114–26.

19. Carl Benedict Frey and Michael A. Osborne, "The Future of Employment: How Susceptible are Jobs to Computerisation?," working paper, 2013, https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

20. Max Rauner, "Die Pi-mal-Daumen-Studie," *Zeit Online*, 2017, http://www.zeit.de/2017/11/kuenstliche-intelligenz-arbeitsmarkt-jobs-roboter-arbeitsplaetze.

is unclear, hardly any occupational field of AI should remain unaffected, including science. Computers and the internet have already redefined entire industries such as media, music, and travel; more are likely to follow. And even if such economic upheavals have already taken place several times, they have always been accompanied by social unrest and crises. Given that modern information technologies have produced considerable wealth for a rather small group of well-trained people and enormous wealth for a very small group of the privileged,[21] the potential for social unrest is undoubtedly there.

The monopoly problem: Another economic problem complex concerns the relevant players in the research and development of AI systems. Since the new forms of ML are strongly data-based, companies with access to enormously large data sets have a competitive advantage. Leading technology companies from China and the United States such as Alibaba, Amazon, Baidu, Facebook, Google, and Microsoft are redesigning their internal business processes and products around AI. The well-known "winner takes all" effect of the internet economy and the associated danger of monopoly formation is likely to intensify in view of the large resources required for the development of successful AI systems. This could make science increasingly dependent on large tech companies.

Geostrategic issues: A final, important point concerns geostrategic issues. China has defined AI as a key element in its strategic goal of becoming a global leader in the development of new technologies. At the same time, AI is a powerful instrument for supporting totalitarian efforts such as mass surveillance of the population and "big nudging." In 2020, China plans to introduce a nationwide social credit system based on comprehensive monitoring and assessment of citizens by AI systems.[22] The question is to what extent the national application of AI technologies developed in societies with divergent social norms and democratic traditions raises ethical or political problems. Military uses of AI also fall within this complex of topics, and scientists are already warning of an "AI arms race."[23] This is a dynamic that is difficult to understand and even more difficult to control.

This is an impressive list of issues related to the current digital transformation powered by AI and Big Data—and they raise many questions far beyond this short essay. Nevertheless, let us take this list as a framework for assessing the potential impact of using digital tools in science.

Digitalization of Science Impact Assessment: What Can We Expect?

We have to be aware of the pitfalls of the current discourse on the digital transformation of science and society. Some claims are exaggerated and partly driven by the economic interests of either the tech industry or the consultancy industry. Nevertheless, digital transformation is an ongoing process that will likely affect the practice of science in many ways. Some recent examples illustrate this:

- The ability to analyze large, unstructured data sets will increase tremendously. Unlike earlier attempts, "deep learning" systems do not need to be programmed with a human expert's knowledge. Instead, they learn on their own, often from large training data sets, until they can see patterns and spot anomalies in data sets that are far larger and messier than human beings can cope with. This can be used to greatly decrease the time needed in discovery processes, for

21. Erik Brynjolfsson and Andrew McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (New York: W.W. Norton, 2014).

22. Felix Lee, "Die AAA-Bürger," *Zeit Online*, 2017, http://www.zeit.de/digital/datenschutz/2017-11/china-social-credit-system-buergerbewertung.

23. Jürgen Altmann and Frank Sauer, "Autonomous Weapon Systems and Strategic Stability," *Survival* 59.5 (2017): 117–42.

example when analyzing complex chemical reactions.[24]

- Digital tools will also allow new ways of visualizing large data sets, including interactive visualizations and embedded simulation tools to make immediate predictions.[25]
- A startup called iris.ai creates exploration tools, starting from free-text description of the problem and a result editor, to build a large corpus of documents related to the problem statement with the aim of generating a precise reading list. In the long term, they want to build an "AI scientist" that can create a hypothesis based on existing publications, run experiments and simulations, and even publish papers on the results.[26]
- This goal of a "robot scientist" has already been realized in genetics: At the University of Wales at Aberystwyth, Ross King's program "Adam" designed and ran genetics experiments. Its successor "Eve," at the University of Manchester, is designed to automate early-stage drug development: drug screening, hit conformation, and cycles of hypothesis learning and testing.[27]
- A team at IBM and colleagues has created a system that can generate scientific hypotheses automatically by mining academic literature. Moreover, their algorithms, they say, can be used to make new scientific discoveries. Their goal is to combine text mining with visualization and analytics to identify facts and suggest hypotheses that are "new, interesting, testable and likely to be true,"[28]
- The system "Science Surveyor" uses algorithms to characterize the scientific literature on a selected topic. Using the abstract and citations of a peer-reviewed paper, Science Surveyor provides journalists context about that paper in several easy-to-read visualizations.[29]

These examples show that digital support is or will be available for various aspects of scientific work such as:

- Deciding what to read through systems that assess the importance of published scientific work
- Deciding which scientific question to assess through systems that are able to systematically explore the "problem space" for interesting spots.
- Creating hypotheses through systems that can survey what has been published so far.
- Deciding on the originality of research questions through systems that gain semantic under-

24. Zachary W. Ulissi, Andrew J. Medford, Thomas Bligaard, and Jens K. Nørskov, "To Address Surface Reaction Network Complexity Using Scaling Relations Machine Learning and DFT Calculations," *Nature Communications* 8 (2017), https://doi.org/10.1038/ncomms14621.

25. For an illustration, see the work and publications of the University of Washington Interactive Data Lab: http://idl.cs.washington.edu/.

26. See https://iris.ai/.

27. Kevin Williams, Elizabeth Bilsland, Andrew Sparkes, Wayne Aubrey, Michael Young, Larisa N. Soldatova, Kurt De Grave, Jan Ramon, Michaela de Clare, Worachart Sirawaraporn, Stephen G. Oliver, and Ross D. King, "Cheaper Faster Drug Development Validated by the Repositioning of Drugs Against Neglected Tropical Diseases," *Journal of the Royal Society–Interface* 12 (2015), https://doi.org/10.1098/rsif.2014.1289.

28. Scott Spangler, Angela D. Wilkins, Benjamin J. Bachman, Meena Nagarajan, Tajhal Dayaram, Peter Haas, Sam Regenbogen, Curtis R. Pickering, Austin Comer, Jeffrey N. Myers, Ioana Stanoi, Linda Kato, Ana Lelescu, Jacques J. Labrie, Neha Parikh, Andreas Martin Lisewski, Lawrence Donehower, Ying Chen, and Olivier Lichtarge, "Automated Hypothesis Generation Based on Mining Scientific Literature," paper presented at KDD 2014, New York, NY, August 24–27, 2014, http://dx.doi.org/10.1145/2623330.2623667.

29. See https://science-surveyor.github.io/.

standing of what already has been explored (one could imagine some kind of higher-level "plagiarism engine.")

- Actually performing the experiments, or at least the repetitive, "boring" parts of some experiments.
- Perform deductive reasoning based on the results generated in the experiments.
- Writing the papers (at least some sections with a high degree of standardization, such as the methodology section) or ensuring that the text written by scientists is "machine readable" (that it will be legible to the systems that automatically "read" them after publication and keep track of the scientific literature body).
- Reviewing papers through systems that may assess novelty of findings or find shortcomings in the argumentation or even data fraud.
- Deciding who would be a good collaboration partner through reputation systems that evaluate the "match" of scientists or teams.

This list is not conclusive; all aspects of scientific practice can be shaped at least partly by digital tools. However, as practicing science is the way scientific virtues are trained and shaped, I ask, how will these digital tools affect those virtues? In the following, I will provide a (speculative) assessment of the six virtues proposed by Pennock and O'Rourke using an evaluation framework that is based on the issues of the general AI and big data discourse mentioned in the previous section.

How Virtues May be Affected by AI in Science

The first relevant scientific virtue is *curiosity*. Curious scientists want to discover something. They want to find the answer to a question or they want to test whether some hypothesis is true. They have the drive to find new interesting questions. In short, they want to know something about the world. Although AI-supported digital tools lack the intrinsic motivation of generating knowledge about the world,[30] they may indeed be used by scientists to explore a problem space systematically in a way the single scientist never can do by himself or herself. One may say that curiosity is "externalized" from the scientist to such a system; the scientist then would be less involved in the process of finding questions, but is presented with questions that result from an externalized problem space exploration. As finding new interesting questions is a competitive advantage in today's science funding and career system, curiosity as a virtue might be hampered, particularly in scientific fields, where the availability of data allows for the construction of problem spaces. The problem of *bias* then could become particularly relevant, as an incomplete problem space (whose incompleteness remains undiscovered) could make relevant questions inaccessible for the AI system. Depending on what algorithms are used, the *black box* issue may have some relevance (because the scientist does not necessarily see why the system believes a certain question is promising); and in this way, the *trust* problem is intensified. As the data sets need to be large for creating the problem space, in some fields the *monopoly* problem—that is, the dependence of scientists on the data of large platform providers—could be relevant. Finally, AI-driven problem-space exploration may also have the effect that creative thinkers would not be attracted to science any longer.

30. In the following, I do not discuss the speculation that AI may lead to a (self-conscious) "super-intelligence," which may develop such intrinsic motivations.

The second key virtue is *intellectual honesty*, honesty in the acquisition, analysis, and transmission of scientific ideas, theories, or models. The vices corresponding to this virtue, such as deliberately ignoring facts, falsifying data, or plagiarism, are recognized as major problems for scientific advancement. Here, AI systems, perhaps used in the peer review process, indeed have the potential to support intellectual honesty by identifying scientists who infringe against this virtue. Used in this way as a control instrument, however, the digital tools would not directly enhance intellectual honesty; they would be instruments to detect "sinners." An obvious issue here is *fairness*, as it may be opaque why a control system qualifies a certain scientist as intellectually dishonest. Some tools may be used by intellectually honest scientists themselves, to check whether a seemingly new idea is indeed original. However, whether using such tools in the process of becoming a scientist indeed supports intellectual honesty might be questionable: the repeated experience that one's own ideas are evaluated to be "not original" by such systems (which is a likely scenario for students) may have unintended effects, creating frustration and even the motivation to "trick" such systems.

The virtue of *meticulousness* might be most strongly affected by automating some aspects in (experimental) science that are repetitive and "boring," but such "boring" parts of practicing science might be exactly what is needed to develop meticulousness. Thus, this virtue might eventually be externalized to the machine. Furthermore, the issue of *economic effects* may come into play here, as AI support systems may replace human workers in those repetitive or monotonous tasks where young scientists get their first involvement in the actual practice of science.

The virtue of *objectivity* involves a lack of bias or prejudice when making scientific judgments as well as the ability to make decisions based on facts rather than on personal feelings or beliefs. Digital tools that would be used for hypothesis finding, deductive reasoning, or assessment of scientific publications are likely to have a "flavor of objectivity," and their use by scientists may indeed be motivated by this virtue. Surely, the issues of *bias* (in the data) and *fairness* (of the algorithms) may come into play here, depending on the concrete applications. A more interesting problem, however, could be that the use of digital tools to increase objectivity may lead to an "exaggeration" of this virtue by downplaying the diversity of ideas that is likely important for scientific progress. If a well-constructed AI system relying on a large scientific database "decides" that a certain question is the relevant one—who could argue against that? The use of AI tools may create high standards of objectivity that undermine the chances to be wrong and learn through those mistakes.

The virtue of *perseverance* is important in a scientific culture where people know that progress is slow and that many ideas do not work, and where frustration due to failure is common. The various ways digital tools can be used indeed have the potential to make scientific practice much more efficient (inducing the *economic effects* already mentioned)—and perseverance may lose much of today's importance in the scientific domains where those tools allow for substantial efficiency gains. Whether this will actually be the case is hard to say, because one could imagine that a new type of perseverance might become relevant—the perseverance necessary to make the digital tools work the way they are expected to work. People dealing with complex software need a lot of patience until they really understand their tools; the same might happen with the digital tools intended to make scientific practice more efficient. However, people would then spend less time with the object of scientific inquiry and more time with their support tools.

Finally, the virtue of *skepticism* could be affected by those tools as well, maybe as a side effect of "over-

enhanced" objectivity and the use of such tools as control instruments to detect intellectual dishonesty. Obviously, the issue of *trust* comes into play here; whether the problem is too much or too little trust will depend on the concrete application. One aspect to consider here, however, concerns the *geostrategic implications* of a widespread promotion of AI applications for pursuing political goals ("big nudging," mass surveillance, and so forth.) Skepticism (and non-conformist behavior) is often the target of such goals, and tools for evaluating the reputation of the work of a scientist may be turned against the skeptical scientist.

Conclusion

This brief outline is sketchy and needs more reflection, but it makes clear that there is reason to believe that digital tools for scientists emerging from the progress in big data analytics and AI will likely affect scientific virtues. The perspective here is rather critical with respect to the impact of AI on those virtues. To what extent these potential dangers will be realized certainly remains an open question—on the one hand, because the promises of the "new AI" may (once again) go unfulfilled, as the usefulness of AI for complex scientific tasks remains limited. In such a scenario, AI systems would be just one tool out of many, and thus not this technology, but other factors related to the social conditions in which science is performed will likely have a stronger impact on scientific virtues.

On the other hand, the rise of AI in scientific practice is not an inevitable and deterministic phenomenon. Human considerations do play a role and they have an impact on how we train and use machine learning applied to various social domains.[31] The possibility that future scientists may have "AI companions" supporting their research in various ways is not restricted to a purely instrumental and uniform worldview. Depending on the use of this technology, it may also enhance pluralism in thinking. If AI systems in the far future may indeed gain a degree of autonomy with respect to the scientific ideas they suggest or the honesty they demand, they may remind us that scientific practice can also be holistic and respectfully, relationally attuned to the natural world and to the autonomy of other-than-humans.[32] But ensuring that the digitalization of science fosters scientific virtues demands a reflective use of the digital tools that will likely change scientific practice tremendously.

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31. Michele Loi and Markus Christen, "How to Include Ethics in Machine Learning Research," *ERCIM News* 116 (2019), 5.
32. Markus Christen, Darcia Narvaez, and Eveline Gutzwiller, "Comparing and Integrating Biological and Cultural Moral Progress," *Ethical Theory and Moral Practice* 20 (2016): 55.

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CHAPTER 18.

MACHINE LEARNING, AUTOMATED SCIENCE, AND VIRTUES

EMANUELE RATTI

One important ideal aspect of the scientific method is the fact that it is rule-based. This allows for transparency; anyone can go through the rules and replicate results. However, scientific practice is far from being strictly rule-based in the sense that scientific discovery is not constituted by a rigid set of steps that one has to follow to discover something scientifically valuable. Given the opacity of the way scientists discover things, a logic of discovery—strictly rules-based—has always been a dream of both scientists and philosophers.[1] Recently, developments in AI have been envisioned as likely to be effective in automating scientific discovery.

Big data analytics are only the most recent candidate for automated discovery within the tools provided by AI. In particular, it is now often said that methodologies and tools associated with big data can approximate the ideal of automated science such that humans will become dispensable. This is because human cognitive abilities will be rapidly surpassed by AI, which will take care of every aspect of scientific discovery.[2] However, it is not clear what "automated science" means in this context. Here, I argue that the idea behind automated science is not substantial, *at least in biology* (and in particular molecular genetics and genomics, my main case studies) and that big data analytics (machine learning in particular) are not independent of human beings and cannot form the basis of automated science, if by science we refer to a specific human activity.

