LUND UNIVERSITY

Ted Chiang's Counterphysical Stories and History of Science Pedagogy

Hennessey, John L.

Published in:
History and Speculative Fiction

DOI:
10.1007/978-3-031-42235-5_8

2023

Document Version:
Publisher's PDF, also known as Version of record

Link to publication

Citation for published version (APA):
Hennessey, J. L. (2023). Ted Chiang's Counterphysical Stories and History of Science Pedagogy. In J. L. Hennessey (Ed.), *History and Speculative Fiction* (pp. 151-168). Palgrave Macmillan. https://doi.org/10.1007/978-3-031-42235-5_8

Total number of authors:
1

Creative Commons License:
CC BY

General rights
Unless other specific re-use rights are stated the following general rights apply:
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.
• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: https://creativecommons.org/licenses/

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

CHAPTER 8

Ted Chiang's Counterphysical Stories and History of Science Pedagogy

John L. Hennessey

Introduction

Could things have been different? We tend to think so, at least when it comes to human decisions and actions. The answer is much less clear when it comes to nature or the universe. Advances in mathematically-based particle physics have given rise to a so-called Fine-Tuned Universe Argument, in which life on Earth could only exist under extremely specific conditions. It is far less likely, or perhaps impossible, that analogous life could have developed if Earth were outside of the so-called Goldilocks zone in its orbit around the Sun, if the Solar System had been located closer to the galactic center, with its higher level of deadly cosmic rays, or if Jupiter had not existed in its relative position to divert most extinction-level asteroids.[1] More broadly, tweak the value of a universal constant, or the initial conditions of the Big Bang, and galaxies, stars, and the relative abundance of certain life-sustaining elements might no longer be possible. Such lines of thought have led to bitterly contested arguments about intelligent design or the existence of our universe as but one instance in a multiverse,

J. L. Hennessey (✉)
Lund University, Lund, Sweden
e-mail: john.hennessey@kultur.lu.se

© The Author(s) 2024

J. L. Hennessey (ed.), *History and Speculative Fiction*,
https://doi.org/10.1007/978-3-031-42235-5_8

but regardless of one's position on such issues, most physicists seem to agree that life as we know it was made possible by very specific conditions that could hardly have been much different (Landsman 2016).

These disparate ways of thinking about contingency are reflected in literature. Counterfactual histories constitute a prominent subgenre of speculative fiction, imagining how the shape of history would have turned out if, say, Nazi Germany had won World War II, and often dramatizing what this would mean for individuals "on the ground" (see, for example, Gallagher 2018; Hellekson 2001). Nevertheless, in spite of diverging from history *wie es eigentlich gewesen*, such works tend to otherwise be highly realistic. In several of his stories, award-winning speculative fiction author Ted Chiang goes much further, setting his narratives not only in an alternative timeline, but in an alternate reality in which the very laws of nature differ in significant ways. Echoing the established concept of the "counterfactual," this chapter coins the term "counterphysical" to describe this type of literature. Counterphysical literature plays with the very laws of physics or the nature of the universe, but still within a rules-based, science-inspired paradigm that distinguishes it from systems of magic in fantasy literature. The existence of counterphysical literature has been noted in several scholarly works on alternative history fiction, but to my knowledge has received no extensive attention as a subcategory or subgenre of its own (Hellekson 2001, 50, Baxter 2019, 2–3).

This chapter will examine two such stories by Ted Chiang, "Seventy-Two Letters" (2002 [2000]) and "Omphalos" (2019), and argue that they can serve as a useful pedagogical tool for teaching the history of science. In the pedagogical framework "Decoding the Disciplines" developed by David Pace, instructors should identify and actively remedy "obstacles to learning in the discipline and the kinds of mental operations that students must master to overcome such obstacles" (Pace 2017, 4). In the history of science, a crucial but difficult "mental operation" is to suspend one's present-day understanding of science in order to comprehend the worldview and mindset of historical scientists operating in a very different epistemological milieu. I argue that counterphysical fiction like Chiang's can usefully be employed to help train students to overcome such obstacles to thinking about alternative science epistemologies.

Counterphysical Speculation and Its Implications

What I term *counterphysical* literature is far less common and diverges in important ways from the more widespread counterfactual fiction.[2] It involves a setting in which the laws of physics or of nature (whether gravity, electromagnetism, biological processes, and so on) are significantly different from those of our known universe. Beyond this positive definition, it may be most helpful to provide a series of negative definitions, that is, types of fiction that do *not* count as counterphysical.

