"PROTOPLASM FEELS": THE ROLE OF PHYSIOLOGY IN CHARLES SANDERS PEIRCE'S EVOLUTIONARY METAPHYSICS

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This essay is an attempt to explain why Charles Sanders Peirce's evolutionary metaphysics would not have seemed strange to its original 1890s audience. Building on the pioneering work of Andrew Reynolds, I will excavate the scientific context of Peirce's *Monist* articles—in particular "The Law of Mind" and "Man's Glassy Essence," both published in 1892—focusing on the relationship between protoplasm, evolution, and consciousness. I argue that Peirce's discussions should be understood in the context of contemporary evolutionary and physiological speculations, many of which were featured in late-1880s issues of *Open Court*, sister journal to the *Monist*.

Introduction

"There is no doubt," wrote Charles Sanders Peirce (1892b, 547–48) in an early issue of the *Monist*, that "protoplasm feels." This is not the sort of claim one would encounter today in that journal, still published quarterly but now with each issue devoted to a particular philosophical topic. Popular articles from recent years such as De Caro (2015) and Rossi and Tappolet (2016) have contrib-

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uted to standard debates in philosophy. But in the first years of the *Monist*, the article titles look positively weird by comparison: for instance, "The Immortality of Infusoria" (Binet 1890a) or "Five Souls with But a Single Thought: The Psychological Life of the Star-Fish" (Sterne 1891).[1] This same weirdness characterizes a series of articles that Peirce published in the *Monist* from 1891 to 1893, outlining his famous evolutionary metaphysics. Or perhaps I should say infamous—even Christine Ladd-Franklin, Peirce's own student, was reportedly unimpressed with his *Monist* series and especially with the discussion of protoplasm in "Man's Glassy Essence" (Peirce 1892c): "Mrs. Ladd-Franklin told me that she considered several of his later essays (and in particular 'Man's Glassy Essence') as largely meaningless, that in his later years his mind evidently gave way and that she had often wondered whether it was not already doing so when some of those later essays were written."[2]

Those Peirce scholars who are more sympathetic to his metaphysical program still usually glide over its stranger features: protoplasm is not mentioned in most discussions of Peirce's metaphysics, even though Peirce devoted an entire article to the topic (Esposito 1980, chap. 5; Hookway 1985, chap. 9; 1997; Anderson 1987, chaps. 4–5; Hausman 1993, chap. 4; Burks 1996; Parker 1998, chap. 8; Kronz and McLaughlin 2002; de Waal 2013, chap. 9; Atkin 2016, chap. 6).

This essay is an attempt to explain why Peirce's evolutionary metaphysics would not have seemed strange to its original 1890s audience. Building on the pioneering work of Reynolds (2002), I will excavate the scientific context of Peirce's *Monist* articles, focusing on the relationship between protoplasm, evolution, and consciousness.[3] I argue that Peirce's discussions should be understood in the context of contemporary evolutionary and physiological speculations, many of which were featured in late-1880s issues of *Open Court*, sister journal to the *Monist* (both were published by the Open Court Publishing Company). Peirce was academically isolated for the last 25 years of his life, and the discussions facilitated by Open Court were among his few opportunities for intellectual interaction.[4]

1. At least as of December 12, 2016, De Caro (2015) and Rossi and Tappolet (2016) were among the five most-read articles in the *Monist*. Carus Sterne was the anagrammatic pseudonym of Ernst Krause.

2. Edwin Bidwell Wilson to Charles Hartshorne, November 10, 1946, "Wilson, Edwin B." folder, Max H. Fisch Collection, Institute for American Thought, Indiana University–Purdue University Indianapolis. Thanks to André De Tienne for providing me with a partial transcript of this and several related letters. Shortly after the publication of Peirce's *Monist* series, Ladd-Franklin (1895, 155) contrasted "hard and close-grained science" with "the all-embracing and incomprehensible 'systems' of the metaphysicians" in a review of a book by Eduard von Hartmann.

3. My story is complementary to that of Reynolds: although he does discuss protoplasm, he focuses on physics rather than biology (2002, 77–97). For a popular introduction to the scientific contexts of Peirce and other pragmatists, see Menand (2001).

4. Fisch (1967) designated the years from 1891 to 1914 as Peirce's "*Monist* Period." On Peirce's isolation, see Brent (1998, 232, 270).