By referring to machine learning methodologies (ML) in particular, I have made the point that any ML task is faced with a number of operations that require humans to make decisions based on aspects which are hardly reducible to computational abilities *tout court*. I report several of these examples.[3] A paradigmatic example of a task somehow irreducible to computational abilities is the choice of

1. Kenneth Schaffner, *Discovery and Explanation in Biology and Medicine* (Chicago: University of Chicago Press, 1993).

2. Tal Yarkoni, Russell A. Poldrack, Thomas E. Nichols, David C. Van Essen, and Tor D. Wagner, "Large-scale Automated Synthesis of Human Functional Neuroimaging Data," *Nature Methods* 8 (2011): 665–70; Michael Schmidt and Hod Lipson, "Distilling Free-Form Natural Laws from Experimental Data," *Science* 324 (2009): 81–5; Ahmed Alkhateeb and Aeon, "Can Scientific Discovery be Automated?," *The Atlantic*, April 25, 2017, https://www.theatlantic.com/science/archive/2017/04/can-scientific-discovery-be-automated/524136/.

3. Emanuele Ratti, "Phronesis and Automated Science: The Case of Machine Learning and Biology," in *Will Science Remain Human?*, edited by Fabio Sterpetti and Marta Bertolaso (Berlin: Springer, 2019).

the algorithm,[4] in particular between supervised and unsupervised learning. Sometimes the choice is straightforward; if no labeled data set is available, then unsupervised learning is the only option. However, having a labeled data set does not necessarily imply that supervised learning is mandatory. In fact, as Libbrecht and Noble have pointed out, "every supervised learning method rests on the implicit assumption that the distribution responsible for generating the training data set is the same as the distribution responsible for generating the test data set."[5] This means that sometimes data sets are generated in different ways and have different underlying characteristics. Libbrecht and Noble report the case of an algorithm trained to identify genes in human genomes; this probably will not work equally well for mouse genomes. However, it may work *well enough* for the purpose at hand. In these situations, the computer scientist has to first identify the fact that there might be a divergence between training and test sets. This divergence in ML, applied to biology, may also have a biological meaning, and it has to be scrutinized biologically and not only numerically.

Another task irreducible to computational tractability is *labels interpretation*. In cases of unsupervised learning, algorithms cluster data points that are similar according to a specific measure established by the algorithm. However, the algorithm itself must be informed at first about the number of groups into which the data points should be clustered. Hence, it is provided with a number of empty labels. However, when we apply such algorithms to biological data, we have to assign an interpretation to the empty labels: we have to say to which biological objects those labels represent. This usually requires collaborative research between different epistemological cultures,[6] and the way people negotiate such interpretations is opaque and difficult to reduce to rules.

I have interpreted all these problems in light of a virtue that Shannon Vallor has identified for experimentalists, namely *perceptual responsiveness*, defined as "a tendency to direct one's scientific praxis in a manner that is motivated by the emergent contours of particular phenomena and the specific form(s) of practical and theoretical engagement they invite."[7] To simplify, this virtue is a disposition to direct scientific praxis towards the affordances that a phenomenon under investigation yields. According to Vallor, a virtuous scientist is one who "properly reads or 'decodes' all of the salient invitations to measurement implied by the phenomenon…and creatively finds a way to take up just those invitations whose answers may shed the most light."[8] Vallor explicitly frames perceptual responsiveness in a virtue ethics/epistemology framework, such that scientific inquiry on this matter looks like value judgment rather than a mere procedure applying rules. To stress this further, the way a phenomenon is investigated scientifically is a function of the interaction of scientist's background, experiences, aims, ability to affordances, and so forth. It is a habit of seeing things under a specific light.

My claim is that the irreducibility to rules and clear-cut procedures identified in ML methodologies is a sign that ML practitioners may have to cultivate a computer science-version of *perceptual responsive-*

4. Maxwell W. Libbrecht and William Stafford Noble, "Machine Learning Applications in Genetics and Genomics," *Nature Reviews Genetics* 16 (2015): 321–32.

5. Ibid., 323.

6. Evelyn Fox Keller, *Making Sense of Life: Explaining Biological Development with Models, Metaphors and Machines* (Cambridge, MA: Harvard University Press, 2002).

7. Shannon Vallor, "Experimental Virtues: Perceptual Responsiveness and the Praxis of Scientific Observation," in *Virtue Epistemology Naturalized: Bridges Between Virtue Epistemology and Philosophy of Science*, edited by Abrol Fairweather (Berlin: Springer, 2014), 271.

8. Ibid., 276.

ness (a sort of *phronesis*). If this is the case, then science cannot be automated, not even under a strict AI regime.

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CHAPTER 19.

STUDENT MENTAL HEALTH, JOB CONCERNS, AND ISSUES IN ACADEMIC PUBLISHING: STIFLING THE ACQUISITION OF VIRTUE AND THE POSSIBLE PERPETUATION OF INJUSTICE IN THE PURSUIT OF SCIENCE

BRADEN MOLHOEK

This chapter examines how the practice of science in the Western academy at best inhibits the acquisition of some of the moral virtues, and at worst, perpetuates vices such as injustice. I examine the differences in health and stress between undergraduate and graduate students, arguing that failing to address student mental health concerns makes it more difficult to cultivate intellectual and moral virtues. I then give further attention to the health of graduate students and postdocs. As a direct extension of these concerns, the argument shifts to the academic job market. The problems facing doctoral students and postdocs raise questions about whether virtue can be cultivated at all in these circumstances. Even if virtue can be acquired, graduate students and postdocs are either failing to be told, or failing to internalize, the realities of the employment landscape, affecting how they understand the virtues of magnanimity and prudence. The final part of the argument points to issues in academic publishing, suggesting how the current situation contributes to injustice for scholars. The conclusion of the chapter suggests first steps that can be taken in order to address these concerns.

Undergraduate and Graduate Student Mental Health

The current model of higher education requires both undergraduate and graduate students. There is growing evidence that higher education is affecting the mental health, as well as the overall health, of students. Depression and stress are common in both populations, but it is important to investigate the similarities and differences in the underlying reasons of undergraduate and graduate student mental distress.

In a 2013 study, Wyatt and Oswalt recorded data from over 34,000 undergraduate and graduate students in the United States in order to attempt to answer this question.[1] They used data compiled in the American College Health Association-National College Health Assessment (ACHA-NCHA) II, using the data of part-time and full-time students at fifty-seven institutions, including two-year and four-

1. Tammy Wyatt and Sara B. Oswalt, "Comparing Mental Health Issues Among Undergraduate and Graduate Students," *American Journal of Health Education* 44.2 (March 2013): 97.

year schools.[2] The ACHA-NCHA II includes demographic information as well as a variety of health and behavioral information. In order to see how mental health might interact with school performance and behavior, the researchers chose to look at four collections of issues around mental health: "feelings and behaviors related to poor mental health, mental health diagnoses, use of mental health services, and perceived impact of mental health on academics."[3] After exclusions, the eventual data set included 27,387 students under the age of fifty. The vast majority were undergraduate students (88.9%) and almost all (94.6%) came from four-year schools.[4]

At first glance, the undergraduate and graduate data are extremely similar. 17.1% of undergraduate respondants were diagnosed with depression, compared to 17.0% of graduate students. Where results differed was in the self-reporting of feelings. Undergraduates "reported higher rates of feelings and behaviors related to poor mental health. Undergraduates also reported experiencing traumatic situations within the last 12 months at higher rates than graduate students."[5] Graduate students, on the other hand, reported higher level of stress than undergraduate students, with the most common underlying reasons being "schoolwork, finances, graduate/teaching assistantships, career planning, and family issues."[6] The researchers acknowledge that given the low response rate of graduate students, there are limitations to the study. Of particular note, they believe that their results may only reflect the mindset of graduate students with "less severe mental health challenges," with the assumption that those who suffered higher rates of stress or mental health challenges may have opted to not to respond to the survey.[7]

So while both undergraduate and graduate students experience depression, it seems that the underlying reasons for mental distress are different. For undergraduate students, greater independence at a time of significant transition, combined with insufficient experience and coping skills, makes them more vulnerable to stress.[8] The most common underlying causes of stress for graduate students, however, include schoolwork, finances, and career concerns. These differences mean that these populations need unique solutions in order to address mental distress as well as the issues that contribute to it.

To move the discussion into the realm of virtue studies, undergraduates are being given greater agency than they had previously had, but this freedom can have negative effects on their mental health. Certainly, making mistakes and learning from them is part of the development of a moral agent, but as the brains of undergraduates are still developing, they will need more support than those who have more practical experience. For graduate students the underlying issues generating mental health problems may be different and require different solutions, but the effect these stresses have on the acquisition of virtue is the same as it is for undergraduates, although most graduate students are old enough that at least their brains have finished developing. This does not change the fact, however,

2. Ibid.
3. Ibid., 98.
4. Ibid., 100.
5. Ibid., 102.
6. Ibid., 104.
7. Ibid., 105.
8. Ibid., 102.

that disorders such as depression disrupt the acquisition of virtue because of how it distorts perception and reasoning.

Depression is not only a mental health concern; it also affects moral deliberation. It affects a person's optimism, or what might be possible in terms of deliberative action. The experience (or lack thereof) of pleasure is also affected, with depressed people getting less enjoyment from experiences than they would if healthy. These two examples alone suggest how the virtues of prudence and temperance are affected by depression. If one has a skewed sense of what is possible or likely to be successful, it becomes more difficult to anticipate how one should react in any given situation. Likewise, if people do not receive pleasure from things they might otherwise enjoy, they may turn to other things in order to experience pleasure, such as overeating or abusing alcohol.

Mental and physical health also play a role in how the brain functions, so there are concerns for the intellectual virtues as well. Suffering from disease makes it harder for students to excel in their studies. Depression and physical health concerns stemming from poor decision-making affect not only the acquisition of the moral virtues, but also the cultivation of the intellectual virtues. Wisdom, understanding, and *techne* all require proper use of reason, and therefore are more difficult to acquire if students are not adequately healthy. In order to encourage the cultivation of both the moral and intellectual virtues, institutions need to provide resources to students, or at least find ways to encourage increased use of existing services.

Further Attention to Graduate Student Mental Health

Because the mental distress graduate students face has different contributing factors, it is important to look in greater depth at the effects of graduate school on students. The academic study of science requires graduate students in order to perpetuate the field. Doctoral students in the sciences are needed in order to continue research but also contribute to the academy itself upon graduation, theoretically replacing current professors as they retire. Three recent studies provide a more comprehensive examination of graduate student mental health.

A 2017 study by Levecque and Anseel surveyed 3,659 doctoral students in Belgium and compared those results to three other populations: those who are highly educated in the general population, highly educated employees, and higher-education students.[9] In order to assess mental health, they relied on a version of General Health Questionnaire that has twelve parts. In this context, a mental health problem is scored on a twelve-point scale, and Levecque and Anseel used a score of GHQ2 as the starting point for problems. They also examined scores of GHQ4 as an indicator of having developed a more serious disorder like depression.[10]

The results show that "51% of PhD students experienced at least two symptoms (GHQ2), 40% reported at least three symptoms (GHQ3), while 32% reported at least four symptoms (GHQ4)."[11] These numbers were significantly higher than for any of the comparison groups. The higher education students scored the closest, and their symptom scores were 30.61%, 22.21%, and 14.55% for two,

9. Katia Levecque, et al., "Work Organization and Mental Health Problems in PhD Students," *Research Policy* 46.4 (March 2017): 868.
10. Ibid., 873.
11. Ibid, 874.

three, and four symptoms respectively.[12] This means that doctoral students were more than twice as likely than any comparison group to exhibit three or four symptoms, four symptoms being the threshold for developing a disorder such as depression. Age did not appear to be a relevant factor for mental health, but female doctoral students were 34% more likely to report two or more symptoms than male doctoral students. Having a partner seemed to decrease the probability of symptoms, and having children made students less likely to score a GHQ4 but did not affect scores of GHQ2 .[13]

A March 2018 study by Evans and Bira examined the mental health of graduate students by surveying 2279 students (90% Ph.D., 10% Master's students) from twenty-six countries. The students came from a variety of academic disciplines, with 56% in the humanities and 38% in the biological and physical sciences.[14] The scales used for assessing mental health were the GAD07 (Generalized Anxiety Disorder, 7-point) scale for anxiety and the PHQ09 (Patient Health Questionnaire) scale for depression. The Generalized Anxiety Disorder scale awards zero to three points for each of seven questions; the Patient Health Questionnaire scale does the same for nine questions. The results of these surveys are quite striking.

Evans and Bira's first conclusion is that "graduate students are more than six times as likely to experience depression and anxiety as compared to the general population."[15] With specific reference to anxiety, 6% of the general population reported moderate to severe anxiety, a score of 10 or more on the scale, whereas 41% of graduate students reported the same. 6% of the general population also reported having moderate to severe depression, a score of 10 or more on the PHQ09 scale, compared to 39% of graduate students. Gender also made a difference in this study, with women more likely than men to experience anxiety and depression, and those who identify as transgender or gender non-conforming more likely to experience anxiety and depression than women.[16]

Evans and Bira identified two factors that made a great difference in students' mental health. The first of these is having a good work/life balance. 56% of those who scored as having moderate to severe anxiety did not believe they had a good work/life balance, whereas 24% believed they did. The numbers are very similar for those who scored as having moderate to severe depression, with 21% believing they had a good work/life balance and 55% disagreeing.[17] The second factor was having a supportive PI. In response to every question about how a PI could support a student, at least 48% of those suffering from anxiety or depression disagreed that their PI was supportive.[18]

The final aspect of graduate student health I will examine comes from the Graduate Student Happiness & Well-Being Report, done by the University of California-Berkeley in 2014.[19] Cal randomly chose 2500 graduate students to survey, with 32% (or 790 students) responding, covering a wide range

12. Ibid., 875.
13. Ibid.
14. Teresa M. Evans, et al., "Evidence for a Mental Health Crisis in Graduate Education," *Nature Biotechnology* 36.3 (2018): 282.
15. Ibid.
16. Ibid.
17. Ibid.
18. Ibid., 283.
19. Galen Panger, Janell Tryon, and Andrew Smith for The Graduate Assembly, "Graduate Student Happiness" (2014), http://ga.berkeley.edu/wp-content/uploads/2015/04/wellbeingreport_2014.pdf.

of schools and professional goals.[20] The authors used a ten-question Center for Epidemiologic Studies Depression Scale (CES-D) scale for their depression evaluation.[21] Similar to the previous studies, the report identifies roughly 47% of Ph.D. students as having moderate to severe depression. Although humanities students depression, 43–46% of biology/physics/engineering/"Other Professional" students also scored as moderately to severely depressed.[22]

The Berkeley report identifies the top ten predictors of graduate student health, the first of which is career prospects.[23] In the Recommendations section of the report, the authors state that "[i]mproving students' feelings about their career prospects may involve doubling-down on efforts to help graduate students understand and prepare for career opportunities available to them, especially 'beyond academia.'"[24] Finding full-time work in academia is becoming increasingly difficult, so I can understand the school's strategy to encourage student health by expanding the definition of what "career success" means. However, I imagine many students pursue a Ph.D. for a job in academia, though perhaps fewer in the sciences than in the humanities, and concerns about the increase of contingent faculty exacerbates concerns about justice in the academy.

The top ten also contains predictors related to physical health, such as overall health and the amount of sleep students are able to get.[25] The remaining predictors can generally be categorized into two groups: financial and engagement. The financial predictors include living conditions and financial confidence, that is, how much students worry about money. The engagement predictors include social support, academic engagement, academic progress and preparation, feeling valued and included in the department, and mentorship and advising.[26] Again, we see significant overlap across studies regarding the underlying contributors to graduate student health.