Most basically, counterphysical literature must go beyond a mere alternate timeline. How would history be different if (most famously) Hitler had died before coming to power, the Confederacy had won the American Civil War, the Soviet Union did not collapse, Chinese had discovered the Americas before Europeans, and so on? Such questions have given rise to a great deal of provocative, creative, and useful speculative fiction, but this nearly always takes place in the same physical universe as our own. Thus, Ward Moore's *Bring the Jubilee* (1953), Philip K. Dick's *The Man in the High Castle* (1962) (despite some speculation on connections between alternate timelines) and Robert Harris' *Fatherland* (1992) count as counterfactual, but not counterphysical, fiction.

Less obviously, I do not count as counterphysical speculative fiction in which a new invention or scientific discovery opens up new realms of possibility or a new understanding of the physical universe. Narratives involving the discovery of time travel, artificial intelligence, faster-than-light travel, new forms of genetic engineering, or whatever, while more or less plausible, nevertheless generally have their implicit starting point in our familiar physical universe. The same is true of technology introduced by aliens, even if it leads to new understandings of reality. Even if reality is revealed to be a simulation, or the laws of physics do not apply on a higher plane that humans have not yet come to understand, or the like, the starting point is still a familiar physical universe. In contrast, in a counterphysical reality, the different physical and natural laws are a priori; they have always existed and (if the author is skillful) are largely taken for granted by the characters that populate it. Like counterfactual literature, the characters in counterphysical literature generally do not understand or notice that something about their universe is "wrong" or "unnatural," allowing the reader to speculate on how life might otherwise be or have been.

A related riff on the previous examples that can be excluded from the definition of the counterphysical is the combination of counterfactual

fiction with new inventions or scientific discoveries. William Gibson and Bruce Sterling's *The Difference Engine* (1990) is a well-known example, exploring the question of how history might have been different if computers had been invented in nineteenth-century Britain. As we shall see, this novel bears many similarities to Chiang's "Seventy-Two Letters." But again, rather than taking place in a different physical universe, the Babbage Engines of this alternative timeline are simply invented earlier, even though this of course has significant ramifications of all kinds. A similar example, *Äkta människor* [Real Humans], envisions an alternate contemporary Sweden in which people can purchase highly intelligent "hubot" androids for a variety of uses, sparking a populist political backlash (Hamrell and Akin, 2012–2014). But although the technology does not yet exist, it is certainly well within the realm of imagination and once again originates in the same physical universe as us. Such stories can generate similar reflections on society, life, the universe, and everything, and indeed other examples of Chiang's fiction fall into this category, but counterphysical fiction operates slightly differently.

Lastly, and less unambiguously, counterphysical fiction is characterized by a scientific idiom. This can be difficult to precisely define, just as it can sometimes be difficult to distinguish between science fiction and fantasy, but a general rule of thumb is that counterphysical fiction does not involve magic. Instead, it is interested in questions of alternative physical or natural laws that can be investigated through empirical, scientific methods. Thus, historical fiction with fantastic elements, like Susanna Clarke's *Jonathan Strange & Mr. Norrell* (2004), is not counterphysical (although the depiction of an early-nineteenth-century scientific society for the study of magic at the beginning of the novel comes close). Tales of Jane Austen with zombies or the Middle Ages with dragons can generally be ruled out as they are typically not interested in scientific questions. The most difficult-to-place example with which I am familiar is Brandon Sanderson's *Mistborn* series (first installment 2006). The novels' idiom is unquestionably high fantasy, but the series' world is characterized by a very complex alchemical system in which certain individuals can ingest and "burn" different metals in order to gain various powers. This system is rigorously and predictably regulated by physical laws, and it is difficult to say whether it counts as "magic" or as an alternative physical reality. Even though the series is not concerned with what would generally be characterized as scientific inquiry, the social, economic, political and religious implications of such a world are explored in great detail, just as in Chiang's stories, as we shall see.