There is another upshot of this recontextualization, beyond its contribution to Peirce scholarship: it supports Hutton's (2014, 935–37; 2015, 2–3) "conversation model" of the history of philosophy, which views philosophy in concrete terms as a conversation between various actors at a given time. The rich conversations that took place in *Open Court* and the *Monist* included not only canonical philosophers such as Peirce, William James, and John Dewey, but also physicists, chemists, biologists, and psychologists. As historians of philosophy, we need to listen to all of these voices and not only to those taught in philosophy classes. These late nineteenth-century discussions should also be of particular interest to readers of *HOPOS*, since the *Monist* was the first American journal devoted to the philosophical discussion of science.[5]

Focusing on the Open Court conversation offers an additional lesson for historians of philosophy: we should not neglect institutions and venues. When one reads the collected works of some philosopher, it is easy ignore the fact that individual texts are often interventions into specific debates happening in specific journals—especially when the other voices in those debates belong to lesser-known figures. Although some of this context is available in the textual apparatus of collected-works volumes, such sections are not always read, and they are necessarily confined to the immediate conversational context. Moreover, as the case of *Open Court* illustrates, greater attention to publication venues can help break down two sorts of boundaries. First, it can bring us into contact with those studying different philosophical traditions. Because the Open Court Publishing Company was owned and operated by German expatriates, it was dedicated to creating a truly transatlantic conversation. Peirce, by joining this conversation, was thus entering into a whole series of controversies in science and philosophy—*Materialismusstreit*, *Darwinismusstreit*, *Ignorabimusstreit*—that were central to post-Hegelian debates in Germany (Beiser 2014a, chaps. 2–3; 2014b, chap. 11; Edgar 2015). Second, it can connect us to researchers in other disciplines. Exploring the scientific context of Peirce's work leads one directly to two brief but helpful discussions of his interest in protoplasm by historians of science—discussions that, if citations are any indication, are simply not on the radar for Peirce scholars (Schloegel and Schmidgen 2002, 642; Brain 2008, 216–17).[6] Thus, attention to the diversity of past conversations—and to the venues in which they took place—can also enrich present conversations.

5. David Stump's "Defining the Field: Early Venues for the Philosophy of Science," presented at the HOPOS 2016 conference in Minneapolis, focused on the *Monist* and the *Revue de métaphysique et de morale*.

6. Reynolds does cite Schloegel and Schmidgen (2002) in some of his later work on the history of biology, but he does not mention their treatment of Peirce (see Reynolds 2008, 324 n. 63).

This essay has three main sections. First, I will give a brief overview of Peirce's evolutionary metaphysics, concentrating on his cosmology rather than his triadic framework.[7] Next, I will provide a brief history of protoplasm theory, emphasizing the writings of two philosophically inclined evolutionists: Ernst Haeckel and Edward Drinker Cope. Both Haeckel's hylozoism and Cope's archaesthetism were part of the Open Court conversation, but it was Cope's treatment of protoplasm and consciousness that had the greatest influence on Peirce. Finally, I will examine Peirce's account of protoplasm in his *Monist* series, focusing especially on "The Law of Mind" and "Man's Glassy Essence," both published in 1892. These articles, partly inspired by Cope and his interlocutor Edmund Montgomery, linked protoplasm to consciousness and ultimately to Peirce's broader evolutionary metaphysics.

Evolutionary Metaphysics

Peirce's evolutionary metaphysics is seen as central to his work as a whole: almost every overview of Peirce's philosophy devotes at least a chapter to it (Esposito 1980, chap. 5; Hookway 1985, chap. 9; Anderson 1987, chaps. 4–5; Hausman 1993, chap. 4; Parker 1998, chap. 8; de Waal 2013, chap. 9; Atkin 2016, chap. 6). As Hookway (1997) has shown, Peirce began to develop a kind of evolutionary cosmology in the mid-1880s. In "Design and Chance," a paper read at Johns Hopkins in 1884, Peirce (1982–, 4:553) asked, "May not the laws of physics be habits gradually acquired by systems?" Writing anonymously in the *New York Times* in 1890, he contrasted his own "thoroughgoing evolutionism" with that of the English philosopher Herbert Spencer: Peirce (1890a, 4) was attempting to find a real explanation of "the general laws of mechanics" rather than gesturing vaguely at "the Unknowable" as Spencer had done (see Spencer 1862, 47–67). A few months later, on July 2, Peirce was invited to write something for the Chicago weekly *Open Court* or its new sister journal the *Monist*, both of which were edited by the German émigré philosopher Paul Carus (Charles Sanders Peirce Papers [hereafter Peirce Papers], Houghton Library, Harvard University, L77).[8] The next day, Peirce told his friend Francis Calvin Russell, who acted as the initial

7. For ease of exposition, and so as not to duplicate excellent work by others, I have avoided discussion of Peirce's famous triad of First, Second, and Third; although he did apply his triadic framework to protoplasm, this application is not relevant to the central thread of my argument. For a recent overview of the framework, see Atkin (2016, 226–41).