Employment: Postdocs

One way in which doctoral students in the sciences might try and improve their career prospects, particularly if they are not able to secure a full-time position in academia before graduation, is to become a postdoctoral fellow, commonly known as a "postdoc." Such a position keeps a young scholar in academia and provides opportunities to research and publish. However, these are not permanent positions, and research shows that life satisfaction for postdocs is no better than for graduate students. In 2013, Gloria and Steinhardt published a study which applied the positivity ratio to a sample of two hundred postdocs from a research school in Texas. To determine a person's positivity ratio, researchers use "the 20 item Modified Differential Emotions Scale (mDES; Fredrickson *et al.* 2003, Frederickson 2009). Ten of the scale's items assed the participants' positive emotions (e.g. amused, hopeful, inspired, and proud) while the remaining 10 items examined negative emotions (e.g. angry, distrustful, fearful, and overwhelmed)."[27] The positive score is then divided by the negative score to

20. Ibid., 2.
21. Ibid., 17.
22. Ibid., 6.
23. Ibid., 2.
24. Ibid., 13.
25. Ibid., 2–5.
26. Ibid.
27. C.T. Gloria and Mary Steinhardt, "Flourishing, Languishing, and Depressed Postdoctoral Fellows: Differences in Stress, Anxiety, and Depressive Symptoms," *Journal of Postdoctoral Affairs* 3.1 (January 2013): 2.

obtain the positivity ratio. The scale presents a ratio of greater than 2.9 as a flourishing individual, a ratio between 1.0 and 2.9 as a languishing individual, and a ratio below 1.0 as depressed.[28] Researchers wanted to see whether these ratios were related to individuals' stress, anxiety, and depressive symptoms, so they also used a ten-point stress scale and twenty-point anxiety and depressive symptom scales.[29]

The relationship between the positivity ratio and stress, anxiety, and depressive symptoms aligned with the researchers' hypothesis. Individuals identified as flourishing based on the positivity ratio also had the lowest level of the other symptoms, with an increase in these among the languishing, and the highest totals among the depressed.[30] The languishing, who made up 58% of the two hundred subjects, were the largest group. Depressed postdocs represented 29% of the sample, followed by the flourishing at 13%.[31] The differences in stress, anxiety, and depressive symptoms were statistically significant.[32] Not only did the depressed category, according to the positivity scale, have the highest rates of stress, anxiety, and depressive symptoms, but the average rates of depressive symptoms were high enough "for clinically significant levels of depressive symptoms."[33] In both the depressed postdocs sample and the general population, 21% reported a depressive symptom score of 16 or higher, which indicates moderate levels and could be a sign of clinical depression.[34] In this sample the rate of depression was much closer to the general public than in the earlier studies I described, which could mean that postdocs fare better than doctoral students. But even if that is the case, postdocs still have major concerns about the next step in employment, being hired as faculty.

In the discussion of virtue, these studies make it increasingly clear that graduate students especially, and postdocs to some degree, experience severe mental health stressors as a part of their academic lives. As stated previously, disruptions to mental health can make it more difficult to deliberate or reason, thereby making the acquisition of virtues more difficult as well. An additional virtue to bring into the conversation at this point is Aristotle's virtue of magnanimity. In this virtue, the great-souled person is aware of what they are capable of doing. Given the disparity between the academic jobs that graduate students and postdocs want, and the availability of these jobs, it is clear that academic institutions have not been effective at conveying the nature of the job market and job prospects to students. By not being transparent or completely honest about placement rates for tenure-track positions, schools are allowing students to believe that long-term academic employment is far more likely than it actually is. Whether this is because they have a financial interest in recruiting and retaining graduate students, or whether they have just been unable to provide accurate information (as opposed to making their placement stats look better than they are) or to convince potential graduate students, the results are the same. Far more graduate students are interested in long-term tenure-track employment than can be placed in available jobs.

It is also worth mentioning that the postdoc study uses the category of "flourishing." In a virtue

28. Ibid., 3.
29. Ibid.
30. Ibid., 5.
31. Ibid.
32. Ibid., 4.
33. Ibid., 6.
34. Ibid.

approach, the ultimate end for humans is flourishing, as in a life well lived, a life that led to the cultivation of the virtues. Aristotle argued that "because human nature is not self-sufficient for the purposes of contemplation, the body must be healthy, and food and other amenities must be available."[35] In other words, in order to even speak of the acquisition of virtue or flourishing, people need their basic material needs met. Survival, therefore, is a necessary prerequisite for flourishing. Even with one's basic needs met, Aristotle still believes that "it is difficult if not impossible to do fine deeds without any resources."[36] Although there is a chauvinist aspect to this position, which suggests that the wealthy Greek elite are the only people capable of virtue, Aristotle's point is still valid in that people require a basic standard of living to even be capable of moving from survival to flourishing. Any increase in resources beyond subsistence can then contribute to the furthering of virtue.

Aristotle's point is especially relevant in the context of the concerns of graduate students and postdocs. If financial matters and future employment are some of their greatest concerns, and the uncertainty of being able to survive after graduation or the end of a contract is causing mental distress to the levels being reported, then academic institutions are not providing enough financial support to graduate students or postdocs. The acquisition of virtue is difficult enough in light of mental health concerns. Adding pressure about basic needs into the mix means that it might not be possible for graduate students or postdocs to even consider the cultivation of the virtues. These concerns will remain a part of the discussion as attention is given to issues of contingent faculty.

Employment: Contingent Faculty

According to the 2015–2016 Annual Report on the Economic Status of the Profession from the American Association of University Professors, there has been a seismic shift in higher education hiring over the past forty years. Since 1975, the percentage of full-time tenured and tenure track professors has fallen significantly while the percentage of part-time faculty has almost doubled. Full-time tenured faculty made up 29.03% of all faculty in 1975, bottomed out at 16.82% of faculty in 2011, and rose to 21.45% of faculty in 2014. Part-time faculty, on the other hand were 24% of all faculty in 1975, reached their highest percentage in 2011 at 41.45%, and only dropped slightly to 40.93% in 2014. While the percentage of tenured professors has only dropped approximately 8% over the past 40 years, the percentage of full-time tenure-track professors has dropped from 16.12% in 1975 to 8.05% in 2014.[37] The rise in part-time faculty has led to major concerns. While many of those concerns affect part-time faculty primarily or exclusively, they are also relevant to higher education in general. Part-time faculty are paid less for their labor, usually without any kind of employee benefits. With adjuncts often being hired on a quarterly basis, these positions provide neither stability nor the chance to plan ahead more than a few months at a time. But there are concerns for higher education that go beyond those that part-time faculty experience themselves.

A 2017 literature survey by Kimmel and Fairchild examines how part-time faculty are affecting higher education. Although part-time faculty "tend to be dedicated teachers, and presumably, without scholarship or service expectations, can devote all their efforts to student learning," the reality is that many part-time faculty have a higher teaching load than those who are tenure-track. This load is often

35. Aristotle, *The Nicomachean Ethics*, edited and translated by J.A.K. Thomson (London: Penguin, 2004), 275.

36. Ibid., 20.

37. AAUP, "Higher Education at a Crossroads: The Annual Report On the Economic Status of the Profession, 2015–16" (March-April 2016), https://www.aaup.org/sites/default/files/2015-16EconomicStatusReport.pdf, 14.

spread across multiple schools, limiting the time faculty can give to any particular student body.[38] Grade inflation is also a significant issue. This has been a problem for years, but it turns out that, *ceteris paribus*, part-time faculty give higher grades than full-time faculty. This could be in part because they want to minimize criticism from students that could lead to unemployment.[39] (Student course evaluations are virtually the only way that part-time faculty are evaluated.)[40]

Looking at part-time employment in academia makes it clear that some of the issues affecting the mental health of graduate students do not end with graduation. If part-time faculty have higher teaching loads than tenure-track faculty, then it becomes even harder to establish a healthy work/life balance. If contingent faculty do not know whether they will have a job in three months, there is not a healthy or supportive relationship with the department, school, or institution. Finally, if future job prospects are a top indicator of mental health, part-time faculty have little to look forward to in light of the hiring trends in the AAUP report. Putting together a teaching load to pay the bills can prohibit a part-time faculty member from doing other things, such as writing, publishing, and presenting at conferences, to build their resume.

As stated previously, there are serious consequences for not having adequate financial support; one cannot begin to think about flourishing is one is fighting for survival. This is not to say that all Ph.D. graduates are owed a job in academia, but those that are employed by academic institutions should be compensated properly for their labor. The move to contingent faculty has certainly saved institutions money, but college tuition increases continue to outstrip inflation, so the money saved is not going to make education more affordable. It seems to be largely going to upgraded facilities with additional amenities to entice students, as well as to administrative staff, who make more than contingent faculty.

Another virtue to be brought into the conversation, then, is the virtue of justice. If justice is the disposition of giving people what they are due, it is questionable whether academic institutions are doing this with part-time or contingent faculty. They may not be doing research for schools the way that many tenure-track professors are, but they are not being compensated equally for the same kind of teaching work. Contingent faculty may not receive a research budget, travel accounts, or other research-related financial support, but they should receive benefits such as health care and receive at least a living wage for their work, if not wages that are commensurate with the teaching responsibilities of tenured faculty.

Academic Publishing

Academic institutions may not be giving contingent faculty what they are due, but at least they are providing some compensation. Academic journal publishers, on the other hand, often fail to provide any financial compensation to authors, regardless of whether they are tenured or not. The dissemination of research is thus another source of justice problems for the academy, both for those doing the research and those who depend on access to it.

38. Krista M. Kimmel and Jennifer L. Fairchild, "A Full-Time Dilemma: Examining the Experiences of Part-time Faculty," *The Journal of Effective Teaching* 17.1 (March 2017): 53.

39. Ibid., 54–55.

40. Ibid., 55.

There was once a variety of ways in which research was published. However, in the nineteenth century academic journals became the best way to spread results because they were faster and more convenient than other options. Their influence continued to grow, and eventually journals became the dominant method of publishing academic research, particularly in the sciences.[41] In the first half of the twentieth century, journals were operated by scientific societies, but following World War II, corporations began playing a larger role in the publishing of academic journals.[42] Since then publishing companies, and specifically the largest companies, have continued to increase their market share. In 1973 the five largest publishers, four of which are corporations, published 20% of all articles in the natural and medical sciences. By 1996, this figure had grown to 30%. By 2006, the top four corporate publishing companies and the American Chemical Society published half of all natural and medical science articles. This percentage remained stable until 2013, when it increased to 53%, with the three largest of the top five publishing over 47% of all articles.[43]

As these companies were able to minimize their competition, their profits increased greatly as well. For example, Reed-Elsevier's "profits more than doubled" from 1991–97, growing "from 665M USD to 1,451M USD—profit margins also rose from 17% to 26%."[44] Over the next six years profit margins dropped while profits remained steady, and then following 2003, with the exception of the economic downturn in 2008–09, profit margins and profits grew again, to over $2 billion in 2012 and 2013.[45] Profit margins never dropped below 30% after 2006 and grew to 38.9% in 2013.[46] These numbers are consistent with the other three companies in the top five.[47] Springer, John Wiley & Sons, and Taylor and Francis had profit margins of 35%, 28.3%, and 35.7%, respectively, in 2012 or 2013.[48] In order to give these margins some context, the Larivière study compares these companies to the most successful banks, drug companies, and car companies. The most profitable bank, the Industrial & Commercial Bank of China, had a profit margin of 29%; Pfizer, the top drug company, had a profit margin of 42%; and Hyundai Motors, the most profitable car company, had a profit margin of 10%.

The question could be asked how these publishing companies are able to generate such profit. The publishing world has a unique set of contributing factors. Larivière argues that

> [u]nlike usual suppliers, authors provide their goods without financial compensation and consumers (i.e. readers) are isolated from the purchase. Because purchase and use are not directly linked, price fluctuations do not influence demand. Academic libraries, contributing 68% to 75% of journal publishing revenues, are atypical buyers because their purchases are mainly controlled by budgets. Regardless of their information needs, they have to manage with less as prices increase. Due to the publisher's oligopoly, libraries are more or less helpless, for in scholarly publishing each product represents a unique value and cannot be replaced.[49]

The cost of physical journals includes "manuscript preparation, selection and reviewing as well as

41. Vincent Larivière, Stefanie Haustein, and Philippe Mongeon, "The Oligopoly of Academic Publishers in the Digital Era," *PLOS ONE* 10.6 (June 2015): e0127502, http://dx.doi.org/10.1371/journal.pone.0127502, 2.
42. Ibid.
43. Ibid., 3.
44. Ibid., 10.
45. Ibid.
46. Ibid.
47. Ibid., 3.
48. Ibid., 10.
49. Ibid., 11.

copy- editing and layout, writing of editorials, marketing, and salaries and rent."[50] The two greatest of these costs are writing and reviewing, and these are free for the publishers. Authors are also forbidden from submitting a potential article to more than one publisher at a time, so publishers are not competing with each other for content; each publishing company offers a unique product. The rise in digital technology reduces post-publication costs as well. For each copy of an article accessed online or reproduced digitally after initial publication, there are virtually no costs, and "when the marginal cost of goods reaches 0, their cost becomes arbitrary and depends merely on how badly they are needed, as well as by the purchasing power of those who need them."[51] If I did not have access to several academic libraries as part of my employment, I would have had to rent or purchase some of the articles I used in researching and writing this paper. Those costs are well above zero and all of the profits made from renting or purchasing papers go to the publisher, not to the authors of these texts.

Previously, corporate publishers added value to the process with layout, printing, and distribution, but as their own profits increased, their added value did not grow at anywhere near a similar rate. Authors and reviewers currently provide the most value. Of course, suggesting there are ethical issues with publishing is nothing new, but when young scholars are facing a job market for tenure-track positions that is constantly shrinking, publications are needed to try to secure jobs, and if by chance a tenure-track position is secured, publishing is a requirement of these positions. Likewise, tenured professors need to continue to publish to maintain or increase their status and to ensure they still have access to future grant funding. The more prestigious the journal, the better for them—and all of the prestigious journals are controlled by the top five publishers.

The practices of academic journal publishers present the clearest argument thus far for the perpetuating of injustice. Publishers could argue that they are not doing anything unethical and that they are simply following market trends while providing authors with the proper compensation for their work: exposure. There are always people looking to publish, so there is no leverage on the part of academics to expect financial compensation for their work. However, just because it is legal does not mean it is ethical. Authors are not operating in a free market where they can solicit multiple publishers for their work; they must deal with one publisher at a time, granting each publisher a monopoly on what they produce. And given the financial success of these publishing companies, it is clear that there is a market for academic research, although this market is also not free. Because each publisher has a unique portfolio, they can choose to charge whatever they want and institutions cannot get access to that material from other sources. Scholars and students need access to research, so academic libraries are atypical buyers and placed in difficult spots. Nevertheless, in late February 2019, the University of California system cancelled its subscription contract with Elsevier. During the negotiations, administrators at UCLA urged their faculty not to review Elsevier articles in order to highlight concerns with its current business model.[52] Although the UC system is not the first institution to engage in these behaviors, it is one of the largest to do so and has brought additional attention to these important issues.