While the dearth of scholarship on what I have defined as counterphysical literature makes it difficult to produce a list of examples, in her 2001 book on alternate history fiction Karen Hellekson mentions two works that clearly fall into this category (2001, 50). The first, Philip José Farmer's short story "Sail On! Sail On!" (1979 [1952]), is a dialogue between sailors and a friar on Columbus' *Santa Maria*. These individuals, who live in an alternate fifteenth century marked by a version of wireless communication and a firm belief in the roundness of the earth, discuss the possibility of parallel universes with alternate timelines and even physical laws, before falling off the edge of what turns out to be a flat Earth. Richard Garfinkle's 1996 novel *Celestial Matters* is perhaps the most important contribution to the subgenre, creatively combining both counterfactual and counterphysical speculation. Counterfactually, the story is set in a world that has for centuries been divided between two warring superpowers: the Classical Greek Delian League and China. Christianity has apparently never emerged (although pacifist Buddhists are a thorn in the side of both empires), and the balance of power between different regions of the world is considerably different, with Northern Europeans serving as slaves while many Africans, Indians, and Native Americans are fully assimilated into Greek society. Counterphysically, the universe in which the characters live and operate is consistent with the understandings of the Ancient Greeks from our universe (as well as traditional Chinese medicine and philosophy, as becomes evident later in the book). The celestial bodies, composed of special matter, are set in crystalline spheres, animals arise through spontaneous generation, matter is composed of the four classical elements and medicine effectively makes use of the human body's humors. In his blurb on the book cover, Harry Turtledove describes the book as "hard science fiction," and the novel has been widely praised for its rigorous application of Ancient Greek understandings of the physical world, which are continually important for the novel's plot. Like "Omphalos," examined below, *Celestial Matters* is a useful resource for understanding the full implications of an alternate, discredited set of physical laws, indirectly revealing how we know they are false.

Counterphysical literature, according to this stringent definition, is an unusual subgenre of speculative fiction, but one with a perhaps unique potential to explore deep existential questions about human society and the physical universe. The following section will present Ted Chiang's two stories "Seventy-Two Letters" and "Omphalos" and their counterphysical

elements, before subsequent sections develop how these could be used to help students to better grasp the history of science.

Playing with the Laws of Physics: "Seventy-Two Letters" and "Omphalos"

From the beginning, it becomes clear that "Seventy-Two Letters" is set in a version of Victorian England, complete with the industrialization of textile manufacture and its resultant class conflicts, the rapid advance of scientific discovery under the auspices of the Royal Society, and even the Crimean War. Nevertheless, it also becomes apparent almost immediately that the world of this Victorian England is subject to vastly different physical and natural laws than our reality. There are three major differences in Chiang's alternative England: human reproduction occurs very differently, the origin of species and their evolution is decidedly non-Darwinian, and most notably, seventy-two-letter written "names" contain the power to animate dolls formed of metal or clay and affect other aspects of the physical world, such as human health or heat transfer. On top of this, in only around sixty pages, Chiang manages to combine a gripping narrative with deep reflections on class, industrialization, the relationship between science and religion, medical ethics, eugenics, and reproductive freedom. It is an astoundingly unique literary achievement.

Treating one counterphysical element at a time, we are introduced to this Victorian England's peculiar mode of human reproduction when the protagonist, while still a schoolboy, is confronted with a backyard experiment undertaken by one of his friends, in which he has incubated and grown the embryos in his sperm. Without any indication of the strangeness of this experiment, we learn that in this reality, the entire line of a species is simultaneously created and stored in the males' sperm; every man literally contains all of his descendants within himself. Nevertheless, although containing the basic human form and substance necessary for life, the sperm cannot "quicken" by itself nor take on any unique characteristics (physical or mental), until animated by the "vital force" provided by the mother in her ovum. The implications of this counterphysical reproductive order become clear when the protagonist is informed of secret experiments conducted by the Royal Society and its French counterpart that have revealed that the line of embryonic generations contained in all human males will soon come to an end; soon, all men will

become infertile and the human race will go extinct. The protagonist and his colleagues propose a bold solution to this existential threat to humanity, but one which raises stark ethical questions about reproductive ethics, socioeconomic equality, and human freedom.

Although not a primary focus of the story, the discussion of the future of the human race and artificial means of reproduction naturally leads to a consideration of the origin of species and their extinction. The fossil record in this reality indicates that species do not change over time, but rather appear suddenly and eventually go extinct. We learn that although a familiar "Catastrophist" explanation of species extinction has been proposed, this appears less probable in light of the discovery of finite generational lines of fetuses. Instead, major catastrophes are postulated as the possible origin of life (the trustworthy elder scientist who explains this also takes the spontaneous generation of simple organisms as a matter of fact) (166). Thus, the origin and development of species and interpretation of the fossil record is very much on the agenda of these alternative Victorian scientists, even though the empirical facts they produce are strikingly different than those proffered by Darwin and others in our own reality.

