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The Science of Middle-earth (2021), edited by Roland Lehoucq, Loïc Mangin, and Jean-Sébastien Steyer. Translated by Tina Kover. Illustrated by Arnaud Rafaelian.

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The Science of Middle-earth, edited by Roland Lehoucq, Loïc Mangin, and Jean-Sébastien Steyer. Translated by Tina Kover. Illustrated by Arnaud Rafaelian. New York: Pegasus Books, 2021. xxiv, 392 pp. \$29.95 (hardcover) ISBN 9781643136165. Also available in ebook format.

The first rule of popularizations of science should be “do no harm,” meaning to avoid introducing or reinforcing misconceptions, or otherwise confusing the reader. A true balance between education and entertainment is difficult to attain, but is the hallmark of the best works in the genre (e.g. the works of the late Carl Sagan or Stephen Jay Gould). Examples of popular-level explorations of the science in specific fictional universes that this reviewer has personally found worthy of note include Mary and John Gribbin’s *The Science of Philip Pullman’s His Dark Materials*, Lawrence M. Krauss’s *The Physics of Star Trek*, Roger Highfield’s *The Science of Harry Potter*, and the more recent *Fire, Ice and Physics: The Science of Game of Thrones* by Rebecca C. Thompson.

There is a common misconception held by too many in the scientific community that popularization equals the simple watering down of “pure” science in order to make it palatable to the general public (Gavroglu 85). As anyone who has written such works can attest, it is not that simple. Instead, the effective popularization of science requires two skill sets rather than one; not only must the author possess an understanding of the science at hand, but the effective communication skills to *translate* the science for a nontechnical audience. In the case of this volume we have two dangers, over-simplifying the science as well as mis-representing the subtleties of Tolkien’s legendarium.

Works on science and Tolkien generally fall into one of several camps: analyses of Tolkien’s use of science and the influence of Primary World science on Tolkien’s writings (Tolkien Studies); explanations of how Tolkien’s science works from an internal standpoint, i.e. assuming Middle-earth is real (Middle-earth studies); and using Middle-earth as a “hook” with which to interest the reader in some aspect of Primary World science. In some cases, aspects of all three can be rolled into a single study. The tone of such works can vary from serious to playful to openly satirical. The very best works leave the reader more knowledgeable about both Tolkien and science and wanting to know more about both topics as well.

The production of a well-crafted volume on science in Middle-earth is especially important due to the persistent misconception that Tolkien was anti-science (e.g. Brin, n.p.; Bushwell n.p.; Kugler 1). On the contrary, he reported in his famous essay “On Fairy-stories” that as a young child “a liking for fairy-stories was not a dominant characteristic of early taste.... I liked many other things as well, or better: such as history, astronomy, botany, grammar, and etymology” (Flieger and Anderson 56). In other drafts of the essay he noted that “In that distant day I preferred such astronomy, geology, history or philology as I could get, especially

the last two” (Flieger and Anderson 189). In a 1964 letter Tolkien explained “I am primarily a scientific philologist. My interests were, and remain, largely scientific” (Carpenter 345). This scientific view of the study of language was applied to his own sub-creation as well as our Primary World. For example, in a 1951 letter to Milton Waldman, Tolkien explained of the two Elvish languages, Quenya and Sindarin, that their “forms (representing two different sides of my own linguistic taste) are deduced scientifically from a common origin” (Carpenter 143).

For this reason, the announcement of a book entitled *The Science of Middle-earth* was welcomed by this reviewer, despite the accompanying sense of déjà vu, as the zoologist Henry Gee, editor for the prestigious scientific journal *Nature*, published a book of the same name in 2004 (revised edition 2014). However, interest quickly turned to concern a mere few pages into the work, a response that is, unfortunately, not unique.

Brandon Moskun, Ph.D. candidate in the Department of Anthropology at the University of Notre Dame, began a Reddit thread on the book by calling it “SHOCKINGLY bad” (emphasis original). In particular, Moskun was

shocked at the number of mistakes made. Most of the chapter authors seem to have no relationship with Tolkien's work and it seems that no one on the team who put this book together was a Tolkien scholar or considered having the book read by a Tolkien scholar.

A “stickied comment” linked by the moderator directs to a post by a user named “Druss” on the *Tolkien Collector's Guide Forum*:

As one of the authors (I wrote the one about archeology, the first one of chapter 2) [Vivien Stocker], I have the same main problem: the book wasn't mainly written by Tolkien scholars that know science or are scientists, but by scientists that think they know Tolkien (and most of the time, don't). Only four people, Isabelle Pantin, Michael Devaux, Damien Bador and myself that can pretend to be Tolkien scholar[s] or near enough... and none of us had read the whole book before its publication in France to maybe correct some big errors. So, it's not a book about science in Tolkien's works, it's a book that use[s] these works to talk about science, except for few articles.

This evaluation of the book’s intent aligns with a statement by the three co-editors in the foreword explaining the book’s goal as “to use Tolkien’s universe... to speak about the human, physical, and natural sciences” (vii). This being true, the book is curiously mis-named, reportedly being a book about science *and* Middle-earth (with the latter possibly being clearly secondary in importance to the former). While I respect and appreciate “Druss’s” overall frustrations with the rather obvious limitations of the volume, I find both his and the editors’ explanation of the book’s

intention to be misleading, as far more than a few of the essays are, clearly, attempting to examine aspects of Middle-earth through a scientific lens – engaging with the science *of* Middle-earth. Whatever the actual goal of the book, it does not excuse the blatant misrepresentations of Tolkien’s Secondary World and sloppy mistakes referenced by Moskun and “Druss,” as well as many others this reviewer was faced with while reading it. Examples of careless typos include “Dúndedain” (84), “the river Arnor” (147), “The Yale” (Dale) (164), “the witch-king Angmar” (149), and “Thorn” (Thorin) (229). Some of the errors could have been due to translation, although Tina Kover, whose translation of Négar Djavadi’s *Disoriental* was a finalist for the 2018 National Book Awards, does not seem likely to put her name on a translation that was not carefully done. Rather, it was the responsibility of the editors to ferret out such errors (including providing the contributors one last chance to review their article before publication). Of course, this is limited by the level of expertise of said editors and contributors.