50. Ibid.

51. Ibid., 12.

52. Lindsay Ellis, "U. Of California System Cancels Elsevier Subscriptions, Calling Move a Win for Open Access," *The Chronicle of Higher Education*, February 28, 2019, https://www.chronicle.com/article/U-of-California-System/245798.

Conclusion

Although the practice of science has given us knowledge about life, the universe, and, if not everything, then many things, it is safe to say that science is not perfect. What I have tried to do here is to identify what lies in the shadows of the practice of science. Identifying concerns that affect both those who practice science as well as those being taught to practice science should be beneficial to the field. Though there is not time to delve deep into solutions, I want to share some first steps towards addressing these concerns.

For undergraduate students, Wyatt and Oswalt found that students were better able to tolerate stresses associated with the transition to college with "a strong social network, good physical health, and a sense of control over one's personal life and academics."[53] Including first-year programs that allow for the growth of these things would help students proactively. Another way to assist undergraduate students is to keep track of overall negative behaviors. Undergraduates are more likely to react to mental pressures in ways that are also unhealthy for them in general, such as smoking or drinking, and these decisions also have an effect on academic performance. By monitoring academic performance as well as "health risk behavior trends," institutions are more likely to identify at-risk students sooner.[54] Having programming specifically designed to engage with the negative effects of poor health choices, such as the dangers of binge drinking and smoking, again particularly in the first year of school, can also inform students of the dangers and remind them of the available of existing health services.

For graduate students, there are several clear ways to help them deal with mental health pressures. The first of these answers involves improving advising. Almost all of the studies examined here state that a positive relationship with one's PI makes a significant difference in the mental health of graduate students. It is also shown that this positive relationship can make students more likely to seek out and utilize campus counseling services.[55] The Berkeley report showed the importance of a strong social network, which can be more difficult for graduate students than undergraduates because they are often more separated from campus life. Another way to help graduate students, then, is to provide opportunities for them to be more engaged in the community, and not only in academic settings.[56]

Just offering graduate students opportunities to be more engaged on campus is not enough, however, particularly if students are already feeling stressed and do not feel they have the time or resources to participate in these activities. Financial concerns are paramount for graduate students. Ensuring graduate students are compensated fairly for the work they do is probably the single thing schools could do that would have the most impact, but also the thing that would likely cost them the most. However, though proper compensation in the present cannot alleviate fears about career prospects, it would greatly enhance graduate students' experience.

Employment issues are far more complex because they do not involve individual institutions where administrators can make specific changes. Rather, these concerns involve systemic change across not only the United States but the entire world. Graduate institutions need to be transparent through-

53. Wyatt and Oswalt, "Comparing Mental Health Issues Among Undergraduate and Graduate Students," 102.

54. Ibid., 103.

55. Ibid., 104.

56. Ibid.

out the entire graduate education process, including about how they benefit from having students and about the realities of the job market. Prospective students need to be informed about the vastly reduced opportunities to pursue an academic career before they decide to invest time and money in a graduate program. Schools can also work on assisting students in job placement when nearing graduation and afterward.

The other thing graduate institutions can do is to reverse past hiring trends. With ample evidence of the problems contingent faculty create for both students and the faculty themselves, schools need to invest more money in properly compensating teachers. Instead of replacing a retiring professor with multiple adjuncts to save money, schools need to provide additional opportunities for people looking for jobs. Institutions continue to flood the market with graduates in order to sustain their own finances, but they do so at the expense of their own students.

Finally, academic publishing could also be changed to reduce the existing injustice in the system. My first suggestion is that the government should stipulate that any research done using government funds needs to be accessible to those who helped fund it. If taxpayer money is spent on research, then citizens have a right to access the published results of that research with little or no charge. Additionally, both the business model of the journals and copyright practices should changes. Authors should not have to give up the rights to their work in order to get it published, and because they provide content to journals, they should be compensated, both upfront and with royalties from secondary sales of issues/article reprints. Doing so would also raise the level of content for journals, because people would be more invested in publishing high-level work if they were compensated properly. Peer review is another practice requiring compensation. People do not routinely go to their lawyer or doctor and ask for free services, so why should journal publishers be able to get away with it? Again, compensation for this work will also increase quality, because peer reviewers will be more invested in the process and will give the review more time than they might otherwise. These forms of compensation would help graduate students and contingent faculty even if schools are unwilling to reform.

I have tried to identify a number of ways in which the academic study of science perpetuates injustice. Almost everyone involved, from undergraduates to tenured faculty, is affected by these issues—if not through teaching or advising, then through the problems associated with academic publishing. These problems do not have simple solutions. I have only tried to point in the direction of some steps that could be taken to address these concerns. It is my hope that through continued study, and through individuals and institutions that act as exemplars, the academy can begin to move from stifling the acquisition of virtue to cultivating and promoting virtue.

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CHAPTER 20.

JUSTICE ON THE BLOCKCHAIN? WHAT MIGHT "SMART CONTRACTS" MEAN FOR VIRTUOUS ACTION?

MICHAEL YANKOSKI

Introduction

"The Times 03/Jan/2009 Chancellor on brink of second bailout for banks."

[1]This headline from the British Newspaper is encoded in the "genesis block"[2]—the very beginning—of the Bitcoin blockchain. Amidst the chaos of the global economic crisis and the printing of extraordinary amounts of money in order to prop up an over-leveraged financial system, the pseudonymous Satoshi Nakomoto (the person or group of persons responsible for theorizing, designing, and releasing the first version of the open-source blockchain/cryptocurrency technology known as Bitcoin[3]) placed a cryptographic hash of this headline in the genesis block as a permanent statement of disapproval toward the existing global monetary system. Nearly a decade later, advocates of blockchain technology suggest this new technological category may well become as disruptive (in the positive sense) to human society as the Internet itself.[4] While there is much about this new technology worth engaging and questioning from an ethical perspective—not least this technology's enormous environ-

1. An earlier, shorter version of this chapter was presented at a conference in London, UK titled "Practicing Science: Virtues, Values, and the Good Life" in August, 2018. The conference was organized by the Center for Theology, Science and Human Flourishing at the University of Notre Dame, and funded by the John F. Templeton Foundation. I am grateful both to this Center as well as to the John F. Templeton Foundation for generous support and funding not only for the opportunity to present at the conference, but also for their support of my graduate studies.
2. A "genesis block" is the first block of a blockchain. It is the foundation of everything that subsequently is added.
3. Though Satoshi built on previous attempts at creating "digital cash", "The Bitcoin Whitepaper" contained at least two novel concepts that solved longstanding problems in distributed systems computing. See Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," October 2008, commonly referred to as "The Bitcoin Whitepaper," http://www.bitcoin.org/bitcoin.pdf.
4. For example, Tim Draper, a billionaire venture capitalist and early investor in Tesla, Skype, and Hotmail, has stated that the advent of blockchain is more significant than the Iron Age, the Renaissance, and the Industrial Revolution. See Kate Rooney, "Early Investor in Tesla, Skype and Hotmail says Bitcoin Will Be Bigger Than All Those Combined," CNBC.com, April 23, 2018, https://www.cnbc.com/2018/04/23/early-tech-investor-says-bitcoin-will-be-bigger-than-the-internet.html.

mental implications[5] and the profound inequality in the distribution of its wealth[6]—this chapter seeks to place one aspect of blockchain technology—so-called "smart contracts"—into conversation with the virtue of Justice as traditionally construed in Thomas Aquinas.[7]

One clarification is necessary at the outset of this chapter: as will become clear in subsequent paragraphs, advocates of blockchain technologies make rather extraordinary claims about the implications of these new technologies. At the time of this publication, it is too early to tell if any of these claims will prove to be accurate, or if the passage of time will reveal the blockchain buzz to be just another form of techno-utopian fantasy. What *is* clear now, however, is that major financial and technological organizations are dedicating significant resources to the advancement and deployment of these technologies. Microsoft integrated the Ethereum blockchain technology into its widely utilized Azure platform in 2015.[8] Jack Dorsey—the billionaire founder of Twitter—tweeted in 2018 that he believed Bitcoin was likely to become the world's "single currency" within a decade.[9] And Fidelity Investments—the asset management corporation with more than $7.2 trillion US under management—launched a custodial service for cryptocurrencies in spring 2019.[10] My point here is simply that blockchain technologies have gone from being the niche interest of a few geeks in 2009 to major foci of major corporations in less than a decade. While I do not believe all of the expansive claims of crypto enthusiasts will prove accurate, there is enough activity in this space to warrant sustained attention from ethicists. I hope that this chapter will help extend this area of consideration.

That clarification established, let's spend some time considering what blockchains are.

Although the first block in the Bitcoin blockchain was mined on January 3, 2009, Satoshi released the theoretical structure of Bitcoin in the "Bitcoin Whitepaper" in 2008.[11] In the whitepaper, Satoshi suggested that Bitcoin could function as a better form of money, one that could—thanks to its cryptographic underpinnings—vastly supersede the vulnerabilities and drawbacks of traditional forms of money that depended upon centralized institutions in order to function. Without need for a centralized authority to issue, secure, or guarantee its value, Bitcoin would be impervious to traditional methods of monetary control, attack, and corruption. Instead of these institutional forms of authority, Bitcoin would function through a decentralized, globally distributed, unhackable network employing sophisticated cryptographic technologies. Bitcoin thus purported to offer a new paradigm, a new

5. "Mining" is an astonishingly energy-intensive process wherein computers "compete" for a solution to a mathematical puzzle required in order to add the next block to the blockchain and are rewarded with new "coins" if they win. For estimates of total energy usage, see Mike Orcutt, "Blockchains Use Massive Amounts of Energy—But There's a Plan to Fix That," *MIT Technology Review*, November 16, 2017, https://www.technologyreview.com/s/609480/bitcoin-uses-massive-amounts-of-energybut-theres-a-plan-to-fix-it/.
6. For example, as of August 4, 2018, the top fifty addresses in the Bitcoin network controlled approximately 15% of the total wealth in the ecosystem, a figure calculated from information at https://bitinfocharts.com/top-100-richest-bitcoin-addresses.html.
7. It is critical to note that in what follows I am **not** arguing that bitcoin (or any other cryptocurrency) will succeed in fulfilling its purported use cases. Rather, I am seeking to engage in a thought experiment *as though* the ideal purported use cases were to be realized.
8. Marley Grey, "Ethereum Blockchain as Service now on Azure," *Microsoft Azure Blog*, November 9, 2015, https://azure.microsoft.com/en-us/blog/ethereum-blockchain-as-a-service-now-on-azure/.
9. Evelyn Cheng, "Jack Dorsey Expects Bitcoin to Become the World's 'Single Currency' in About 10 Years," *CNBC,* March 21, 2018, https://www.cnbc.com/2018/03/21/jack-dorsey-expects-bitcoin-to-become-the-worlds-single-currency-in-about-10-years.html.
10. Kate Rooney, "Fidelity Just Made It Easier for Hedge Funds and Other Pros to Invest in Cryptocurrencies," *CNBC*, October 15, 2018, https://www.cnbc.com/2018/10/15/fidelity-launches-trade-execution-and-custody-for-cryptocurrencies.html.
11. Nakamoto, "The Bitcoin Whitepaper."

system of money that could exist outside the traditional financial world. Indeed, the whitepaper implicitly suggested that if the Bitcoin experiment gained enough users, it would prove profoundly disruptive, rendering traditional financial institutions obsolete—or at least vastly less necessary to the instant global exchange of value—by supplanting their centralized, trust-based models with these "trustless" cryptographic technologies supported by decentralized, globally distributed networks.

Bitcoin is today a flourishing, if relatively small, financial ecosystem. The total value of the Bitcoin network today is approximately $130 billion, compared to the trillions of USD in circulation.[12] Approximately $1 billion US equivalent in value is transacted every day on the Bitcoin blockchain,[13] and some $18 Trillion of US equivalent of Bitcoin have been transacted across the Bitcoin network to date, without a single cent unaccounted for.[14] Satoshi's elegant cryptographic idea succeeded in generating a viable new monetary ecosystem wherein anyone with an Internet connection is able to instantly transact and verify the validity of their transactions within the public, open-source, distributed ledger of Bitcoin's blockchain.

Inspired by Bitcoin's success, new blockchain projects are deployed frequently. All told, more than fifteen hundred blockchain-based cryptographic tokens have been released into the wild, purporting to revolutionize everything from identity management to land ownership, air traffic control systems to global supply chains. Indeed, blockchain is a new buzzword among many of the world's top financiers, even as the Ethereum blockchain is being used by the World Food Programme to help keep track of aid provided to Syrian refugees at a refugee camp in Jordan.[15] Put simply, the blockchain era is rapidly dawning and disrupting traditional sectors even as it creates new spheres of innovation.

While the angles of worthy analysis on the blockchain phenomenon are at least as varied as the problems these new blockchain implementations seek to address, in this chapter I want to consider whether blockchain technology is really as disruptive as it purports to be, a task I pursue by examining blockchain from the perspective of the virtue of justice as traditionally formulated by Thomas Aquinas. This chapter proceeds by first outlining what are purported to be especially salient aspects of the cryptographic mechanisms of blockchain technologies, followed by consideration of some of the implications these nascent technologies would have—in a hypothetical scenario wherein they succeed in substantially achieving their purported ends—on the formation of the virtue of justice within an agent who chooses to utilize such technologies in her dealings with others.

Blockchain Technology

First, a brief description of some technical underpinnings of blockchain technology, for the cryptographic mathematics upon which it is based are purported to eliminate the need for—or at least radically reconstitute the nature of—trust between people. Note that I am not here suggesting that I agree

12. "Top 100 Cryptocurrencies by Market Capitalization," http://www.CoinMarketCap.com, accessed August 1, 2018.
13. "Estimated Transaction Volume," https://www.blockchain.com/charts/estimated-transaction-volume-usd?timespan=60days, accessed July 28, 2018.
14. This figure is calculated by totaling the total daily transaction volume available from Blockchain.com (https://www.blockchain.com/charts/output-volume?timespan=all&scale=1, accessed August 1, 2018) and multiplying it by the current exchange rate of approximately 00 US. This is somewhat misleading, however, as the USD/BTC exchange rate varies daily, and has not always been 00.
15. Russ Juskalian, "Inside the Jordan Refugee Camp that Runs on Blockchain," *MIT Technology Review*, April 12, 2018, https://www.technologyreview.com/s/610806/inside-the-jordan-refugee-camp-that-runs-on-blockchain.

with these claims. Rather I am trying to summarize how blockchain proponents understand the technology to function in an ideal state.

Timothy May, an engineer for Intel who retired at the age of thirty-four and dedicated the rest of his life to the development of the philosophy and technology known as "Crypto Anarchism," penned the "Crypto Anarchist Manifesto" in 1992.[16] Describing advances in cryptographic math made practically accessible through widespread deployment of sufficiently powerful computers into the hands of larger and larger populations of people, May noted that "these developments will alter completely the nature of government regulation, the ability to tax and control economic interactions, the ability to keep information secret, and will even alter the nature of trust and reputation."[17] While there is much worth considering and critiquing in May's Manifesto, I'm going to leave aside much of the libertarian and crypto-utopian implications in the first clauses of the quoted section for now, and focus specifically on the claim that cryptographic technologies are capable of altering the nature and of trust.