The powerful "names" that animate dolls and other "engines" are unquestionably the most dramatically counterphysical aspect of the story. The seventy-two letters of the story's title are typically written in Hebrew on slips of paper that are then inserted into prepared "automata," usually clay or metal dolls with a more or less human or animal form. One inside, these "names" somehow touch the essence of the form that is being animated, and careful combinations of distilled terms and synonyms prepared by "nomenclators" can give the automata increasing dexterity and ability.

This clearly differs sharply from the physical laws of our universe, but Chiang once again explores the socioeconomic, cultural, and even religious consequences of a universe in which names are imbued with power. Automata are put to work as children's toys, carriage-pullers, engines powering spinning factories (rendering steam technology superfluous), and even animated sex dolls. The best names are protected by patents, and the development of increasingly able automata leads to worker unrest, as skilled tradesmen fear for their jobs. Most interestingly, the power of names has long been seamlessly integrated into Christianity in this alternate Victorian England. A Biblical reference to an automata sex doll made by Jacob's sons makes it clear that the universe of the story has always been different from the reader's own (177). Names are still written in Hebrew letters, and their power is traditionally explained as their reflecting God's

name or the names He granted to His creation (148). A younger generation of nomenclators and scientists has started to question this reasoning, however, seeking instead a secular explanation for the power of names (149–150). Even in the absence of Darwin and the steam engine, this Victorian England increasingly moves towards secularism and industrialization. Here, as elsewhere in Chiang's speculative fiction, the reader is left to wonder whether apparently key historical developments or natural laws were really necessary to the broad strokes of modern history or whether these would have happened anyway.

The same question arises in Chiang's later story "Omphalos," which takes place in a world at once startingly similar to and shockingly different from our own. The premise of this counterphysical world is less original but no less compelling: it is a creationist Earth, in which the physical fingerprints of God's creation are readily apparent to empirical scientists. Archaeologists have uncovered a great deal of "primordial" fossils and other remains of God's original creation that are collectively referred to as "relics," whether trees whose rings stop at a certain point (the core of the trunk being homogenous at the size in which the adult tree was brought into being), mummified humans without navels or adult animal bones without lines where they fused together in infancy. Using various scientific methods, scientists have been able to determine that the Earth's age is exactly 8912 years (240). Nor is this all; there are exactly 5872 stars in the sky, all of which are "identical in size and composition" (254). It is taken for granted that the Earth is the center of the universe, hence the story's title, although this is eventually challenged in an unexpected twist that remains true to the story's reality. The universe of "Omphalos" is thus very similar to familiar ancient and medieval understandings of our universe; only in the story, these can be corroborated with modern science.

Naturally, a great deal of this story deals with the relationship between science and religion, as well as their implications for the purpose of humanity. But just as in "Seventy-Two Letters," society in the world of "Omphalos" is not as different as we might expect, given the vast differences in physical and natural laws. Scientists, like the archaeologist protagonist, are typically deeply religious individuals seeking to reveal God's purpose for the world through their empirical work, and much of the story is narrated in the form of this character's prayers. Of course, even in our reality, many scientists have such motives, but "Omphalos" has few indications of any religious-secular divide in society or the academy. Nevertheless, even in a world with such unambiguous evidence of intelligent design, the

pious narrator and others are constantly concerned about people straying from God's path and feel a strong need to invigorate their faith, whether through scientific lectures about God's creation or the experience of coming into contact with primordial relics. Nor is the interpretation of God's will unambiguous and unchanging. Indeed, the purpose of science, for the protagonist, is to better understand God's intentions with creation. As a female scientist, she rejects the church's traditional teachings in which "every woman… continue[s] to live in Eve's shadow," pointing out that science had disproven the Biblical account of human creation (apparently the same as ours) by showing that humans were created simultaneously around the world (264). The Church in this reality, like many Christian churches in ours, had accepted the scientific evidence and decided to reinterpret the story of Adam and Eve as an allegory (264). In short, the relationship between science and religion seems to be less fraught in this creationist universe, but still not completely straightforward.