These three co-editors are: Roland Lehoucq, astrophysicist at the French Atomic Energy Commission and writer for the science fiction journal *Bifrost*; Loïc Mangin, associate editor of the magazine *Pour La Science* [*For Science*] and author of *Pollock, Turner, Van Gogh, Vermeer and Science*; and Jean-Sébastien Steyer, paleontologist at the French National Center for Scientific Research and the Museum of Paris and author of *Anatomie comparée des espèces imaginaires : De Chewbacca à Totoro* (*Comparative anatomy of imaginary species: from Chewbacca to Totoro*). While they certainly have experience in the popularization of science, as “Druss” notes, their expertise in either Tolkien Studies or Middle-earth Studies is not well-established. The same is true of the contributors; many are associated with Sorbonne University, the French National Centre for Scientific Research, or the National Museum of Natural History, Paris, and are presumably scientific colleagues of the editors. Similarly, illustrator Arnaud Rafaelian previously worked on Steyer’s *Anatomie comparée des espèces imaginaires*. His black and white line drawings are interesting and add some value to the volume.

In addition to the aforementioned typos and errors, there are three central issues with this volume. First is a frustrating paucity of citations. Lists of references appear at the end of the book, but only for certain essays, and in many cases these lists are clearly incomplete. Some essays at least include informal citations, an offhanded mention of an author as a way of giving some credit. In the case of Tolkien, we sometimes get enough information to find the original passage without too much effort (although far more effort than should be necessary). Other times we are left with little to no guidance as to where the original information is to be found. As the author of several books on popular-level science, this reviewer can certainly verify that it is possible to include unobtrusive citations in books for a popular-level audience. Such attribution is important on several levels. First, it gives proper credit to the original thoughts and analysis of others. Second, it provides the interested

reader with a means to follow up on aspects of the work that particularly interest them. Third, in the case of errors, it shifts the blame from the author to the erroneous reference (as this reviewer recently experienced firsthand).

A second general problem is the lack of apparent cognizance of secondary works that have been written on these topics over the past few decades. While some of these sources might have been difficult to access, especially in a language other than English, in many cases a simple Google search will at the very least alert the author of their existence, and online translations can easily render an abstract readable. The specific harm here is that a non-technical audience may interpret the findings of a particular essay as being “ground-breaking” in being the first to realize a particular insight into Tolkien’s work when, instead, it is a well-tread idea that has long been known to the Tolkien scholarship community.

A third issue, and perhaps the most important, is that some of the essays demonstrate a lack of knowledge of Tolkien’s works themselves. While it is noted within the volume that the second half of the *History of Middle-earth* volumes have yet to be translated into French (71), this does not excuse a lack of inclusion of details from *Unfinished Tales* or *The Silmarillion*, or, even worse, a lack of relevant details from *The Hobbit* or *The Lord of the Rings*. The inclusion of fundamental errors concerning these two seminal works is also inexcusable, and suggests some contributors’ knowledge of Tolkien is rudimentary.

As selected contributors managed to avoid the above pitfalls it suggests that they are not unreasonable expectations. We can also look to Henry Gee’s book of the same name as another example. Indeed, a handful of the authors in the present volume reference Gee’s book, suggesting that it should have been known to the editors (or at the very least the marketing department of the publisher), who could have insisted that the authors covering material previously surveyed by Gee at the very least give credit to his precedence. But they apparently didn’t; as a result, this volume retreads a not-insignificant number of topics already covered, and covered far better, by Gee. A point-by-point comparison of the two works is beyond the scope of this review, therefore these concerns about overlap will stand with only cursory additional comments.

The work begins with a short foreword by the editors, “Tolkien, Lord of the Sciences,” which makes it clear that the editors define science fairly broadly, to include the “human, physical, and natural sciences” (vii), although natural sciences normally includes the life and physical sciences. The “human” sciences appear to be what is termed social and behavioral sciences (e.g. history, economics, psychology) (vii).

After an introduction, the book is divided into six roughly thematic sections. Section 1, entitled “World-building,” should perhaps better be described as Tolkien and the Social Sciences (sociology, economics, politics, language, philosophy). Section 2, “An Anchoring in Space and Time,” examines archaeology, history,

linguistics, and psychology, while “A Complex Environment” considers the natural sciences of geology and climatology. The first two essays in Section 4, “Spectacular Settings,” would have perhaps been better included in the previous section (since they deal with botany and caves), leaving the remaining essays in that section a more-or less coherent whole, examining magical materials through the lens of science (chemistry, physics, and metallurgy). “Remarkable Characters” is a potpourri of largely biological essays, as is the final section, “A Fantastical Bestiary.”

Curiously, there is even less astronomy in this volume than in Gee’s, which is to say there is basically none. In the case of the earlier single-authored volume this is no surprise, given Gee’s background as a zoologist. However, the present volume has an astrophysicist as one of three co-editors; it is therefore disappointing that his contributions do not invoke Tolkien’s extensive use of astronomy in his world-building (as noted by the fact that after twenty years this reviewer has not run out of new things to say about it). Having discussed the overall structure of the work, the individual essays will be addressed in roughly the order in which they appear.