Proponents of blockchain technologies argue that blockchains anchor trust not in people or in institutions, but rather in asymmetric cryptographic mathematics that serves as the arbiter between people.[18] One oft-repeated saying in the blockchain community is "Don't trust. Verify." Mathematic verification becomes the new form of trust, for the possibility to verify another's claim is precisely what asymmetric cryptographic mathematics makes possible. This kind of cryptography is based upon what are called "key pairs," consisting of a one-to-one mathematically linked private key and public key. While a few lines of code are all it takes to generate a new key pair in a few milliseconds on a smartphone, it is "computationally impractical"[19] to reverse-compute ("crack") the private key corresponding to a public key. So long as the private key is kept private (that is, known only to the owner/user), the cryptographic scheme is computationally unbreakable. The full weight of the known physical properties of the universe prevents the private key from being hacked: that is to say, there are approximately as many possible key pair combinations in a 256-bit public/private key pair[20] as there are atoms in the visible universe. As such, unless someone actually knows the one and only private key that unlocks a particular public key, trying to brute force the correct key isn't just a needle-in-a-haystack scale problem, but an atom-in-a-universe scale problem. What this means practically is that the cryptography upon which blockchains are built is unassailable with contemporary computing technology, and is likely to be unassailable into the distant future.[21]

16. See Timothy May, "A Crypto Anarchist Manifesto," quoted in Peter Ludlow, *Crypto Anarchy, Cyberstates, and Pirate Utopias* (Cambridge, MA: MIT Press, 2001), 62–63. May was also a member of the so-called "Cypherpunk" online community—an email-list connected group focusing on cryptography and its political and social implications. Satoshi sent the Bitcoin Whitepaper to the Cypherpunk mailing list in 2008. For more history surrounding the intellectual lineage and development of Bitcoin in 2008 and 2009, see Paul Vigna and Michael J. Casey, *The Age of Cryptocurrency: How Bitcoin and the Blockchain Are Challenging the Global Economic Order* (New York: Picador, 2016).
17. May, "A Crypto Anarchist Manifesto," quoted in Ludlow, *Crypto Anarchy, Cyberstates, and Pirate Utopias*, 62.
18. I recognize that this claim requires substantial consideration and unpacking, but simultaneously refrain from doing so because sufficient treatment of it is simply beyond the scope of this chapter. In addition, and to reiterate, I am not suggesting that I agree with the validity of these claims. Rather, I am seeking to engage with these arguments as they emerge from the blockchain community in order to understand what it might mean *if* blockchain technology actually succeeded in its purported goals.
19. Nakamoto, "The Bitcoin Whitepaper."
20. Bitcoin utilizes the SHA-256 hash algorithm.
21. Discussions about the implications of quantum computing are often brought up in online discussion forums, but it is believed by many in the crypto community that by the time quantum computing becomes practically applicable, new quantum-hardened cryptographic functions will be devised.

A critical aspect in blockchain technology is the "distributed network" of computers that comprise the ecosystem. These computers (called "miners" and "nodes") are distributed all over the world and individually operate a software protocol that receives, validates, transmits, and records transactions within the ecosystem. These miners and nodes collectively examine and maintain the so-called "blockchain," which is the historical record of *every* transaction that has ever occurred within the *entire* ecosystem. The miners and nodes examine and verify the blockchain and any newly proposed transactions in a consensus method based on the pre-determined rules that are built into the software protocol they are each running. The code running on this distributed network collectively acts as a decentralized arbiter between the network's participants. No transaction that invalidates the rules of the network is accepted as valid. Any transaction that succeeds in meeting the pre-determined rules of the ecosystem is accepted and permanently recorded in the blockchain. Furthermore, because the software is open-source, any potentially nefarious code that an attacker might seek to introduce is flagged and rejected by the community before it is merged into the main code distribution. What this arrangement creates is a profoundly robust and fault-tolerant, automated, unhackable trust machine.

In Bitcoin, a public key is an address in the Bitcoin blockchain to which any amount of value within the Bitcoin ecosystem may be sent. Spending the value held in that address requires a cryptographic signature from the private key associated with that public key. If the private key is in fact cryptographically associated with the public key, the transaction is cryptographically valid, and the network of miners and nodes accepts the transaction and confirms the transfer of value between the specified addresses. Every ten minutes (approximately) a new "block" of transactions is added to the blockchain. The credit and debit to each address is then immutably recorded into the blockchain.

Satoshi's idea—the technical ingenuity that ignited the blockchain era—was to utilize the insurmountable strength of cryptographic math so as to remove the need for trusted intermediary parties such as banks, governments, and courts for the transfer of value to occur between parties. In doing so, blockchains anchor their validity and trustworthiness not on the strength or efficacy of existing political or economic institutions, but rather on the mathematical and thermodynamic laws of the universe.

Because blockchains are immutable ledgers maintained by distributed networks, proponents of these technologies believe that many of the vulnerabilities facing traditional, centralized financial institutions are avoided. There is no building, no physical address, no monolithic entity to target and attempt to subvert. As such, there is no central point of failure. Blockchain advocates argue that the robust diffusion of blockchain technologies into distributed networks is another source of and mechanism for their trustworthiness. It is as difficult to stop a blockchain once it is up and running as it is to stop the Internet itself. If one group of computers in the network is attacked or shut down (as has happened many times), the network's traffic is simply routed around it, in a way totally transparent to the end user. The network continues functioning.

Other blockchain projects, such as Ethereum, extend this underlying cryptographic structure into novel applications like "smart contracts." In smart contracts, a pre-programmed function executes once certain conditions are met, with the full weight of the blockchain network acting as enforcer of the contract. For example, when a person who controls the private key of an address on the Ethereum blockchain signs a transaction with that private key, a separate smart contract built to monitor that address might release a trust fund, issue a purchase order, unlock a hotel room door, or pay for a

refugee's foodstuffs. Proponents of such smart contract blockchains argue that it is this kind of systematic enforcement of autonomous code-based agreements that will enable the "Internet of Things" to flourish (think: smart refrigerators that automatically order and pay for food when items get low, or autonomous vehicles that pay their bill at a charging station without human interaction).

While there is much more worth discussing regarding the technical accomplishments of blockchain technologies—including a thoroughgoing analysis of whether trust is actually transformed as proposed by blockchain advocates—such analysis is beyond the scope of this chapter. My purpose above was to outline the ideal case as advanced by proponents of blockchain. I pivot now to focus specifically on the implications of these technologies for a traditional formulation of the virtue of justice. My particular question is this: if they actually function as they purport to function, should blockchain technologies be considered a help or a hindrance to the cultivation of the virtue of justice?

Justice as Traditionally Articulated in Aquinas

I begin with Thomas Aquinas's definition of the virtue of justice: "justice is a habit whereby a man renders to each one his due by a constant and perpetual will."[22]

Of necessity, I impose a certain critical limitation of scope. Obviously there is much contained in a robust conception of justice that exists outside the narrow realm of explicit agreements made between human agents, that is, the realm typically known as contractual justice. But, as "smart contracts" purport to be a kind of contract, in what follows, I'm only addressing this narrowly defined aspect of justice. Put differently, what someone is due in the name of justice contains the contractual obligations owed to her. But contractual justice does not fully encapsulate all that she is due, all that justice requires. (It would indeed be worthwhile to consider whether and how smart contracts might relate to a broader conception of justice, extending beyond the narrow realm of contractual justice. However, such an inquiry is beyond the scope of this chapter).

One critical way that a blockchain-powered smart contract differs from a traditional legal contract is its purported un-breachability. In a traditional contractual agreement, parties to the contract establish the terms of their agreement, including specifications for what to do in the event of breach of contract. Indeed, typical contract arrangements *assume that breach is a real possibility*. The contract is then signed by the parties, and becomes binding and in force. However, even once a traditional legal contract is in force it does not guarantee that the human agents will inevitably execute the contract. Breach is still always possible in a traditional contractual agreement.

In contrast, a smart contract is designed to be, and is believed to be by its participants, unbreachable. Once the smart contract is coded and activated, it will execute in the way it is designed to execute with perfect, binary precision. Once its specified conditions are met, it will deliver the specified consequences. Take, for example, a smart contract designed to make a mortgage payment on the second day of the next month. Once such a contract is generated and activated on the blockchain, the funds committed into the contract will be transferred to the lender on the specified day, no matter how potent the payees' desire to breach the contract may become during the intervening time. Here, it is worth reiterating the mechanisms underlying blockchain technologies: the strength of the cryptogra-

22. St. Thomas Aquinas, *Summa Theologica*, translated by the Fathers of the English Dominican Province, second revised edition (London: Burns & Oates, 1920), II-II 58.1. All citations of the *ST* herein are from this translation, unless otherwise noted.

phy upon which blockchain technology is built is believed to guarantee that nobody—literally, mathematically, *nobody*—can breach a smart contract once it is in force. Governments can't. Billionaires can't. Banks can't. Blockchain-based smart contracts make incorruptible contractual guarantees both technologically feasible and deployable at scale.

Assuming this holds true, what might the unbreakable assurance of a smart contract's execution mean for the "constant and perpetual" aspect of Aquinas's definition of justice? It would seem on the one hand that the utilization of a smart contract guarantees the "constancy" and "perpetuality" of the fulfillment of the contractual arrangements. Precisely to the degree that they are irrevocable, blockchain-based smart contracts are profound aids and supports to durably rendering what is due to the other. A person who enters into a smart contract guarantees that she will render to the other party what that party is due once the conditions of the contract are fulfilled. In this sense, utilizing smart contracts as a way of guaranteeing that one renders to the other what the other is due can be viewed as a profound aid to the habit of justice. One might even go so far as to suggest that blockchain technologically perfects justice.

But alas, it may not be so simple.

What about Aquinas's emphasis on the "will" in the definition of the virtue of justice? In the same article quoted above, Aquinas notes:

> Hence the definition of justice mentions first the "will," in order to show that the act of justice must be voluntary; and mention is made afterwards of its "constancy" and "perpetuity" in order to indicate the firmness of the act.[23]

As Jean Porter points out, for Aquinas, "justice is a virtue of the will."[24] If an action is to be ordered toward the virtue of justice, the human will must be engaged when rendering to another what the other is due. In an important way, a smart contract short-circuits the utilization of the agent's will in following through in rendering to the other what is due: a mechanism in a distributed network autonomously activates upon pre-determined preconditions and *then,* and *only then*, is the other rendered what she is due. This seems to be a problem. For in order for the habit of justice to be perfected, it is not just that the specifications of the contractual agreement must be rendered with constancy and perpetually, but rather that the human agent must *choose* to act in a way that is constant and perpetually committed to the good, and, accordingly, to constantly and perpetually choose to render to the other what justice demands.

Viewed from this angle, it would seem that in a critical way smart contracts obviate the need for the human will to be engaged in the act of rendering to the other what is due, for the rendering to the other is accomplished on the blockchain, activated by the code that operates a smart contract. Smart contracts therefore not only do not perfect the habit of justice, but may actually render the formation of such a habit and disposition of justice impossible: one is not engaging the will in order to practice or perfect a disposition when one is not actually choosing to act but rather having a machine act in one's stead. And, if an agent just has a smart contract act on her behalf instead of actually choosing

23. *ST* II-II 58.1.

24. Jean Porter, *Justice as a Virtue: A Thomistic Perspective* (Grand Rapids, MI: Eerdmans, 2016), 59.

to render to another what is just—well—it would seem that she isn't shaping a habit or a disposition toward justice in any meaningful sense.

A Possible Resolution

In the arguments presented above, smart contracts are either a mechanism for perfecting the habit of (an albeit limited form of) justice by guaranteeing that what is contractually obligated is rendered to the other at the appropriate time, or it is a technology that makes the habituation of justice almost impossible because the agent is no longer responsible for actually choosing to act so as to render what is due to the other. We can't have it both ways, so let me try to offer a possible resolution to this seeming impasse.

The resolution I'd like to propose depends upon Aquinas's sense of the structure and operations of the human will, and also on the careful distinction he makes between remote causes and proximate ends. First, concerning the human will. In Question 83 of the *Prima Pars*, Aquinas writes:

> But man acts from judgment, because by his apprehensive power he judges that something should be avoided or sought. But because this judgment, in the case of some particular act, is not from a natural instinct, but from some act of comparison in the reason, therefore he acts from free judgment and retains the power of being inclined to various things.[25]

What Aquinas is getting at here is the distinctive relationship in human agents between the faculty of reason and the operations of the will, particularly as the operations of these human qualities is distinct from the operations of non-human animals. Compared to natural instinct—the form of reason non-human animals possess—human reason presents a possible course of action to the will as the most reasonable course of action in relation to the agent's perception of the good. Summarizing Aquinas's argument, Jean Porter notes, "The will is the capacity to desire and pursue one's own overall existence and full development in accordance with some reasoned conception of what it means to live an appropriate or desirable or ideal human life."[26] This broad conceptual realm upon which the human will operates suggests that the human will possesses capacity far beyond that of non-human animals, precisely to the degree that human agents interact with a conception of the self in relation to an overall conception of the good. This broad conception of the good, which is operative in the rationality of the human agent, includes—in our particular topic of consideration—the requirements of justice.

Because the human agent is free, she must choose whether to act in accordance with what reason presents to the will as a good course of action. The human agent does not act out of necessity or compulsion on what is presented as a good course of action by reason. By contrast, non-human animals are not free to choose whether to respond or not to what their natural instinct presents to them as the required course of action. Non-human animals simply act. Recall Aquinas's example that a sheep does not need a faculty to choose to avoid the wolf—natural instinct is sufficient for the sheep to avoid the wolf.[27] But when a human agent chooses consistently in accordance with what reason presents as in accordance with the good and with the requirements of justice, she forms within herself the virtue of justice. To be a just person is to be habituated in choosing to do what is just. This is precisely why freedom is so central to Aquinas's formation of virtue: it is the agent's free choice of what is required

25. *ST* I 83.1.

26. Porter, *Justice*, 71, summarizing *ST* I-II 8.2; 9.1,3; 10.1.

27. *ST* I 83.1.

by justice that ultimately forms the habit of justice within her. It is here that we see more clearly how the virtue of justice is a habit of the will. As Porter further explains, "A habit of the will emerges out of, and expresses itself through, a range of choices and acts through the agent's characteristic motivations and ways of perceiving the world."[28] Emerging from the agent's characteristic motivations and ways of perceiving the world, the agent chooses to act consistently with the requirements of justice. As such, the agent is habituated into being a just person.

The specific question for our line of inquiry, therefore, is whether choosing to engage in a smart contract in order to ensure that the other is rendered what she is due is in fact an action that marginalizes or obviates the engagement of the human will. One straightforward way of responding to this would be to argue that choosing to engage in a smart contract does not obviate the agent's formation as a just person precisely insofar as the agent's reason for engaging the smart contract *is as a means of pursuing justice*, and as an outworking of what Porter described above as "the agent's characteristic motivations and ways of perceiving the world." Indeed, engaging external mechanisms in order to render to the other what is due is something that happens all the time in human affairs without any suggestion that such a decision inhibits the formation of justice. Trusting the post office to deliver a repayment check I owe to a friend does not obviate my commitment to repaying my friend simply because I am not the one who delivers the check. When chosen as a means of rendering to the other what she is due, a blockchain smart contract is a viable way of choosing to act in conformity with the dictates of reason regarding the just action to take.

But there is another, more interesting way to go about responding to the two lines of confused reasoning presented above. This route centers on the careful distinctions Aquinas makes between remote causes and proximate ends. Joseph Pilsner's *The Specification of Human Actions in St. Thomas Aquinas*[29] is particularly helpful in interpreting Aquinas's rather complex treatment of the relationship between proximate and remote ends, and I follow a line of Pilsner's reasoning below.