"Seventy-Two Letters" and "Omphalos" are both clear examples of what I have described above as "counterphysical" literature. Their realities differ from ours in fundamental, obvious ways, whether through the power of names to animate clay dolls, the presence of all future generations in each male individual or unambiguous evidence that the world and its inhabitants were created fully formed less than 10,000 years ago. Nevertheless, in Chiang's telling, these factors do not cause human history or society to diverge in terribly significant ways from those familiar to the reader. This is not for a lack of exploration of the social, economic, and cultural consequences of, for example, name-animated "engines" or an empirically-backed theology. Like all speculative fiction, Chiang's stories invite the reader to scrutinize the believability of the alternative reality that they offer, which I will discuss more below. First, however, it is necessary to briefly return to the "real world" and discuss the field of history of science education to which I argue counterphysical literature can be fruitfully applied.

Decoding the History of Science

The history of science as a field of study has expanded dramatically since the mid-twentieth century, but even as it has become an increasingly popular subject for students, there has not been an equivalent expansion of research into history of science pedagogy. What research exists on methods of history of science education has been dominated by discussions of

the need to integrate the history of science into the curriculum of the natural sciences and how best to do so (see, for example, Gooday et al. 2008; Kolstø 2008; Duschl 2006).[3] Here, I will argue that the Decoding the Disciplines Paradigm developed by historian David Pace (2017) can fruitfully be applied to the teaching of the history of science, before connecting this to counterphysical literature in the following section.

Pace's starting point is the insight that "Knowing how to do something is a different thing than knowing how to teach that thing" (2012). Like other higher education researchers, Pace argues that being an expert in an academic field is insufficient for being a good teacher—instead, it is necessary to critically reflect on students' learning process and needs and apply the findings of pedagogical research. Pace's Decoding the Disciplines Paradigm distinguishes itself from other pedagogical approaches through its adherence to three basic principles: (1) many questions of learning are discipline-specific, and it is at the level of the discipline that the most detailed pedagogical reflection should be conducted; (2) it is more productive to "concentrate on what students have to *do*, not what they have to *know*"; and (3) how to perform the most basic tasks necessary to a discipline is not self-evident, but may have become invisible and taken-for-granted by specialists in the field, necessitating very deliberate reflection on these processes (2017, 4–5, original emphasis). Decoding the Disciplines is therefore oriented toward making explicit and modeling the detailed "mental operations" and other steps necessary to a specific discipline.

Pace next details "seven steps of decoding" that the instructor should use to operationalize this educational philosophy (2017, 6):

1. Identify a bottleneck (as Pace elsewhere puts it, "Where in my courses do many students consistently fail to master crucial ideas or actions?" (2012, 50))
2. Define the mental operations needed to get past the bottleneck.
3. Model these tasks explicitly.
4. Give students practice and feedback.
5. Motivate the students and deal with potential emotional blocks.
6. Assess how well students are mastering the mental operations.
7. Share what you have learned about your students' learning.

Here again, Decoding the Disciplines shows itself to be a very hands-on, problem-solving approach to education, seeking out the detailed steps

that students need to learn and hammering these home with an almost engineering mentality.

Considering all of these steps in detail in the context of teaching the history of science could easily take up several articles of its own, so here I will focus on one common "bottleneck" in this field: understanding the often unfamiliar social and epistemological context and worldview in which past scientists operated. This is one of the signature questions of the history of science, and many of its best-known classics, like Thomas Kuhn's *The Structure of Scientific Revolutions* (1962) and Steven Shapin and Simon Schaffer's *Leviathan and the Air-Pump* (2011 [1985]), center on such issues. Both of these address widespread misconceptions about the field as telling a heroic, teleological story of universal scientific truths being steadily uncovered, a journey from ignorance to enlightenment and the "right" way of understanding the universe. As Kuhn notes at the beginning of his book, the tendency to view the history of science as a movement from superstition *to* "science" was increasingly questioned even at the time of writing in the 1960s:

> historians confront growing difficulties in distinguishing the "scientific" component of past observation and belief from what their predecessors had readily labeled "error" and "superstition." The more carefully they study, say, Aristotelian dynamics, phlogistic chemistry, or caloric thermodynamics [all discredited systems], the more certain they feel that those once current views of nature were, as a whole, neither less scientific nor more the product of human idiosyncrasy than those current today. (1996, 2)

Kuhn's discussion of phlogiston theory, an explanation for combustion and other processes in terms of an element ("phlogiston") contained inside combustible materials that was released when they were burned, and its subsequent supersession by a new oxygen paradigm, requires a detailed understanding of how the proponents of phlogiston viewed the world. It is far from sufficient to simply label them as "ignorant" or "unenlightened"; they must be assumed to be intelligent individuals and their reasons for believing in phlogiston must be properly considered. Similarly, Kuhn notes that our current scientific theories are not always completely satisfying, pointing out the resistance to ideas of fundamental forces by many historical scientists because they lacked a satisfactory explanation, rather seeming to attribute an "occult quality" to matter (1996, 105). Was it so irrational for scientists to express skepticism of understandings of

gravity as an innate, invisible force whose mechanism of operation was unknown?