The introduction, “Tolkien and the Sciences: A Relationship with Many Faces,” by Isabelle Pantin, echoes this wider net cast to define science, as “the rational effort made to learn about and understand natural reality” (ix). The historian and author of *Tolkien et ses légendes* [*Tolkien and his legends*] appears to make the argument that Tolkien is a scientist because he seeks the truth and refuses to “lie about reality” (xi), a rather curious definition. Thankfully she refers to the essay “On Fairy-stories” and Tolkien’s childhood interest in science. The essay does a reasonable job of examining the subtleties of Tolkien’s views on science – as not anti-science but rather anti-reductionist/materialist, suspicious of technology, and cautionary concerning the application of science towards achieving Power. However, the analysis suffers from a problem all too common in this book: it just ends, rather abruptly, as if truncated once a word limit was reached.

The rather choppy chapter “Tolkien: Scholar, Illustrator . . . and Dreamer” by Cécile Breton focuses on Tolkien’s illustrations for *The Lord of the Rings*. Unfortunately this founder and editor-in-chief of the French popular science journal *Species* dismisses his “illustrations for children (for his *Letters from Father Christmas* and *Mr. Bliss*)” as “deliberately far more simplistic in style and deserve analysis elsewhere” (4). Some of these are very much science-related, as noted by Hammond and Scull (who are included in the bibliography, although the reader is never told of their analysis). Tolkien himself is rather unfortunately described thus: “Daydreaming with his nose buried in an atlas was a favorite pastime of this little man born in the 1880s” (4). Of course, he was actually born in 1892. The well-tread topic of “Magic and the Machine” is briefly given lip service here before returning to the question “do scientists have imagination?” (10). Fortunately, Tolkien already answered this question decades before in “On Fairy-stories,” which the author does

not reference; in Tolkien's words, fantasy "does not destroy or even insult Reason; and it does not either blunt the appetite for, nor obscure the perception of scientific verity. On the contrary. The keener and clearer the reason, the better the fantasy it will make" (Flieger and Anderson 65).

The following three social science-based essays were written by the same contributor, Thierry Rogel, Associate Professor of Economic and Social Sciences and author of *Sociologie des super-héros [Sociology of super-heroes]*. "Tolkien and Sociology: Facing the Loss of a World" investigates Tolkien's rejection of modernity and search for a sense of community. The essay attempts to find parallels between selected aspects of Middle-earth culture and various sociological theories. The concluding sentence, rejoicing in our having "ceased to believe" that any creatures on our planet are "monstrous half-humans half animals" as a sign of our "embracing unity of humankind at last" (21), is not only patently false, but insulting to the daily experiences of the members of all marginalized groups in various societies around the world. It is also alarmingly out of touch, given discussions on depictions of diversity within both Tolkien's writings and Tolkien scholarship over the past few years (coming to a head in the recent internet controversy surrounding the 2021 Tolkien Society Summer Seminar on the topic, as described by Anna Smol in her blog [n.p.]).

"Mythology vs. Mythology: Tolkien and Economics" contends that "Middle-earth is indisputably a 'pre-economic' world" (23), yet a page later Rogel plays the "what if" game – what would Tolkien have thought about various economic theories. He utilizes quotes from *The Lord of the Rings* to bolster his case, but again it will take the reader a while to chase down a quotation and read it in its proper context based on the lack of a specific book and chapter citation. Rogel concludes that Tolkien's desire to create a mythology for England is the reason why "there is hardly any economics in Tolkien... because two mythologies cannot exist side by side" (28). The third essay "Families, Power, and Politics in *The Lord of the Rings*" examines families and familial power structures in different species in *The Lord of the Rings*. He begins with hobbit relationships, especially between cousins, and then moves on to the line of Elendil before meandering into a discussion of various aspects of the work of sociologists Max Weber and Danilo Martucceli, this rambling structure also seen in a number of other contributions.

Christine Argot and Luc Vivès, researchers and educators at the National Natural History Museum in Paris and authors of *Dinosaurs: A Journey to the Lost Kingdom* (concerning the museum's dinosaur collections) have two offerings in this volume. "Language and Evolution in Tolkien" is one of many essays invoking evolution as a process, here applied mainly to language. There has been much written on both the relationship between Tolkien's languages and his general process of language creation, and an essay of such a short length should not be expected to tread important new ground. Given the breadth and depth of this

aforementioned previous scholarship it is disconcerting that none of it is referenced, as this essay has no bibliography. Indeed, it only makes a handful of intext references to specific sections of Tolkien's writings, apparently expecting the reader to have an encyclopedic knowledge of which linguistic topics are discussed in which chapter of which book. A brief discussion on the cirth writing is interesting but given the lack of references this reviewer (who is not a linguist) has no way to judge its originality without spending far too much time in a literature search. The essay then turns from languages to the fates of the children of Ilúvatar and then on to Lamarck and the One Ring, again demonstrating the propensity for meandering found in many of these pieces.

Their second essay, "Mythotyping Origins," begins the "Bestiary" section of the volume. The themes of the piece set up the section well, although the essay is not without its problems. Again, there are no references, and no acknowledgement of previous work on Tolkien and world-building/mythmaking, for example *Sub-creating Arda*, edited by Dimitra Fimi and Thomas Honegger. There is an interesting suggestion that the fell beast of the Nazgûl are a "pale and weakened imitation of a dragon" made by Sauron, unable to match the powers of his master Morgoth (280). But on the same page they frustratingly bring up that "the specialist [in what?] Edouard Kloczko has suggested that those animals endowed with speech in Tolkien's world are actually Maiar" (280-1). More information is certainly required here. Even more disconcerting is a claim that equates the One Ring's role in the evolution of Sméagol into Gollum and "corrupt Men" into Nazgûl with the metamorphosis of Saruman into Sharkey and trolls into Olog-hai (281). Is this merely academic overreach or a deeper misunderstanding of the text?