It is important to note that at several points Aquinas insists that the moral quality of an action is specified by its proximate end, not its remote end. Were this not the case, it would be, for example, licit to steal instead of earning money in order to give the money as alms. As Pilsner argues, "although 'earning money' and 'stealing' have a distinct and easily identifiable moral character, both would have to be identified as 'almsgiving' if specified by the end."[30] Insisting that an action is specified by its proximate end allows Aquinas to maintain the ability to evaluate actions on the basis of the proximate ends toward which the actions are directed rather than the remote end toward which the action may be ultimately directed. Earning money is good. Stealing is not good. Earning money and giving alms from that money is good. Stealing and giving alms from that money is not good.

However, Aquinas does allow for the possibility that an act obtains a certain moral species from its remote end. Aquinas's regular utilization of Aristotle's example of a person who commits adultery in order to steal emphasizes this point. Indeed, Aquinas distills this example into a dictum: "he who commits adultery for the sake of theft is more a thief than an adulterer."[31] In his *Commentary on Ethics*

28. Porter, *Justice,* 94.

29. Joseph Pilsner, *The Specification of Human Actions in St Thomas Aquinas* (Oxford: Oxford University Press, 2006).

30. Ibid., 135.

31. See *ST* I-II 18.6, quoted in Pilsner, *Specification,* 225.

Aquinas argues the point in this way: "For it is clear that if an act of vice or evil is ordered to some undue end, from this end the [act] obtains a certain new species of evil."[32] This particular distinction between proximate end and the remote cause of an action is insightful, but so too is another, seemingly contradictory point that Aquinas makes in the *Summa Theologica*. In a rather lengthy section of the *Secunda Secundae* that I won't quote here in full,[33] Aquinas makes use of the term "general cause" in such a way that allows a single human action to be specified under *both* its general cause as well as the proximate end toward which the action is immediately directed. Joseph Pilsner comments on this section of the *Summa*: "Just as the sun might be called a 'general' cause on account of the fact that it can illumine or change many kinds of things, so justice is called 'general' on account of the fact that it can direct many kinds of proximate ends to its own end."[34] The implications of this are that there is a simultaneous unity amidst distinction in actions oriented toward a remote end, if such a remote end requires certain proximate ends in order to be secured. As Pilsner writes, "when a proximate end is done for the sake of a remote end, it is a *single human action* with *two ends,* each of which gives its own proper species to this action."[35] Pilsner points to another section of the *Summa*, wherein Aquinas likens such a series of human actions to a geometric line: "just as line A to C is one, even if it passes through point B, so a human action from an end is one, even if it passes through a means."[36] The salient point here is that Aquinas seems to allow for unity amidst distinction in human acts wherein a proximate end is oriented toward a general cause.

This distinction between a "general cause" and a "proximate end" is very helpful in parsing our apparent impasse concerning smart contracts. For it is entirely conceivable that an agent would choose under the general cause of justice to engage a smart contract as a proximate end as a way of ensuring that the other receives her due. Let us consider a situation in which an agent intends to render to another what is due—she is choosing the general cause of justice—and then chooses to engage a blockchain smart contract in order to ensure that the other receives what is due at the appropriate time, when the necessary conditions have been met—the proximate end. Such a course of events does not substantively change what is required for the development of the virtue of justice—that is, consistently choosing to do what justice requires. I submit therefore that such an action is consistent with Aquinas's traditional formation of the virtue of justice, even as the agent pursues it through the engagement of cutting-edge twenty-first century technology.

There is much more that ought to be explored concerning the relationship between blockchain, virtue, and justice. It may well be that blockchain technologies eventually change the means of human interaction as absolutely and irrevocably as the Internet has. But even if blockchain technologies do succeed in many of their purported goals, we would be wise to assume that blockchain will neither perfect nor obviate the need to cultivate the virtue of justice. For even when utilizing smart contracts, in order to be truly just, a human agent must still choose whether or not to act in accordance with the dictates of reason in rendering to the other what is due.

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32. Aquinas's *Commentary on the Nichomachean Ethics, 5, lc. 3, n.4*, quoted in Pilsner, *Specification*, 225–26.

33. See *ST* II-II 58.6, quoted in Pilsner, *Specification,* 232.

34. Pilsner, *Specification*, 232.

35. Ibid., 227.

36. See *ST* I-II 12.2, quoted in Pilsner, *Specification,* 16 and 238.

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CHAPTER 21.

SCIENTIFIC PRACTICE AND DEMOCRATIC VIRTUES

GREGORY R. PETERSON

Introduction

Democracy and science, it might be thought, go hand in hand. As we commonly think of it, science has its roots in the heritage of Greek thought, and the same is true of democracy. And while Athenian democracy developed at best a complicated relationship with its intellectual luminaries, Athens was nevertheless home to both Plato's Academy and Aristotle's Lyceum. Nearly two centuries later, the scientific revolution most quickly took root in those nations that had come to have some semblance of democratic rule. While the Republic of Florence had passed under Medici control by the time Galileo was active, Newton's home was then the most democratic nation on earth. During the Cold War, the scientific achievements of the democratic West were often put forth as signs of its superiority over its communist foes, and the existence of Soviet scientist-dissidents such as Andrei Sakharov supported the narrative that the scientific enterprise, necessarily committed to the free exchange of ideas and the pursuit of truth even when socially inconvenient, simply cannot thrive in more oppressive contexts.[1]

The truth is admittedly more complicated: scientists aided and sometimes enthusiastically abetted the Nazi regime, and ongoing nuclear proliferation occurs only because of the many scientists—not all of them coerced—willing to contribute to such efforts. But such cases seem to be the exceptions, and they generally involve not the *pursuit* of science but its technological application. Genuine science plausibly needs, if not democracy, at least adequate freedom of expression in order for ideas to be communicated and critiqued. This was true enough in Galileo's day that scholars had access not only to the great works of the past but also, with some effort, the works of contemporaries.[2] On this account, if open, democratic regimes do not actively cause the flourishing of science, they at least do not suppress it, enabling the possibility of cumulative success over time.

But the arrow of causality may also run in the other direction. Democracy may not strictly need science, but it may be the case that the scientific mindset contributes to the quality and integrity of democratic forms of government. Indeed, one of the most persistent correlates to the emergence of

1. Audra J. Wolfe, *Freedom's Laboratory: The Cold War Struggle for the Soul of Science* (Baltimore, MD: Johns Hopkins University Press, 2018).
2. Owen Gingerich, *The Book Nobody Read: Chasing the Revolutions of Nicolaus Copernicus* (New York: Walker & Company, 2004).

democracy is the level of its citizens' education, a point first noted by Seymour Lipset in 1959 and which continues to have significant support today.[3] Importantly, education is not the same as *scientific* education, and it is quite possible that other features of education, including relevant components of civic education, account for the relationship. Even so, it is plausible to think that scientific thinking and therefore scientific training contribute to the quality and integrity of democratic regimes, and do so beyond the merely instrumental material benefits that science provides.

This paper briefly explores the case for this proposal. In particular, I argue that what we should think of as *democratic* virtues and *scientific* virtues overlap, and that, whatever other contributions science may bring, encouraging scientific training in a way that contributes to character formation also has positive political effects. First, I lay out a psychologically realistic account of moral and intellectual virtues, one that critically engages contemporary dual-process models of cognition to argue for an account of virtues in terms of integrated harmonic processing that involves both emotion and identity. Second, I introduce the concept of democratic virtues, and I distinguish these from merely civic virtues that support political institutions but not necessarily democratic ones. Although patriotism is a commonly named civic virtue, one can be patriotic with respect to either democratic or undemocratic regimes. But there may also exist specifically democratic virtues, including what we may call democratic trustworthiness, indicating a kind of trustworthiness that is not group-oriented and inversely related to political corruption. Third, I lay out the argument for scientific virtues as central to the conduct of science as a practice. Here I draw on Alasdair MacIntyre's conception of practices in *After Virtue* to explain why scientific practice requires the development of both moral and intellectual virtues. Crucial to this argument is the understanding that science is a practice and not merely a body of knowledge, requiring the existence of social institutions that facilitate that practice. To some extent, my argument here parallels that of Daniel Hicks and Thomas Stapleford, although their account is aimed at sociological analysis, not democratic values.[4] As a practice, science requires the development of both moral and intellectual virtues. That science requires intellectual virtues may seem initially obvious; that science requires the development of moral virtues is perhaps less so. But scientific practice is very much social in character, involving collaboration and mutual trust, and without these qualities present in the community, science cannot advance. Fourth and finally, I bring these threads together. The virtues developed in the practice of science and democratic virtues are intersecting sets, and some of the virtues developed as a consequence of excellence in the practice of science, I argue, can and likely do contribute as well to democratic functioning. While this is to some extent true of moral virtues such as those concerning trustworthiness, the stronger influence likely comes from the intellectual virtues developed in the context of scientific practice that serve to inhibit cognitive biases that can impair the wisdom of the crowd. I conclude by citing some empirical studies that appear to point in this direction and that suggest a differentiation between the impact of science education and education generally.

Although the argument I make is primarily philosophical and conceptual, the overall approach is interdisciplinary. The study of virtue is no longer the province of philosophy alone, and it involves

3. Robert J. Barro, "Determinants of Democracy," *Journal of Political Economy* 107.S6 (December 1999): S158–83; Edward L. Glaeser et al., "Do Institutions Cause Growth?," *Journal of Economic Growth* 9.3 (2004): 271–303; Eduardo Alemán and Yeaji Kim, "The Democratizing Effect of Education," *Research & Politics* 2.4 (October 2015): 1–7.

4. Daniel J. Hicks and Thomas A. Stapleford, "The Virtues of Scientific Practice: MacIntyre, Virtue Ethics, and the Historiography of Science," *Isis* 107.3 (2016): 449–72.

empirical claims that touch on psychology in particular. Any discussion of democratic virtues that claims to have empirical significance must engage other disciplines, notably political science, as well. In this, the argument aims to model an approach that is interdisciplinary in character and that recognizes the connections between philosophical argument and empirical impact.

The Idea of Virtue

When speaking of virtue, I use the term as is roughly typical in philosophical approaches to virtue, which is to treat it as a specific feature or trait of character, and not as a global evaluation of character in general, as it is sometimes used, both historically and in popular discourse. The term 'trait' itself is somewhat problematic, as it can suggest a permanent feature that, like a genetic trait, is fixed and automatic in its operation. The translation of the Greek *hexis* into Latin *habitus* to English *habit* is even worse in this regard, suggesting a trait that is not only automatically activated but thoughtlessly so. For Aristotle, virtues were not merely thoughtless habits, but dispositions produced by the "non-rational" part of the soul that nevertheless operated in accord with reason.[5]

Aristotle's psychology, while insightful, is in important respects premodern, and while contemporary virtue theorists generally agree in thinking of virtues as dispositions, they can mean very different things by this. Some stress an externalist behaviorist account associating virtue primarily with the action outcomes produced,[6] while others stress an internalist account closely linked to psychology.[7] Any genuine virtue theory must acknowledge a role for both. A purely behaviorist theory would not be a genuine virtue theory at all, but merely a theory of moral behavior, and any such theory would likely need to be construed either in strict terms of deontological action or consequentialist outcome in a way foreign to most virtue theories that recognize the context-sensitivity integral to the concept of virtue. Conversely, any theory that focused only on internal qualities such as emotion or motive would not be able to discriminate between the truly virtuous and the merely well-intentioned. Many individuals mean well and may feel appropriate compassion for the suffering or anger at injustice and yet never genuinely follow through or, worse, become complicit in the acts they abhor. To be virtuous at a high level involves not merely the appropriate motive and emotion, but the capacity to act in the right way at the right time.

To say that virtues are traits is to imply that they are more than a matter of consciously willing the right thing, and built into the concept of virtue is the idea that, as traits or dispositions, they are standing features of character that are in certain respects automatic. In modern psychological parlance, virtues can to some extent be explained in terms of contemporary dual-processing models that distinguish between explicit cognitive processes accessible to conscious reflection and implicit cognitive processes that, while possessing content, are in most instances consciously accessible in the form of intuitions or emotion.[8] Dual-process models have limitations, and psychology tends to emphasize

5. Aristotle, *Nicomachean Ethics*, edited by Roger Crisp (Cambridge: Cambridge University Press, 2000).

6. Julia Driver, *Uneasy Virtue* (Cambridge: Cambridge University Press, 2001); John M. Doris, *Lack of Character: Personality and Moral Behavior* (Cambridge: Cambridge University Press, 2002); Christian B. Miller, *Character & Moral Psychology* (New York: Oxford University Press, 2014).

7. Linda Zagzebski, *Divine Motivation Theory* (Cambridge: Cambridge University Press, 2004); Rosalind Hursthouse, *On Virtue Ethics* (New York: Oxford University Press, 1999).

8. Jonathan St.B.T. Evans and Keith Frankish, eds., *In Two Minds: Dual Processes and Beyond* (New York: Oxford University Press, 2009); Keith Frankish, "Dual-Processing and Dual-System Theories of Reasoning," *Philosophy Compass* 5.10 (2010): 914–26; Keith E. Stanovich, *Rationality and the Reflective Mind* (New York: Oxford University Press, 2011).

those cases where processes conflict, what may be called "oppositional processing."[9] Such oppositional processing certainly occurs, and it provides a possibly satisfying explanation for the well-known philosophical problems of weakness of will and conflict of will, perhaps best documented in early form by Augustine.[10] In contrast, fully formed virtues are best characterized in terms of 'harmonic processing,' where implicitly formed intuition and emotion works in concert with our explicit decision-making. Such harmonic processing appears characteristic of other forms of expertise, and a now substantial body of evidence supports this claim.[11] On this account, the implicit processes constitute not mindless reflexes but winnowed wisdom, formed by experience, narrative, and example. Such wisdom is both emotionally embodied and deeply connected to the individual's sense of moral identity. Thus, possessing the virtue of moral courage involves more than the episodic flash of emotion and action that rises in defense of an oppressed colleague, since such flashes may occur unreliably and, more importantly, not be deeply connected in any way to character and long-term dispositions. True moral courage emerges precisely because the being of one's character is so aligned that in many cases, the proper expression of moral courage is a regular feature of who one is. Such expressions are not wooden or inflexible, and part of being truly courageous involves knowing when and how courage should best be expressed in a given context.

Not all virtues are moral virtues, and both Aristotle and Aquinas distinguish between moral and intellectual virtues.[12] Strictly speaking, intellectual virtues such as practical wisdom and understanding are not moral virtues, although their proper functioning is important for the proper execution of moral virtue. The distinction between moral and intellectual virtues is primarily one of domain; intellectual virtues also involve integration with both emotion and identity. This may seem initially counterintuitive, especially since we tend to see the operations of reason and emotion as not only distinct but even diametrically opposed. We now know this claim to be largely incorrect, and a number of studies indicate that severing the neural circuits integrating reasoning and emotional processes leads to severe deficits in judgment, moral or otherwise.[13] Deeper reflection suggests how this is true. Although we tend to stereotype rational reflection and activity—including scientific reflection and activity—as occurring best in the absence of emotion, this is far from true.