Shapin and Schaffer's book problematizes the teleological, heroic narrative of scientific progress in similar ways. By scrutinizing Robert Boyle's famous air pump experiments and their contemporaneous reception, the authors demonstrate that Boyle's experimentally based insights were far from obvious truths that immediately gained widespread acceptance. Rather, making these into generally accepted "matters of fact" required both a great deal of work (including practical work on the air pump apparatus, to ensure the credibility and reliability of Boyle's experiments) and a specific kind of expert community that could evaluate and vouch for Boyle's results and interpretations (2011, 225). For a wide variety of reasons, alternative explanations to Boyle's for the behavior of air have been discredited, but it is difficult to understand this without suspending one's present-day scientific knowledge and seriously considering the positions of Boyle's opponents. Shapin and Shaffer list a large number of often distinguished studies of Boyle and his opponent Thomas Hobbes that either ignore Hobbes' scientific writings (concentrating on his political ones) or else dismiss these as based on "misunderstanding" without a close reading (2011, 12).

Perhaps even more insightfully, Shapin and Schaffer point out that most "historians start with the assumption that they (and modern scientists) share a culture with Robert Boyle, and treat their subject accordingly," a tempting fallacy (2011, 5). In fact, even though his theories are currently recognized as generally correct, it is a mistake to view Boyle as thinking and operating according to our own modern worldview, a fallacious approach that could easily lead to misunderstanding or missing important aspects of Boyle's thought. Shapin and Schaffer express the crux of this key mental operation necessary for historians of science when they assert that "We wish to adopt a calculated and an informed suspension of our taken-for-granted perceptions of experimental practice and its products" (2011, 6). They suggest that researchers proceed by "playing the stranger": "one great advantage the stranger has over the member in explaining the beliefs and practices of a specific culture: the stranger is in a position to *know* that there are alternatives to those beliefs and practices" (2011, 6).

Needless to say, "playing the stranger," or accomplishing a "suspension of our taken-for-granted perceptions" is challenging even for professional

researchers, even as it is arguably crucial for students of the history of science. For this mental operation is necessary to avoid the common but fallacious view of science as inevitably moving toward present-day understandings and to be able to comprehend now-discredited theories without merely dismissing them as erroneous. Identifying this common "bottleneck" in students' understanding in the history of science is one of the first steps in the Decoding the Disciplines paradigm, but what strategies can teachers use to help students move beyond it? The following section will argue that by plunging students into an alternate reality, counterphysical fiction could help students to practice "playing the stranger," training them for a more nuanced understanding of the ("real") history of science.

Counterphysical Fiction as a Pedagogical Tool

Speculative fiction is clearly useful for more general reflecting on large philosophical questions like the nature of the universe and human society, but how can it be connected to such a practical, step-by-step pedagogy as Decoding the Disciplines? In the case of counterphysical fiction, at least, I argue that its exploration of the consequences of an alternate universe with different natural and/or physical laws is singularly useful for illustrating and practicing the "mental operations" necessary to the history of science. For the historical scientists at the core of its curriculum often had radically different understandings of reality, which in some ways resembled a (from our vantage point) counterphysical universe.

In an important book on counterfactual history and fiction, Catherine Gallagher writes that one significant role played by such speculation is that "it helps satisfy our desire to quicken and vivify historical entities, to make them seem not only solid and substantial but also suspenseful and unsettled" (2018, 11). This is a useful description of the very mental operation required by the history of science discussed here: making the history of scientific "discovery" more "suspenseful and unsettled" by showing how it was affected by social factors (and not only empirical "truth") and could have been (and indeed often was) theorized differently. By launching us into such a "suspenseful and unsettled" (and indeed, often unsettling) alternate reality, counterphysical fiction is a useful tool for destabilizing our taken-for-granted understandings of the physical world.