The first section ends with "The Defense and Depiction of Philosophy in Tolkien" by Michaël Devaux, Associate Professor of Philosophy, Université de Caen Normandie and editor of several books on Tolkien's works (including *Tolkien: Les racines du légendaire [The Roots of the Legendary]* and *J.R.R. Tolkien, l'effigie des Elves [The Effigy of the Elves]*). Thankfully Devaux has sufficient experience with Tolkien Studies to include both footnotes and a tighter argument, centered on the question of whether or not Tolkien engages in philosophical contemplation, and if so, is it to the extent that we might consider him to be a philosopher. As this is a volume reportedly on Tolkien and Science, it is satisfying that Devaux connects science and philosophy, at least in a historical sense, for example through the works of Aristotle. Devaux returns to his initial question at the end and actually answers it – Tolkien was not a philosopher, in his opinion, but could talk philosophically within his subcreation. It is disappointing that while the author does reference "The Shibboleth of Fëanor" he fails to take advantage of some of the other deeply philosophical works in that same volume (*Morgoth's Ring*), including "Of Finwë and Míriel" and "Athrabeth Finrod ah Andreth."

The second section of the volume is led off by “Archaeological Remains and Hidden Cities” by chemist Vivien Stocker. With Damien Bador, Stocker is co-editor of *L'encyclopédie du Hobbit*, and one of the directors of the Tolkien association. Stocker demonstrates familiarity with both Tolkien and Tolkien scholarship by including necessary references in the bibliography as well as *some* informal in-text citations. One unattributed claim is that Tolkien once subscribed to *Antiquity* and received a volume of *Scandinavian Archaeology* from colleague E.V. Gordon (61-2). One might scan the bibliography and guess at the source based on a gut reaction, but the reader shouldn't have to rely on intestinal prognostication to divine citations. Again, while Stocker's survey of archaeological borrowings in Middle-earth is interesting, it is hard to know how much of it is original given the obvious lacunae in the references. Of particular interest to this reviewer is the argument for parallels between the Númenor and Ptolemaic Egypt.

Fellow co-editor of *L'encyclopédie du Hobbit* Damien Bador pens the following two articles in the collection. This aeronautical engineer with an interest in Tolkien's invented languages, has published in *Mythprint* and Brad Eden's collection *The Hobbit and Tolkien's Mythology* and is co-editor of *Le monde des Hobbits*. His first offering, “History and Historiography in Middle-earth,” is noticeably written for a non-specialist audience. Indeed, he includes a footnote explaining that *Beowulf* is an “Anglo-Saxon epic poem written between the 7th and 10th centuries A.D., narrating the exploits of the Scandinavian hero Beowulf, and his battles with the monster Grendel and a dragon in particular” (70). Bador similarly oversimplifies his discussion of sagas and historiography in Middle-earth, for example reducing Thingol's remaining behind in Middle-earth with Melian as he “fell in love with a servant of the Valar” (74). Tolkien is simply too subtle to simplify to this extent. In Bador's words, the “Lay of Leithian tells the tale of an improbable love between a man and an Elvish princess, which leads them to undergo all sorts of peril in order to be together” (76). This is true only in the same sense that the silmarils are just three shiny gems. Even worse is his description of the *Tale of the Children of Húrin* as “the sorrowful lives of a courageous and proud brother and sister whose many exploits end in tragedy” (76). His second offering “Linguistics and Fantasy” was better in quality but still rankles scholarly sensibilities, even as a popular-level work. While the bibliography contains a number of references, neither Fimi and Higgins' 2016 seminal volume *A Secret Vice* nor Tolkien's original essay are among them. When Bador notes that in “one of his letters” Tolkien refers to himself as a “*pure* philologist” the reader should not have to pull out their Kindle to figure out *which* letter; a simple “In a letter from [insert date]” or even a mention of whom the letter was addressed to would have been sufficient breadcrumbs.

The final paper in that section, “*The Lord of the Rings: A Mythology of Corruption and Dependence*,” is the work of Thierry Jandrok, essayist and doctor

of psychology and psychoanalyst at the Université de Lorraine. This over-the-top bombast begins with a psychoanalysis of Melkor as an example of a “devil child” who “seeks out a surplus of love, along with boundless admiration and recognition” while simultaneously finding enjoyment in “the pleasure and fulfillment of his fantasies of control and domination” (90). It is impossible to know what specific evidence Jandrok finds for this diagnosis within the legendarium due to a lack of inline citations connecting his presumptions with the list of *History of Middle-earth* volumes included in the bibliography. The result is a word salad that fails as both satire and scholarship. The “Ring of Power is . . . the memory of infantile dreams aborted in the mists of education and Oedipal tragedy,” without any analysis to back up such sweeping claims (91), while the blades of the Nazgûl are proclaimed to be “interdimensional” (96). “Only Elvish blades are able to penetrate” the Nazgûl (don’t tell Éowyn) (95) while Aragorn successfully fights against “Images of power” through his life strategy rife with “metaphors involving the symbolic desire for accomplishment” (96).

Stephen Giner, geomorphologist, archaeologist, and topographer brings his expertise to bear in “Landscapes in Tolkien: A Geomorphological Approach.” Giner analyzes Tolkien’s geology through a strictly scientific lens and, not surprisingly, finds it lacking. He seems to ignore (or perhaps is unaware of) Tolkien’s admission that he had “a very little knowledge” of geology and described the “indication” of geology in Middle-earth as “difficult and perilous!” (Carpenter 248). Giner is certainly not the first to attempt this kind of analysis, but the lack of references to this previous work might erroneously lead a reader from the general public to believe it to be groundbreaking in some way. The oversight is rendered even more egregious by the inclusion of several of the seminal papers in the bibliography of the next essay in this collection. It is generally good scholarly form for editors of a collection to direct authors of similar essays to at least be cognizant of overlapping (or even contradictory) ideas in each other’s works so they can be addressed before publication. For example, Giner asks if Tolkien might have been influenced by the 1902 eruption of Mount Pelée (104); nineteen pages later Laurent Stieltjes flatly states that Tolkien *was* influenced by this event in his description of Mordor (123).