Certainly, some emotions and mood states, such as anxiety, interfere with clear thinking. Most instances of strong emotion are genuinely incompatible with deep explicit reflection on a problem, but scientific reflection and rational reflection more generally are consistent with and supported by a range of emotions, including the joy and pleasure one feels when solving a difficult mathematical or scientific problem and the initial frustration one feels when results don't turn out as planned. Frustra-

9. Jonathan Haidt and Fredrik Bjorklund, "Social Intuitionists Answer Six Questions about Moral Psychology," in *The Cognitive Science of Morality: Intuition and Diversity,* edited by Walter Sinnott-Armstrong (Cambridge, MA: MIT Press, 2008), 181–218; John A. Bargh et al., "The Automated Will: Nonconscious Activation and Pursuit of Behavioral Goals," *Journal of Personality and Social Psychology* 81.6 (2001): 1014–27.

10. Augustine, *The Confessions*, translated by Maria Boulding (Hyde Park, NY: New City Press, 2001).

11. Darcia Narvaez, "Moral Complexity: The Fatal Attraction of Truthiness and the Importance of Mature Moral Functioning," *Perspectives on Psychological Science* 5.2 (2010): 163–81; Merim Bilalić, et al., "It Takes Two –Skilled Recognition of Objects Engages Lateral Areas in Both Hemispheres," *PLoS ONE* 6.1 (January 24, 2011): e16202, https://doi.org/10.1371/journal.pone.0016202; Gary Klein, *Sources of Power: How People Make Decisions* (Cambridge, MA: MIT Press, 1998); Gerd Gigerenzer, *Gut Feelings: The Intelligence of the Unconscious* (London: Viking Penguin, 2007).

12. Aristotle, *Nicomachean Ethics*, edited by Roger Crisp (Cambridge: Cambridge University Press, 2000); Thomas Aquinas, *The Summa Theologica*, translated by the Fathers of the English Dominican Province (New York: Benziger Bros., 1947).

13. Antonio Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: Penguin, 1994).

tion is a negative emotion, and while it may impel the novice to abandon further rational reflection, the expert will often find frustration itself a motivator. While it may not be strictly an emotion, the experience of *flow* first diagnosed by Mihaly Csikszentmihalyi[14] also serves as a subtle positive reinforcement of intellectual activity. Likewise, identity plays a crucial role, a fact borne out by the now numerous studies on how self-perceptions and stereotypes of race and gender imposed by dominant groups can inhibit mathematical and scientific performance. To do science requires being able to see oneself as a scientist, and those who are unable to do so face internal barriers to achievement that can be difficult to overcome.[15] Such achievement is particularly difficult in the absence of good mentoring and role models.

Keith Stanovich has recently argued that while it is standard to divide cognition into dual-processes, what we commonly think of as explicit processing can be further subdivided into algorithmic processing and reflective processing.[16] While the former is characterized by the explicit rule-following characteristic of simple arithmetic or the step-by-step development of a proof or argument, the latter is characterized by more global assessments. While algorithmic processing consists in the kind of rationality captured by IQ tests, reflective processing is characterized by "cognitive styles" that protect against issues such as confirmation bias or my-side bias. Although Stanovich treats reflective processing as explicit, it would seem to have a clear implicit component as well, and much of what Stanovich describes as reflective processing bears more than a family resemblance to intellectual virtues.

The Idea of Democratic Virtues

Although Aristotle spoke only in terms of moral and intellectual virtues, it has been common, especially in recent decades, to speak also of civic virtues.[17] For the ancients, the distinction between moral and civic virtue was not clear cut, and for Aristotle in particular moral virtues simply *were* civic virtues, since a life of virtue for Aristotle was a life lived in the context of a Greek polis committed to the flourishing of its citizens. This civic dimension of virtue revived with the rise of the Italian republics in the Middle Ages, most notably Florence and Venice.[18] Although these republics defined themselves by their opposition to tyranny and their commitment to citizen flourishing, they typically lacked many of the ingredients we would now think essential to democratic governance. The point is an important one, for while their legacy is frequently pointed to as an a important source for the concept of civic virtue, influencing later reflection and debate on the topic in England and North America, the specifics of their histories also highlight the fact that civic virtues are not necessarily synonymous with democratic virtues, and it is conceivable to be, for instance, deeply patriotically committed to a regime that is anything but democratic.

14. Mihaly Csikszentmihalyi, *Creativity: Flow & the Psychology of Discovery & Invention* (London: Harper & Row, 1997).

15. Thomas Breda, Elyès Jouini, and Clotilde Napp, "Societal Inequalities Amplify Gender Gaps in Math," *Science* 359.6381 (March 16, 2018): 1219–20; Domna Banakou, Sameer Kishore, and Mel Slater, "Virtually Being Einstein Results in an Improvement in Cognitive Task Performance and a Decrease in Age Bias," *Frontiers in Psychology* 9 (June 11, 2018), https://doi.org/10.3389/fpsyg.2018.00917.

16. Stanovich, *Rationality and the Reflective Mind*.

17. Google's ngram viewer reveals a gradual though uneven gain of usage for "civic virtue" over the past two hundreds years, with a sharp increase in the 1980s, perhaps due to the renewed interest in virtues more generally (https://books.google.com/ngrams/graph?content=civic virtue&year_start=1800&year_end=2000&corpus=15&smoothing=3, accessed December 12, 2018).

18. J.G.A. Pocock, *The Machiavellian Moment: Florentine Political Thought and the Atlantic Republican Tradition* (Princeton, NJ: Princeton University Press, 1975).

This raises an important issue regarding what should in fact count as a civic virtue. It might be thought that civic virtues are simply moral virtues and that, for instance, patriotism in support of autocratic regimes cannot be genuine patriotism because its aim is one contrary to proper human flourishing. In this context, it is probably better to think of civic virtues more like the way intellectual virtues are frequently conceived. Just as intellectual virtues are commonly thought of as qualities of character distinct from moral virtues, so too should we think of many civic virtues as distinct from moral virtues, and just as some intellectual virtues can be employed for bad ends, so too can civic virtues. But there may also be virtues which either directly or indirectly support democratic institutions, and I will refer to these as "democratic virtues." Such virtues may also be intellectual, civic, or moral virtues, and while some civic virtues such as generic patriotism may also serve to support democratic institutions, some may also be distinctive in their support of democratic institutions and opposition to non-democratic ones. These democratic virtues may not be present on traditional virtue lists, with one obvious reason for this being that fully democratic institutions are a relatively modern invention. That a virtue is not named does not mean it does not exist, only that it has not yet been identified.[19]

Thus, patriotism as such may only incidentally provide support for democratic polities, but there may also be a specific form of democratic patriotism, defined in terms of its commitment to not only one's own democratic institutions but also those of others. MacIntyre's analysis of patriotism argues that we should be skeptical of this.[20] On his account, patriotism is rooted in the values of a particular community of which one is a part, and it is precisely because one is so rooted that one is willing to sacrifice and to militarily defend one's country. Liberalism, committed as it is to forms of autonomy and freedom unconstrained by prior commitments, is unable to generate such communal commitment, and as such can never truly serve as the basis of a political system. But it would be a mistake to think that these are the only two options, and a further mistake to think that participating in community and committing oneself to democratic institutions, both at home and abroad, are mutually exclusive. A *democratic* patriotism is one that distinguishes itself not by a nativist commitment to a national community but by a commitment to the very principles and institutions of which one's community is a part. Crucial here is the kind of community with which one identifies, as well as how that identity is expressed. When the community of Le Chambon-sur-Lignon risked its very existence to rescue Jews from the Nazis, for example, they were not betraying their own community for the sake of others but precisely living out the principles upon which their community was founded.[21]

19. Debates exist over the enumeration of virtues; these include whether a full list of virtues can be given, whether such virtues are cross-culturally universal, and whether such a list must even be finite. For instance, Daniel C. Russell, in *Practical Intelligence and the Virtues* (Oxford: Oxford University Press, 2009), argues that there cannot be an infinite number of virtues without the concept becoming vacuous, and, further, that if there are not cross-culturally universal virtues this also raises important issues of moral relativism which would be of particular importance to the political domain. I would suggest that the answer to this question follows a similar line of argument to that concerning the universality of emotions: while there exist emotions that appear to be culturally distinct (e.g., Japanese *ijirashi*—the emotion of admiring of another who has overcome an obstacle—or Ifaluk *song*—a sort of righteous indignation), the specificity of emotions is grounded in features of human biology that are universal or nearly so. Thus, Ifaluk *song* may not be quite the same as "anger" in the American context, but there are significant overlaps, and English speakers can recognize most if not all of the features of *song* if it is adequately explained to them. Similarly, there may be particularity of virtue expression across cultures, but since virtues are deeply connected to human well-being, and since human well-being *is* in significant respects universal by definition of being *human* well-being, there exists a common core of value which virtues must also tap (for more on this argument, see Gregory R. Peterson, *Just Virtues*, in preparation).

20. Alasdair MacIntyre, *Is Patriotism a Virtue?* (Lawrence: University of Kansas Press, 1984).

21. Philip Paul Hallie, *Lest Innocent Blood Be Shed: The Story of Le Chambon and How Goodness Happened There* (New York: Harper & Row, 1979).

Such democratic patriotism would be but one instance of a democratic virtue, but others would be important as well. A substantial body of literature points to the importance of trust and trustworthiness for the success of democratic institutions, and surveys consistently show a significant correlation of generalized trust and democracy.[22] But trust is at best only part of the equation, since it makes little sense to trust individuals who are not in fact trustworthy. Whether or not we think of willingness to trust as a virtue, gullibility—the disposition to trust excessively—is certainly a vice and a trait to be avoided. But trustworthiness is a virtue and a democratic trustworthiness, committed both to the democratic institutions of one's country and to reliable exchange and relation with all of one's fellow citizens and not just those of one's favored group based on class, sex, or race is arguably central to the persistence and success of a democratic polity. It may be democratic trustworthiness that is measured by Transparency International's Corruption Perceptions Index, which correlates inversely with levels of democratization.[23] Individuals with the virtue of democratic trustworthiness holding positions in public institutions can find their character tested when those around them are corrupt, or when leaders who come to power aim to corrupt public institutions to their own benefit. At such times, democratically trustworthy individuals are forced to decide between their own short-term self-interest and their commitment to the public good, and in particular cases they may feel required to act as whistleblowers for the sake of the public interest.

Virtues of Scientific Practice

It is commonplace to think of science first and foremost in terms of its products, whether they be new scientific theories or the capacity for technological achievements. But technological advancement predates what we think of as modern science, as does the idea that science is a received body of knowledge. Indeed, a central feature of the break between modern science and the received science (natural philosophy) of Aristotle and Ptolemy widely recognized in the Middle Ages was the willingness to abandon the notion that science simply is such a received body of knowledge. What makes science *science* is not the body of knowledge that it produces, but the way that such knowledge is produced. This knowledge production requires certain kinds of practices that are sometimes both demanding and difficult to learn. Training is thus essential, and training in turn requires the persistence of communities of scientists committed both to maintaining the norms of practice and to passing the practices and their norms to succeeding generations.

It is commonplace to render scientific practice into the conception of the scientific method, and then to package the scientific method in such a way that it can be easily taught to students in science classes learning both the content and practice of science for the first time. In this narrow view of scientific practice, scientific practice just is a formulaic application of the scientific method, and in such contexts the scientific method is often reduced to a simple script consisting of literature review, hypothesis formation, hypothesis testing, and interpretation of tests in terms of confirmation and/or falsification. The problems with this approach as an actual description of scientific practice are well-known, for it at best significantly underdetermines what is involved in scientific practice and at worst significantly misconstrues how scientific knowledge is generated. These points were first highlighted

22. Christian Welzel, *Freedom Rising: Human Empowerment and the Quest for Emancipation* (Cambridge: Cambridge University Press, 2013); Robert D. Putnam, *Bowling Alone: The Collapse and Revival of American Community* (New York: Simon & Schuster, 2000).

23. https://www.transparency.org/research/cpi/overview.

in a significant way by Thomas Kuhn,[24] and subsequent generations of philosophers of science have sought with varying degrees of success to resolve these issues.

A broader conception of scientific practice is thus needed. The idea that science is an enterprise constituted by a set of practices will seem not at all strange to virtue ethicists. In his influential *After Virtue*, Alasdair MacIntyre lays out an account of practices in relation to the virtues, and he even briefly alludes to science as a practice within which virtues are developed.[25] For MacIntyre, a practice just is a cooperative human activity that is able to produce goods internal to the activity and in which there can be demonstrated forms of excellence.[26] A simplistic game or activity like tic-tac-toe cannot be a practice because it is not sufficiently complex to enable excellence or the production of internal goods. Chess, however, is such a practice, and MacIntyre makes a point of emphasizing that, while the novice chess player may initially play only to seek goods external to the game of chess itself (esteem of one's friends, prize in a competition), the experienced chess player is one who typically learns to internalize the goods of playing chess and to value them in their own right. Certain virtues are required in the playing of chess, and these must be developed through time, experience, and example in order to achieve excellence at the game.

As a game, chess provides a very limited example, but MacIntyre's analysis applies well to scientific practice. While science may be pursued for goods purely outside of the practice of science, there also exist goods internal to the practice of science, and the best scientists are often those who are motivated by the internal goods even in the absence of external ones. As a complex practice, science requires the development of certain moral and intellectual virtues. That the practice of quality science requires the development of intellectual virtues is not surprising, given that we conceive of science primarily as a rational activity—indeed, many would regard the practice of science as the practice of rational activity par excellence. Plausible candidates for intellectual virtues important for the practice of science include curiosity, perseverance, conscientiousness, and creativity.[27] Perseverance may not at first seem like an intellectual virtue, but perseverance in intellectual activity can be an especially important quality for scientists given that research projects often span years or even decades before promising results emerge. Likewise, creativity is often underestimated as an important quality, in part because we often think skill in science to consist largely of mathematical ability combined with in-depth knowledge of the subject material. But the problems that science poses are often quite vexing, and finding a good scientific model requires much more than simple Baconian induction. When we do recognize the importance of creativity, we often then ascribe it primarily to creative geniuses such as Einstein, implying that creativity is simply something one is born with: some people have it and some don't. But in most instances, creativity can to some extent be learned, and scientific creativity is made possible by both deep training and deep knowledge of the material.

But as much as the practice of science requires intellectual virtues, it requires certain moral virtues

24. Thomas Kuhn, *The Structures of Scientific Revolutions* (Chicago: University of Chicago Press, 1962).

25. Alasdair MacIntyre, *After Virtue* (Notre Dame, IN: University of Notre Dame Press, 1981), 188.

26. Ibid., 187.

27. The list is meant to be illustrative. The Scientific Virtues Project, led by Robert T. Pennock, has examined several virtues and their relation to scientific practice, including humility, scientific objectivity, and curiosity (see https://msu.edu/~pennock5/research/SVP.html). Much work has also been done on scientific creativity, although not from the perspective of virtue theory. See, for example, Dean Keith Simonton, *Creativity in Science: Chance, Logic, Genius, and Zeitgeist* (Cambridge: Cambridge University Press, 2004); Csikszentmihalyi, *Creativity*.

as well. Paramount to the practice of science is a commitment to truth, which requires both honesty and integrity. Scientists who willfully fabricate data or results do significant damage to science as a practice, since undetected fraud can lead to much wasted effort by other scientists and significantly damage not only the careers of the scientists who rely on the fraudulent work but also the standing of science with the public. Integrity—understood here as a form of moral courage in the face of adversity—comes into play both with respect to fellow scientists and with respect to a sometimes hostile public that feels threatened by the implications of a scientific theory. Not only may politicians exert pressure on scientists to avoid areas of research that are controversial, corporations may seek to bribe or co-opt scientists to hinder the spread of truths they find inconvenient.[28]

Since science is often if not typically a collective endeavor, the development of a sense of fair play and interpersonal justice can be crucial. The collaborator who brazenly insists that she be first author even when she has only contributed modestly to a project will soon find herself involved in no projects at all. Crucially, scientific fair play involves a commitment to treating scientific collaborators as equals regardless of race or gender and regardless of personal attitudes towards politics and religion. In addition to whatever moral injury is caused by failing to act fairly, successful scientific collaboration requires both mutual respect and a sense of obligation to carry one's own weight. When these are lacking, collaborations break down or become ineffective. This social character of science is in some respects distinctively modern, but it is important to note that science has always involved some level of collaboration. The Royal Society was established in 1660, and it was founded precisely due to the perceived need for scientists to interact and productively disseminate and critique each other's work.