In so doing, counterphysical fiction naturally invites epistemological reflection: How do we know what we know? How can we be so sure that

the universe operates the way we think it does? What aspects of the natural and physical world remain unknown and mysterious? These are of course fundamental questions for the philosophy of science and for understanding the history of the scientific method and the curiosity that drove scientific work both in the past and today. And indeed, both of Chiang's stories devote considerable, explicit attention to epistemological questions. While the power of names in "Seventy-Two Letters" is mostly taken for granted, the pending infertility of male humans is a new scientific discovery, and thus elicits a long discussion of how the scientists at the Royal Society and across the Channel can be so sure of their conclusion. Similarly, "Omphalos" is largely about scientific epistemology, as it centers around the production of evidence of God's creation of the universe. Nevertheless, the meaning of even such seemingly unambiguous evidence as navel-less mummies is to a great extent open to interpretation, as the characters discover at the story's end. When compared to actual examples from the history of science, to what extent are the different scientific worldviews a product of different empirical facts, and to what extent do these depend on the human context of their production?

How is reflecting on these questions using counterphysical fiction different than merely employing historical examples of alternative, now discredited, scientific theories and ways of understanding the world? The very idea of a fictional world with different natural or physical laws can provide an alternative path into reflections that are normally shut down by the strong bias that discredited theories are merely wrong or "unscientific." By positing a world in which the reality of physical and natural laws actually *is* different from ours, a series of "mental operations" is set in motion that can then be transposed to real-world historical cases. Counterphysical fiction helps us to suspend our biases about the nature of the universe (not unlike the "suspension of disbelief" important so speculative fiction overall) in a similar way to what is necessary to understand historical scientists in their own contexts (as best as we can, at any rate). Reading and reflecting on stories like those of Ted Chiang in history of science classes can therefore be a kind of practice for "the real thing" and provide interesting examples that can later be productively compared with historical cases. For example, how did creationist theories and religious reactions to Darwinism in different periods differ from what Chiang imagines would have been the case in a world in which all the scientific evidence in fact pointed to divine creation?

An important difference between counterphysical fiction and superseded historical scientific theories is that fictional worlds are typically not as messy as the real one. In both his stories, Chiang is able to create alternative, but coherent realities that his characters can investigate rationally. In contrast, as Kuhn notes, although "normal science" may seem to be "a single monolithic and unified enterprise that must stand or fall with any one of its paradigms as well as with all of them together," actually "science is obviously seldom or never like that. Often, viewing all fields together, it seems instead a rather ramshackle structure with little coherence among its various parts" (1996, 49). No short story could capture the complexity of the "ramshackle structure" that comprises science both historically or today, and such fiction may risk reinforcing oversimplified understandings of science history. If we are to make a virtue of necessity, however, counterphysical fiction could also be seen as providing an easy point of entry to a difficult subject. Just as it may assist students in learning to temporarily suspend their biases about past theories, fiction like Chiang's stories could also provide an easier practice run before studying the convoluted incoherence of historical scientific debate.

I envision history of science classes beginning with a reading and detailed discussion of counterphysical fiction as a useful point of entry to demanding investigations of historical scientific theories and worldviews. Students would be trained to ask the kinds of questions necessary to the discipline of the history of science about epistemology, scientific methods, and the relationship between social context and science without the same risk of these being shut down by a teleological narrative of scientific progress in which alternate theories are to be discarded as simply false. Understanding the context in which these theories arose, and gauging their explanatory power, while remaining cognizant that they have been disproven by future scientific findings, would help the student to understand the processes by which more successful scientific theories also came into being and gained widespread acceptance.

Conclusions

This chapter has covered much ground: it began by defining a new subgenre of speculative fiction, counterphysical fiction, described two examples of this by Ted Chiang, and then argued for the usefulness of such

fiction for history of science pedagogy within the Decoding the Disciplines educational framework. In short, I contend that the type of epistemological reflections that counterphysical fiction, set in an alternate universe with different physical and\or natural laws, invites the reader to partake in, provide useful training for critical thinking within the history of science. Counterphysical fiction forces the reader to be a stranger in a strange world, providing practice for thinking of historical science in similar ways rather than in ways overdetermined by our familiarity with subsequent developments of modern science.