Continuing with Giner’s essay, he seems to misrepresent the cause of the volcanic eruption of Meneltarma during the Fall of Númenor as described in “Akallabeth” in *The Silmarillion* as “Sauron attempts to take possession of the island” (105). Gone is all the subtlety of Sauron’s insidious plan to surrender to Ar-Pharazôn, worm his way into the king’s confidence, and use the Númenóreans’ desire for immortality against them, turning them into pawns against the Valar. The volcanic eruption is rather one of many portents from the Valar (or Eru himself), a last warning during the siege of the Eagles of Manwë for the Númenóreans to turn aside from their blasphemy and hubris (*Sil* 277). A lack of depth in Giner’s

understanding of Middle-earth can also be seen in the comment “Did Middle-earth experience a rise in water levels during its history” in response to what he describes as the “strange, concave delta” in the Bay of Belfalas (106). In addition to the cataclysmic “rounding” of the world at the destruction of Númenor during the Second Age we also have any number of cataclysmic battles between the Valar and Melkor much earlier in Arda’s history. But of course, given Tolkien’s admission of the limits of his geological knowledge in his letters, we engage in such detailed analysis at our peril, not his. Indeed, the source for Giner’s statement that the delta was “concave” is never stated in his meager bibliography but appears to be the map contained in *The Lord of the Rings*, hardly a geologically rigorous piece of cartography.

“A Geological Stroll Through Middle-earth” by science journalist Loïc Mangin reflects on the possible plate tectonics of Middle-earth, a topic that has been well-tread by prior authors. To Mangin’s credit, the bibliography contain two of the best known early pieces of geological analysis of Middle-earth (Reynolds [1974] and Sarjeant [1992]) and the essay itself is accompanied by illustrations reflecting the plate tectonics analysis of these earlier papers to facilitate a comparison. However this piece suffers from a lack of proofreading. There is a distracting insertion of French with English translation, perhaps the caption of a diagram that was omitted. The essay also simply ends by asking how well the New Zealand landscape fits both “Tolkien’s imagination and the geological history compiled by William Sarjeant,” leaving this reviewer to wonder if there was more to this essay that did not make it into print (117). There is also a rather sweeping generalization near the end, that “Tolkien did not take his inspiration from real-world geography” (117), which can be shown to be false in at least two cases: the Glittering Caves of Aglarond, which Tolkien clearly states “was based on the caves in Cheddar Gorge” (Carpenter 407), and various features associated with the Misty Mountains that reflect Tolkien’s experiences hiking in the Swiss Alps in 1911 (Scull and Hammond 27).

Volcanologist and geological risk consultant associated with the French Geological Survey Laurent Stieltjes offers one of the better essays in this volume in “Volcanoes, Sources of Magic and Legends.” While there is some overlap with Giner’s piece, the fault lies with the editors, who should have done a better job in coordinating the essays into a consistent whole (as noted above).

“Summer is Coming: The Climate of Middle-earth” is a reprint of what has long been one of this reviewer’s favorite pieces of Middle-earth studies. Dan Lunt, expert on climate computer modelling at the University of Bristol’s Cabot Institute for the Environment, first posted this mock scientific paper, penned by “Radagast the Brown,” in 2013. Lunt posted a similar piece on the Climate of Westeros in *Game of Thrones* under the pseudonym Samwell Tarly in 2017. In both works Lunt applies his climate change algorithms to fictional worlds and uses rigorous science

tinged with humor to demonstrate the power of climate change modelling. This is a great example of speculative science done right. While it is heartening that its inclusion in this volume may widen its well-deserved audience, the opportunity should have been taken to fix minor errors, for example, the “Kingdon” of Forodwaith (a typo held over from the original). More to the point, an offhanded comment about Saruman calling the idea that Middle-earth is a “spherical planet... a ridiculous concept” is a tad jarring, given that the “paper” was presumably written in the Third Age (Radagast’s address is given as “Rhosgobel, nr. Carrock, Mirkwood” in the original), well after the rounding of the world in the destruction of Númenor in the Second Age. Again, if the editors had been more well-versed in Middle-earth, this error would not have been promulgated.

Section 4 begins with “Plants and Landscapes in Middle-earth” by Jean-Yves Dubuisson, paleobotanist, and Élodie Boucheron-Dubuisson, botanist, both affiliated with Sorbonne University. Not only does this piece lack a bibliography or informal references to other secondary works, it makes the cardinal sin of lamenting that the plants of Middle-earth “deserve a whole book of their own” (147) when two such volumes already exist: Judd and Judd’s 2017 volume *Flora of Middle-earth* and Hazell’s 2006 *The Plants of Middle-earth*, both of which easily appear in a Google search for “plants Middle-earth.” A translation error (equating sloe berries with blueberries) would normally be easy to overlook, except that the authors are attempting to use the precise flora mentioned by Tolkien to reconstruct the geographical climate (149). But as noted in the book’s bibliography (373), there are two sets of standard French translations of *The Hobbit* and *The Lord of the Rings*, which may explain the confusion here.

Speleologist and veterinarian Sylvie-Anne Delaire next offers one of the better essays, “Subterranean Worlds in Tolkien: An Underground History.” Here we see a discussion of Tolkien’s influential trip to Switzerland previously overlooked in Loïc Mangin’s essay. The editors should have noticed the disconnect between the two essays, especially since Mangin is one of said editors. Delaire’s analysis of the Dwarves’ mining technique is particularly interesting.