Other relevant intellectual and moral virtues could be listed. While some of these virtues may already be possessed to some degree by individuals who choose to pursue science as a passion or career, it is important to note the central role that scientific exemplars and mentors can play in the development of these virtues. This is perhaps most true of intellectual virtues, but it holds for moral virtues as well. Lead scientists who run a lab poorly not only harm the careers of those who work there, they provide a poor model of scientific leadership for those under them. It must also be noted that, while scientists sometimes meet these ideals, many do so only partially, and some act contrary to the norms of science, resulting in all too frequent cases of fraud and misrepresentation of data. As a robust and self-correcting practice, science can often manage such cases. But as with any practice, excessive violation of standards can erode the institution, even enough to cause collapse.

Democratic and Scientific Virtues as Intersecting Sets

It is perhaps obvious that, however we think of scientific virtues and democratic virtues, their relation is not one of identity. Democratic patriotism may be a democratic virtue, but there is little reason to think that it does or should play a role in the practice of science. Somewhat less likely, it may also be the case that the practice of science in particular disciplines requires a damping down of particular emotional reactions that are important to virtuous behavior outside the scientific realm. A number of studies, for instance, show that medical doctors demonstrate lower levels of emotional empathy than average individuals, a process that appears to develop during medical school as students find that

28. Naomi Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York: Bloomsbury Press, 2011).

continual empathizing with patients is emotionally exhausting.[29] This can be problematic for effective communication with patients, and a number of programs now exist to correct the problem.[30]

But there are a number of cases where potentially interesting overlap exists for both moral and intellectual virtues. As already noted, democratic trustworthiness is one potentially important virtue for democratic societies. It is typically not enough to have well-structured institutions and laws that promote trustworthiness, and it is not even enough to rely on a division of powers based on mutual self-interest as a protection against untrustworthy individuals.[31] When democratic institutions are imposed on countries by foreign powers, they often fail, and a central reason for such failure is that even well-designed institutions can collapse when there exists insufficient commitment to the public good. How is such commitment developed? Science as a practice does not directly aim at the production of democratic trustworthiness, but, as mentioned earlier, the practice of science requires the development of honesty and integrity. A scientific community that had an insufficient number of members committed to honesty and integrity would simply die in confusion. In the scientific context, honesty and integrity are strongly complementary virtues, since an honest scientist who lacks the moral courage embodied in integrity will be able to practice science effectively only as long as such science is uncontroversial and lacking the significance to garner significant critical attention. The practice of science thus needs individuals who will stand by their results even when it is unpopular to do so, whether the criticism comes from within the scientific community or outside of it. In this context, it is important to note how such honesty and integrity can conflict with the scientist's own self-interest as normally conceived. In the short run it can be advantageous to yield to criticism, pretend that the results were other than they were, and even in the long run it may be prudent to simply shift focus to topics that are less controversial and possibly more lucrative.

Nonscientists should regard science as a practice to be epistemically trustworthy in part because individual scientists are morally trustworthy. And we might expect that once a scientist has internalized the virtue of trustworthiness within the domain of science, the scientist will carry that norm into areas outside of the practice of science. It would simply be embarrassing and provoke cognitive dissonance for someone who is scientifically trained and who internalizes the norms of science to produce a business report or the minutes of a meeting that were inaccurate, not simply because doing so might lead to bad outcomes and not only because it would reflect badly on her if the mistakes were discovered, but because doing so would be contrary to her understanding of who she is. Good scientists don't falsify or misrepresent data, and this is true whether operating within the context of scientific practice or outside of it. More importantly, individuals who have had sufficient scientific training and have internalized the values of science, whether they go on to a career in science or not, will share these values, and such values, when integrated into a person's identity, will impact the other domains of life.

We begin to see, then, how scientific trustworthiness begins to translate into democratic trustworthiness. Very few professional scientists enter politics directly, but many who receive scientific training

29. Johana Shapiro, Elizabeth H. Morrison, and John R. Boker, "Teaching Empathy to First-Year Medical Students: Evaluation of an Elective Literature and Medicine Course," *Education for Health* 17 (2004): 73–84; Carol A. Williams, "Empathy and Burnout in Male and Female Helping Professionals," *Research in Nursing & Health* 12.3 (June 1989): 169–78.

30. Helen Riess, et al., "Empathy Training for Resident Physicians: A Randomized Controlled Trial of a Neuroscience-Informed Curriculum," *Journal of General Internal Medicine* 27.10 (2012): 1280–86.

31. Montesquieu, *The Spirit of the Laws*, edited by Anne M. Cohler, Basia C. Miller, and Harold S. Stone (Cambridge: Cambridge University Press, 1989).

go on to careers other than in science, including careers in the public sector or careers that disproportionately influence those who are in the public sector. The institution of science contributes to the formation of individuals who possess the virtue of trustworthiness, and these individuals then go on to participate in other institutions, thereby affecting their trustworthiness as well. It is important to note that scientific trustworthiness, much like democratic trustworthiness, involves a commitment to the principles of the institution that transcend the interests of the group. This can produce painful dilemmas for scientists who sometimes have to choose between their commitment to scientific principles and the commitments of, for instance, co-religionists or political community.

Such a model is plausible, but we might also expect the results to be modest: not all professional scientists internalize trustworthiness adequately, and those who receive lesser degrees of scientific training will internalize trustworthiness to a lesser degree as well. It is plausible, therefore, that the intellectual virtues formed as result of participation in scientific practice play a larger role in the functioning of democracy. One standard line of argument in favor of democracy as a form of government is the claim that democracy benefits from the "wisdom of the crowd," the idea that in some contexts groups of individuals make better decisions than an individual does alone. First formalized by Condorcet, modern scientists have observed a number of instances where group estimation of events reliably predict future outcomes.[32] But, as Condorcet noted, the reliability of prediction depends on whether members of the crowd have accurate information, and in some cases individuals make poorer decisions when acting as part of a group than when acting independently. [33]

At least some of this difference in performance is explained by the existence of cognitive biases. Cognitive scientists have diagnosed a substantial number of such biases. Confirmation bias and variations thereof are perhaps the most discussed, but other biases include the anchoring effect and hindsight bias.[34] Biases are not inherently bad, and many such biases operate effectively as heuristics in the proper environment.[35] Take, for example, confirmation bias. If the great majority of one's judgments are well-formed, it will in most cases make sense to rely on such previously formed judgments when encountering new information. If I am sleeping on a train traveling in Europe and wake up to see Greek signs out the window, it is reasonable to infer that I am in Greece rather than that I am passing through a movie set with Greek street signs. Biases become problematic, however, when they activate improperly and contribute to faulty inferences. Confirmation bias can and often does go wrong, and can in this sense be an intellectual vice.

Samuelson and Church have recently argued for an interpretation of the failures of cognitive biases in terms of a lack of the virtue of intellectual humility.[36] They note that in the cognitive bias literature most biases are understood to be failure of implicit processing, often referred to as Type 1 processing. Further, they note that many of these biases are egocentric in nature: the failure of confirmation bias thus gives improper weight to one's own prior commitments. As a result, they argue, overreliance on

32. James Surowiecki, *The Wisdom of Crowds* (New York: Anchor Books, 2005).

33. J. Lorenz et al., "How Social Influence Can Undermine the Wisdom of Crowd Effect," *Proceedings of the National Academy of Sciences* 108.22 (2011): 9020–25.

34. Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus and Giroux, 2011).

35. Gigerenzer, *Gut Feelings*; Ralph Hertwig and Gerd Gigerenzer, "The 'Conjunction Fallacy' Revisited: How Intelligent Inferences Look Like Reasoning Errors," *Journal of Behavioral Decision Making* 12 (1999): 275–305.

36. Peter L. Samuelson and Ian M. Church, "When Cognition Turns Vicious: Heuristics and Biases in Light of Virtue Epistemology," *Philosophical Psychology* 28.8 (2015): 1095–1113.

such automatic, implicit processing can be understood as a form of intellectual arrogance. Such individuals lack intellectual humility, which requires an openness to the other as other and the willingness to consider other sources of information as important as one's own.[37]

Samuelson and Church employ a default-interventionist model of interaction between implicit and explicit processing that is slightly different than the harmonic processing account of virtue I have proposed, but their argument supports the case I am making here: implicit processes are not simply automatic but subject both to training and learning processes and to dynamic interaction with explicit forms of processing. We all may have cognitive biases and we may all be susceptible to them to varying degrees, but we are not all equally susceptible. If we are careful, we can learn to identify and to correct them, internalizing epistemic norms associated with virtues such as intellectual humility which help us to better process information and make good judgments.

Scientific training and participation in scientific practice is one likely source, though not the only one, for the development of intellectual virtues that protect against faulty cognitive biases. Scientific training requires precision in reasoning and causal reasoning in particular, and good scientific training involves recognition of cognitive biases that lead to errors both in interpretation of data and application of theory. Heuristic rules such as "correlation does not necessarily imply causation" and "absence of evidence does not necessarily imply evidence of absence," or even "the simplest explanation is the best," embody principles important to the practice of science that are also context-sensitive and thus associated with the cultivation of intellectual virtues. Good hypothesis testing involves principles of logical inference and falsification, and the practice of science in general requires the development of a healthy skepticism requiring skillful discrimination between reliable and unreliable sources of information.

It is relatively easy to see how the intellectual virtues inculcated in scientific practice benefit democratic institutions, serving not merely as scientific virtues but as democratic virtues as well. If democracy is dependent on the wisdom of the crowds, democracy can only function well if a sufficient proportion of the crowd is able to interpret evidence appropriately. Much recent evidence supports the conclusion that our political decision-making is subject to the same biases found elsewhere and that political decision-making is further influenced by group identity and norms of judgment and, increasingly, by forms of technology and social media that encourage forms of "enclave deliberation" reinforcing these effects.[38]

Recent evidence suggests that college education in and of itself does not protect against these effects, and the highly educated can be even more prone to partisan polarization about subjects such as climate change in ways that suggest, at least sometimes, greater bias than the less-well informed.[39] There seems to be a particular reason for this: many highly educated individuals have the same biases as

37. Michael Spezio, Gregory Peterson, and Robert C. Roberts, "Humility as Openness to Others: Interactive Humility in the Context of L'Arche," *Journal of Moral Education* (April 11, 2018): 1–20.

38. Cass R. Sunstein, *#Republic: Divided Democracy in the Age of Social Media* (Princeton, NJ: Princeton University Press, 2017).

39. Dan M. Kahan, et al., "The Polarizing Impact of Science Literacy and Numeracy on Perceived Climate Change Risks," *Nature Climate Change* 2 (2012): 732. In what follows I assume that polarization is bad, but it is important to note that polarization is a complex phenomenon. Polarization may occur when both parties are improperly influenced to move to extremes and the position of neither party is either epistemically or morally sound. But in some cases polarization can occur when one party is right and the other is wrong. The period of greatest polarization in American politics—the American Civil War—would be such an instance.

less educated individuals, but because they are typically better at explicit (Type 2) reasoning, they are also better able to manufacture reasons justifying their already biased position. Such individuals would appear to lack the intellectual humility championed by Samuelson and Church, although in these cases the vice is located much more in the interaction between the forms of processing.

The fact that the highly-educated may be more biased and polarized in their handling of information may seem surprising at first, especially given the extensive research showing a strongly positive relationship between education and democratization. There are a number of possibilities here, but one possibility is that the *kind* of education citizens receive is important, and the fact that most college students go into fields other than science may be important. Students usually receive some science education in primary and secondary education, and in many cases whatever additional science education they receive in college only adds minimally to what they have already received. In addition, many of those who do receive science training do so in the context of professional training in such areas as engineering and medicine, where the goal is not so much to learn how to be a scientist but to apply the results of scientific knowledge to a particular professional field. Although such individuals would receive considerably more exposure to science than individuals who pursue degrees in marketing or English, their engagement with science as a practice may not be sufficiently different to distinguish the values they internalize from those internalized by people with only a high school education.

More recent research by Kahan, et al, supports this general point,[40] providing evidence that possession of a specific trait, science curiosity, counters biased reception of information and instead encourages open engagement, even when the information received is contrary to a subject's existing views. Further research will be needed to support the empirical claim that scientific virtues positively impact political decision-making, but my point here is primarily conceptual: if we understand what scientific virtues are, we should realize that they are the kind of virtues which, when employed in the political sphere, support democratic institutions and thus may be counted as democratic virtues. In particular, science as a practice encourages and even requires the development of intellectual virtues that are also important for the sustenance of democratic institutions. Given the small percentage of the population that is active in scientific professions or that holds advanced degrees in the natural or social sciences, it might be thought that even if there is such a positive impact, it must be quite small. But a couple of things could be said here. First, a constituency does not have to constitute a majority to have a significant political impact, and influential minorities can sometimes have substantial influence on the course of political deliberation.[41] Second, we need not think of scientific virtues as being the sole possession of practicing scientists; students who receive some modicum of training in primary and secondary education may develop virtues such as scientific curiosity, even if only in attenuated form. But if this analysis is correct, it suggests an added value to science education beyond its clearly economic value and the value of the knowledge it produces. If done right, science education contributes to the development of scientific virtues, and so also to democratic virtues. Science education is thus also civic education, providing an additional reason to improve science education not only locally but also globally.

40. Dan M. Kahan, et al., "Science Curiosity and Political Information Processing: Curiosity and Information Processing," *Political Psychology* 38 (February 2017): 179–99.

41. Damon Centola, et al., "Experimental Evidence for Tipping Points in Social Convention," *Science* 360.6393 (2018): 1116–19.

Conclusion

The argument developed in this paper is admittedly but a sketch, and more work needs to be done to make it conceptually compelling. Particularly needed are philosophically useful phenomenologies of scientific practice, which among other things would aid in our ability to identify relevant scientific virtues and their potential impact outside their immediately relevant context. It is important to note in this context that, while genuinely internalized scientific virtues may in fact contribute to the stability of democratic institutions, this is very different from claiming that scientists are all intellectual or moral paragons. Quite the opposite: the history of science is replete with stories of scientists behaving badly. Many practicing scientists are able to produce good science while never fully internalizing the virtues of their scientific discipline, and many scientists are able to bracket their values while supporting morally troubling or even clearly evil practices in other domains of their lives.

Further, we should understand the present impact of scientific virtues on democratic institutions to be quite modest, given the relatively weak status of scientific education as a whole in the United States if not in Europe. Stronger scientific education would undoubtedly improve the situation, but it is also important to remember that the presence of scientific virtues is but one of many factors that can contribute to strong democratic institutions, and likely not the most significant. Nevertheless, democracies rely on an educated citizenry, and the wisdom of crowds can only be tapped if such wisdom is in fact present.

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