This example of the usefulness of a subgenre of speculative fiction for a subdiscipline of history is but one case of how speculative fiction and history can benefit from close encounters. And indeed, this benefit is often mutual. Although not discussed explicitly above, it is of course the case that Chiang's counterphysical fiction has also been heavily inspired by the history of science, as well as social history more broadly. Chiang's familiarity with the historical structures of scientific knowledge-making greatly enriches his stories' settings, while allowing him to raise provocative questions about society in the limited space provided by the short story form.

Notes

1. Astrophysicist Neil F. Comins explores a variety of such hypothetical scenarios in his books *What If the Moon Didn't Exist?* (1993) and *What If the Earth Had Two Moons?* (2010), but all of his "what if" scenarios follow the known physical laws of the universe.
2. A more detailed breakdown of counterfactual fiction into different subtypes can be found in Gallagher 2018, 2–3.
3. A notable exception is Hendriksen 2020.

References

Baxter, Stephen. 2019. Foreword. In *Sideways in Time: Critical Essays on Alternate History Fiction*, ed. Glyn Morgan and C. Palmer-Patel, 1–10. Liverpool: Liverpool University Press.

Chiang, Ted. 2002. *Stories of Your Life and Others*. New York: Tor.

———. 2019. *Exhalation*. New York: Knopf.

Clarke, Susanna. 2004. *Jonathan Strange and Mr Norrell*. London: Bloomsbury.

Comins, Neil F. 1993. *What if the Moon didn't Exist?* New York: HarperCollins.

———. 2010. *What if the Earth had Two Moons?* New York: St. Martin's Press.

Dick, Philip K. 1962. *The Man in the High Castle*. New York: Putnam.
Duschl, Richard A. 2006. Relating History of Science to Learning and Teaching Science: Using and Abusing. In *Scientific Inquiry and Nature of Science*, ed. Lawrence B. Flick and Norman G. Lederman, 319–330. Cham: Springer.
Farmer, Philip José. 1979 [1952]. Sail On! Sail On! In: *The Road to Science Fiction*, vol. 3, ed. James Gunn, 195–204. New York: Mentor.
Gallagher, Catherine. 2018. *Telling It Like It Wasn't: The Counterfactual Imagination in History and Fiction*. Chicago: University of Chicago Press.
Garfinkle, Richard. 1996. *Celestial Matters*. New York: Tor.
Gibson, William, and Bruce Sterling. 1990. *The Difference Engine*. London: Gollancz.
Gooday, Graeme, John M. Lynch, Kenneth G. Wilson, and Constance K. Barsky. 2008. Does Science Education Need the History of Science? *Isis* 99 (2): 322–330. https://doi.org/10.1086/588690.
Hamrell, Harald, and Levan Akin, dir. 2012–2014. *Äkta människor* [Real Humans]. Stockholm: Sveriges Television.
Harris, Robert. 1992. *Fatherland*. London: Arrow Books.
Hellekson, Karen. 2001. *The Alternate History: Refiguring Historical Time*. Kent, OH: Kent State University Press.
Hendriksen, Marieke M.A. ed. 2020. Rethinking Performative Methods in the History of Science (Special Issue). *Berichte zur Wissenschaftsgeschichte* 43. https://onlinelibrary.wiley.com/toc/15222365/2020/43/3.
Kolstø, Stein Dankert. 2008. Science Education for Democratic Citizenship through the Use of the History of Science. *Science & Education* 17: 977–997. https://doi.org/10.1007/s11191-007-9084-8.
Kuhn, Thomas. 1996 [1962]. *The Structure of Scientific Revolutions*. 3rd ed. Chicago: University of Chicago Press.
Landsman, Klaas. 2016. The Fine-Tuning Argument: Exploring the Improbability of Our Existence. In *The Challenge of Chance*, ed. Idem and Ellen van Wolde, 111–129. Cham: Springer.
Moore, Ward. 1953. *Bring the Jubilee*. New York: Farrar, Straus & Young.
Pace, David. 2012. Decoding Historical Evidence. In *Enhancing Student Learning in History*, ed. David Ludvigsson, 49–62. Uppsala: Opuscula Historica Upsalensia.
———. 2017. *The Decoding the Disciplines Paradigm: Seven Steps to Increased Student Learning*. Bloomington: Indiana University Press.
Sanderson, Brandon. 2006. *Mistborn: The Final Empire*. New York: Tor.
Shapin, Steven, and Simon Schaffer. 1985. *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life*. Princeton: Princeton University Press.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.