In “Precious Stones: Jewels of Middle-earth,” Erik Gonthier, ethnominerologist and expert in precious stones, cave art and megaliths (National Museum of Natural History, Paris) and Cécile Michaux, cultural mediator who works in the performing arts, attempt to identify the exact mineral composition of various important stones in Middle-earth (Arkenstone, Elessar, the three Elven rings, silmarils and the ring of Barahir) based on their descriptions. The basic concept of the article is quite interesting; the execution is uneven at best. For example, the silmarils are said to “display phenomenal powers; in this they are somewhat reminiscent of the Infinity Gems in the Marvel Universe” (170), and Celebrimbor, who crafted the Elven rings of power, is called an “army commander in the Last Alliance of Elves and Men” despite the fact that, according to Appendix B, “The Tale of Years,” in *The Lord of*

the Rings, he had been dead for 1733 years (*ROTK* 364-5). The Three Elvish rings of power are also aligned with specific powers such as “the ability to resist oppression and despair” (171), when we are told in *The Silmarillion* that “those who had them in their keeping could ward off the decays of time and postpone the weariness of the world” (288).

Jean-Marc Joubert, Director of Research, and Jean-Claude Crivella, research chemist, both at French National Centre for Scientific Research, survey weapon making and other metallurgical applications in “Medieval-fantastical Metallurgy.” As in the case of some other essays, the inclusion of sweeping generalizations, gross oversimplifications, and plain errors limit the effectiveness of this essay. For example, the Dwarves are said to “share a direct kinship with the Vala Aülé [sic]” (176) and Celebrimbor “unmasks him [Sauron] and then forges the three Elvish Rings of Power” (178). The existence of an “industrialized society of wizards” would have come as a surprise to Radagast, to say the least (179).

Two of the three editors of the volume, paleontologist Jean-Sébastien Steyer and astrophysicist Roland Lehoucq, contribute two co-written pieces, “Invisible to Sauron’s Eyes” and “The Eyesight of Elves.” Unfortunately, these deeply science-based articles lack bibliographies and the intext informal citations are mainly quotations from *The Lord of the Rings*, leaving the interested reader no recourse but to Google in search of more information. The first piece is an interesting survey of “invisibility” in Middle-earth, loosely defined, making connections to Primary World technology. The second, “The Eyesight of Elves,” treads much of the same ground as a similar essay in Henry Gee’s book, although approaching it from a slightly different scientific viewpoint.

“A Chemical History of the One Ring” is a highly scientific analysis by Stéphane Sarrade, chemist and Director of Research at the French Alternative Energies and Atomic Energy Commission. The discussion of alchemy achieved through neutron capture and radioactive decay is thoughtful and interesting. However, solid science cannot cover for a shaky mastery of Middle-earth lore. For example, the claim is made that Sauron and Bilbo avoided Gollum’s “mutation” by the ring’s “powerful radioactive emissions” only because they were “protected by armor of lead and mithril, respectively” (196). The essay’s final conclusion, that the ring cannot be made of true gold but rather “an unstable alloy,” is interesting, if not forced, and aligns well with more philosophical and metaphysical reasons for considering that the ring was more “fool’s gold” than pure gold.¹

Essayist/novelist and clinical physician Luc Perino begins his piece “Tales of a Young Doctor . . . in Middle-earth” with a mildly humorous chip firmly placed on his shoulder, bemoaning the fact that no medical professionals “have ever met with much success in Middle-earth” (201). While Elrond, among others, might debate

¹ Sara Brown examines the process of transformation in *The Lord of the Rings* and using an analysis of metaphorical alchemy argues that the One Ring cannot be made of true gold.

this fact, it pales in comparison with other generalizations contained within this essay. For example, the “Black Breath of the Nazgûl is clearly meant to evoke pneumonic plague” (203), while “Like many powerful people in this world, Sauron is undoubtedly bipolar. . . . Abandoning the quest for the One Ring is, for him, the only situation capable of triggering a major depressive and suicidal phase” (208). While Perino might be forgiven a single instance of inserting “Sauron” instead of “Saruman” as an innocent typo, his further analysis belies it having been a simple mistake – he clearly does not know the difference between the two characters. “Sauron” is clearly described as manipulating many kings, “directly, as in the case of Denethor, and indirectly, as with Théoden, through Grima” (208).

Perino’s attempts at humor fall flat as well, including a claim that “the risk of being permanently marginalized discourages young hobbits from undertaking medical studies” (204) and that Elrond plies his patients with “opium or other psychedelic drugs” (206). Frodo is described as an “antihero” who suffers from “psychosomatic” illnesses, and it is noted that today Gollum would be treated with “antipsychotic drugs that would make him obese and pathetic” (207). On the other hand, Aragorn has a “superhero-like talent of being able to heal through the power of suggestion” (206).

Perino completely glosses over the important point that Elvish “immortality” is really only being coeval with the world (like the Valar) and tries to joke that “The job of an Elven doctor, then, would be to steer his patients toward the choice of a mortal life – all the more so because the principal source of happiness for Elves is the company of Men and Dwarves” (205). Comments joking about the success of an Elven physician being measured by the number of his brethren “he can convince to die one day” demonstrate a complete disregard for much of the legendarium, starting with *The Silmarillion* and working through to *The Lord of the Rings*, not to mention “The Story of Finwë and Míriel” and “Athrabeth Finrod ah Andreth” in *Morgoth’s Ring*. The author would do well to read some of the scholarly literature on death in Middle-earth that he failed to reference (e.g. Amendt-Raduege’s *The Sweet and the Bitter* [2018]).

Co-editor Jean-Sébastien Steyer offers “Why Do Hobbits Have Big Feet?,” one of the better essays in the collection, one of a number of pieces that tries to apply Primary World principles of evolution to Middle-earth. Steyer takes an anatomical approach to consider the evolutionary advantages of hobbit feet, especially for a “burglar” such as Bilbo (215). Steyer also brings in the so-called “Hobbits” of Indonesia (*Homo floresiensis*), a nice segue to the essay that follows, “When a Hobbit Upsets Paleoanthropologists,” by paleoanthropologist François Marchal. While there is very little connection to Tolkien’s world in the essay, Marchal provides a nice survey of the controversial discovery, including its scientific importance and issues that remain unresolved to this day.

Steyer follows up with a second solo essay, “Gollum: The Metamorphosis of a Hobbit,” in which he attempts to trace the evolution of Sméagol into Gollum through a scientific lens. The piece is marred by several errors, including a statement that Bilbo was “born more than a thousand years earlier” (than what is unclear) and that the One Ring bestows “greatly increased strength, [and] resistance to pain” upon its wearer (229).

The most provocative title in the volume clearly belongs to “Are Dwarves Hyenas?” by evolutionary biologist Sidney Delgado and specialist in French army parlance Virginie Delgado Bréüs. Using evolutionary principles, the authors posit the following hypothesis: (1) Dwarves evolved from humans (Aulë be damned, apparently); (2) Their population became isolated underground with limited resources; (3) Their evolution was directed by these environmental stressors. Real-world hormone science is further drawn upon to explain why there are fewer Dwarf females (and why they have beards). Despite the leaps taken in the initial presumptions, the result is an interesting intellectual exercise that does educate the audience on both science and Tolkien’s Secondary World. The hyena connection is the following: spotted hyena populations, like Dwarves’, have relatively fewer females as compared to males. In a second, likewise interesting, essay, “Saruman’s GMOs (Genetically Modified Orcs),” these authors examine Saruman as mad scientist, for example in his manipulation of orc and Uruk-hai biology. Possible real-world technologies are suggested, from the introduction of “human stem cells into an orc embryo” (261) or genetically modified virus DNA. While the basic premise is not original, the execution offers enough that is new.

Bruno Corbara, lecturer at the Université Clermont Auvergne specializing in the ecology of social insects, ponders the question “Could an Ent Really Exist?” Drawing upon biological definitions of plants and animals, Corbara considers peculiar “plant-animals” (255) in our Primary World (such as a variety of sea slug). The essay is too brief to sufficiently develop the concept, but it still offers points of interest for the reader to ponder. The interested reader should consult Henry Gee’s volume, as he covers many of the same points in far more detail.

Jean-Philippe Colin, associate professor of Life Sciences and Earth Sciences at the Université de Pau, uses his essay, “The Evolution of the Peoples of Middle-earth: a Phylogenetic Approach to Humanoids in Tolkien,” as a vehicle through which to explore a “what-if” scenario: can depictions of various intelligent species (ranging from Valar to trolls) in Tolkien’s writings, derivative artwork (e.g. by Alan Lee and John Howe), and the Peter Jackson films be coupled with phylogenetic analysis software to determine the relative evolutionary kinship of these species? There is much that is problematic with the basic premise, including, but not limited to, the nature of Valar “bodies” (*Sil* 25), Tolkien’s famous decades-long vacillation in his thoughts about the nature of orcs (e.g. *MR* 408-24), and the differences between how illustrators and Peter Jackson portrayed these species relative to

Tolkien's writings. More concerning are the blatant speciesism (Ents are only "full-fledged people in their own right" because they have females, language, and are bipedal [267]), obvious errors (Hobbits are descended from Númenóreans, because all humans are descendent from the island dwellers [273]), and a lack of cognizance of Tolkien's own writings on the topic of Humans and Elves being one species (Carpenter 189). As a result, we are presented with the "scientific" result that Hobbits are most closely related to Humans and Valar to Ents (which might come as news to Yavanna). The hubris in Colin's statement that "the question of the origins of these species and their biological relationship to humans is rarely discussed in a realistic or scientific manner" compounds the error of his lack of references. As noted, Tolkien himself certainly considered the science behind his various talking species, and spent not insignificant time worrying about it, and Henry Gee offers his thoughts on the topic in his earlier work; this reviewer has even briefly wallowed into it, in a 2017 *Amon Hen* article.

The final section on Tolkien's bestiary features essays mainly written by paleontologists, in which they largely attempt to find real-world analogies to one or more of Tolkien's creatures. Birds are the focus of fossilized bird expert Antoine Louchart. "Tolkien the Ornithologist" contains some excellent analysis of the sometimes-subtle importance of birds in giving Middle-earth its standing as a self-contained Secondary World. Some bits could have used more expansion; while eagles are featured in a second article, Tuor's important connection to swans is left out of that species' overview. In the separate piece on eagles, "Flying Giants! Really?," Louchart assesses the plausibility of Manwë's gargantuan eagles and their kin. By examining the fossil record, as well as verified examples of small children carried off by eagles, we get the opinion that Tolkien is dealing with plausible fantasy. Strangely the essay ends with very short comments on the Nazgûl fell beasts and balrogs (hedging his bets on the wings-no wings debate).

Sorbonne University paleoherpetologist Stéphane Jouve teases the reader with the title "Flames *and* Wings: Could it Really Happen?," but this piece and a second essay, "Smaug, Glaurung, and the Rest: Monsters for Biologists Too," discusses dragons rather than balrogs. In the former the potential physics and chemistry of dragon flight and fire is explored. While there are some references in the bibliography, Henry Gee's similar chapter is not referenced. The latter essay examines the taxonomy of Tolkien's dragons based on their descriptions in the narrative, comparing them to both fossilized and extant reptiles and using phylogenetic analysis software to find the closest fossil relatives. The science is clear and interesting and makes sufficient references to Tolkien's works to keep it relevant.

In "Memories of Oliphaunts," Arnaud Varennes-Schmitt, who wrote his Ph.D. thesis on the evolution of elephants and related species, reviews extinct elephant species and notes their similarities and difference to oliphaunts, coming to the

expected conclusion that “oliphaunts are probably an exaggeratedly large member of the elephant family” (296). While the essay is interesting from a scientific perspective, it tells us far more about the author’s knowledge of the topic than what Tolkien might have known or drawn upon. Having been frustrated by the lack of detail in the source material, the essayist turns to Jackson’s depiction of oliphaunts in his films and fixates on the numbers of tusks as unrealistic. He then launches into a theoretical examination of the dentition of Tolkien’s and Jackson’s oliphaunts compared to Primary World elephants, which tells us more about the WETA special effects artists than Tolkien himself. However, the section on elephants as “weapons of mass destruction” (302) in history is interesting and the list of references does allow for further investigation by interested readers.

Paleontologist Vincent Dupret and Romaric Hainez, associate professor of Life Sciences and Earth Sciences, contributed two analyses, “Wargs: War-Dogs of Scandinavian Origin?” and “Beorn: Man-Bear or Bear-Man?,” both of which include lengthy bibliographies. The former utilizes Tolkien’s description of wargs to posit a Scandinavian inspiration before analyzing the creatures’ anatomical and behavioral characteristics through a scientific lens. The authors take part in a recurring mistake in this volume, claiming that Tolkien did not do something when in fact he did, in this case that he “left no notes regarding his choice of name for wargs” (306). As noted by Douglas Anderson in *The Annotated Hobbit*, Tolkien explained his choice in a 1966 letter: “It is an old word for wolf” (146). Anderson explains the etymology of *warg* as derived from “Old English *wearg*-, Old German *warg*-, Old Norse *varg*-r” (147). Therefore, the good news is that Dupret and Hainez’s hypothesis to this effect is correct, the bad news, of course, being that it had already been established in Tolkien scholarship for at least two decades. While it is indeed possible that Anderson’s volume has yet to be translated into French, a simple Google search for “warg Tolkien etymology” will bring one to the exact same information. The other trap that the essay falls prey to is moving from book canon to film canon, as Jackson often takes artistic liberties with visual aspects of Middle-earth (as seen in the oliphaunt discussion). This scientific deconstruction of the film wargs might be of interest to film fans but offers little for book purists. Dupret and Hainez’s second offering appears at first glance to be a close reading and analysis of Beorn. In reality, it is an excuse to discuss possible explanations for Viking berserker behavior with little direct connection to Tolkien (although reading “medieval literature specialist” Tom Shippey’s name written as “Thomas Alan Shippey” [315] was a welcome source of amusement).

The obligatory essay on spiders is penned by paleontologist Romain Garrouste of the National Museum of Natural History and scientific illustrator Camille Garrouste. “The Bestiary of Arthropods” is advertised as an attempt to use Tolkien’s descriptions of arthropods to uncover his influences from zoology and cryptozoology, a laudable task (323). The essay includes scientific references in its

bibliography but does not make reference to related Tolkien Studies research. One should not generalize the relationship between Galadriel and Shelob without referring, at least in passing, to the sizable secondary literature on the topic, for example Leslie Donovan's "The Valkyrie Reflex in J.R.R. Tolkien's *The Lord of the Rings*." Despite this limitation, the scientific discussion is engaging, coming to the (not surprising) conclusion that the fossil and extant species records do not support the possibility of a gigantic spider, in agreement with Henry Gee's (228) earlier essay on the topic. The essay then turns to a rather shallow survey of insects in Middle-earth before taking a hard righthand turn into species named after Tolkienian characters in our real world. Interestingly, Henry Gee is invoked in this final section, having devoted an entire chapter to this topic in his own volume (57-68), although his book is not listed in the Garroustes' bibliography.

In "The Watcher Between Two Waters" Jérémie Bardin, a Ph.D. engineer specializing in taxonomy and phylogenetic analysis, and Isabelle Kruta, an expert on fossil cephalopods, investigate one of the less-often studied entries in Tolkien's bestiary. After surveying what little Tolkien actually says of the beast, the authors attempt to compare it to both other mythical creatures, such as the kraken and hydra, and real-world cephalopods. While they are unable to come to a definitive phylogenetic address for the creature, the analysis is cogent and interesting, and, to the best of this reviewer's ability to ascertain given the lack of secondary references, largely original.

The final essay, "The Cryptozoological Bestiary of J.R.R. Tolkien," by Benoît Grison, biologist and scientific sociologist at Université d'Orléans, surveys a number of fantastical beasts in Tolkien's works, and, in a refreshing change from the vast majority of pieces in this collection, brings in Tolkien's non-Middle-earth works, such as the Sea Serpent of *Roverandom* and the giant turtle of the poem "Fastitocalon." Grison demonstrates a relatively superior knowledge of both Tolkien's life and works as compared to most of the other contributors, referencing Tolkien's finding of a fossil jawbone as a child, although the source of this anecdote (which may be unknown to many readers) is not given (e.g. Rateliff 539). Thematically this essay belongs earlier in the volume, perhaps as an introduction to this section, although it is always positive for a book to end on a relatively strong note.

Books like this reflect the lingering lack of respect some academics (unfortunately including some of this reviewer's university colleagues) still have toward Tolkien Studies. They consider it a trivial topic that one can easily dabble in as a hobby. Some still buy into the hierarchical belief that scientists are superior scholars who deign to lend some of their credence and academic authority to the study of literature and popular culture. Instead, some of the more deeply flawed essays in this volume prove the converse.

The Tolkien scholarship community faces a possible onslaught of mass-produced and lightly researched Middle-earth media such as this in the wake of the Amazon series (and its reported 5-year contract). How we will successfully meet the challenge needs to be a topic of serious discussion throughout the Tolkien scholarship community right now. How can we most effectively fan the flames of interest in Tolkien that are sure to be sparked by the Amazon series while preventing the acceptance of sweeping generalizations of the source material and simultaneously encouraging fresh analyses, insights, and perspectives? It is a delicate balance that we need to master as a community before the deluge begins.

Tolkien noted of his childhood that he was “ready enough to study nature scientifically – very ready, quite as ready as to read fairy-stories. But I was not going to be quibbled into science nor cheated out of Faerie” (Flieger and Anderson 234). The readers of this volume are instead quibbled out of Tolkien and cheated out of a true appreciate of the science *of* Middle-earth.

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