8. Peirce was already familiar with *Open Court*, having cited it in one of his *Century Dictionary* entries (Whitney 1889–91, 3:2943, s.v. "hylozoistic"). A list of Peirce's entries for the *Century Dictionary* can be found in Ketner (1986, 43–83). For more on Peirce's relationship with Carus, see Henderson (1993, chap. 8).

intermediary with Carus, that he would like to write a whole series of articles examining "the laws which have been found to govern the evolution of the leading ideas of mathematics and physics."[9] Carus, who had seen Peirce's discussion of Spencer in the *New York Times*, suggested to Peirce on July 22 that they stage a similar debate in *Open Court*. They settled on something closer to the former plan, and Carus acknowledged receipt of Peirce's first submission to the *Monist* on August 3 (Peirce Papers, L77).

In this article, "The Architecture of Theories," Peirce (1891a, 166) repeated his *New York Times* accusation that Spencer, because he claimed that we could never know the basis of the most general laws, was "not a philosophical evolutionist but only a half-evolutionist." Peirce's evolutionism, in contrast, would attempt to explain the laws of nature as "results of evolution," supposing "them not to be absolute, not to be obeyed precisely" (165). According to Peirce, mechanistic accounts of evolution failed to acknowledge that "exact law obviously never can produce heterogeneity out of homogeneity; and arbitrary heterogeneity is the feature of the universe the most manifest and characteristic" (165). This was a direct attack on Spencer, whose very definition of evolution was "a change from an indefinite, incoherent homogeneity, to a definite, coherent heterogeneity" (1862, 216).

"The Architecture of Theories" provided a preview of Peirce's whole *Monist* series. He declared allegiance to objective idealism, the view that "matter is effete mind, inveterate habits becoming physical laws" (1891a, 170); he stated that variety and heterogeneity in the universe could only be explained by the existence of an inherent "swerving" or "spontaneity" (165); and he concluded with a short but spectacular summary of his evolutionary cosmology:

> In the beginning,—infinitely remote,—there was a chaos of unpersonalised feeling, which being without connection or regularity would properly be without existence. This feeling, sporting here and there in pure arbitrariness, would have started the germ of a generalising tendency. Its other sportings would be evanescent, but this would have a growing virtue. Thus, the tendency to habit would be started; and from this with the other principles of evolution all the regularities of the universe would be evolved. At any time, however, an element of pure chance survives and will remain until the world becomes an absolutely perfect, rational, and symmetrical system, in which mind is at last crystallised in the infinitely distant future. (176)

9. Peirce to Russell, July 3, 1890, folder 9, box 91, Open Court Publishing Company Records (1/2/MSS 027), Special Collections Research Center, Southern Illinois University. For a short obituary of Russell, see *Chicago Daily Tribune* (1920).

Peirce promised that this "Cosmogonic Philosophy" not only accounted "for the main features of the universe as we know it" but also predicted "many more things which new observations can alone bring to the test" (175–76).[10]

The main topics of the other four articles in Peirce's *Monist* series were chance and necessity, the transmission and development of ideas, the nature of protoplasm, and neo-Lamarckian evolution. From our present point of view, these topics seem idiosyncratic, to say the least; at the time, however, they were seen as related. Chance and spontaneity were central to debates at the time between neo-Darwinians and neo-Lamarckians over the production of variation in evolution (Pearce 2014, 18–20). More importantly for our purposes here, evolutionary biologists of a speculative bent thought that protoplasm was the key to understanding the relationship between mind, matter, and evolution. As we will see, protoplasm allowed Peirce to make connections between physiology, psychology, and cosmology.

Protoplasm, Hylozoism, Archaesthetism

Why was Peirce so interested in protoplasm? Schloegel and Schmidgen (2002, 642) and Brain (2008, 216–17; 2015, 57) have highlighted the role of the German biologist Ernst Haeckel and his followers, and I agree that this Haeckelian tradition had an indirect influence on Peirce. Brain has also described a broader "protoplasmania," a disease spread by German naturalists that was running rampant by the 1870s.[11] One of its English vectors was Thomas Henry Huxley, who was full of praise for Haeckel's work (e.g., Huxley 1869b, 13). In an infamous 1869 essay, reprinted several times in the United States, Huxley (1869a, 145) declared that protoplasm was the "physical basis of life" and claimed that "materialistic terminology" was most conducive to "the progress of science" (reprinted in Huxley 1871, 120–46; and in Porter 1871, 7–35). Peirce must have been familiar with Huxley's essay, and protoplasm was often discussed in *Popular Science Monthly*, which published a series of Peirce's articles in 1877–78 (Haeckel 1877a; Montgomery 1878; Allman 1879). However, I demonstrate in what follows that Peirce was in direct conversation with another set of authors writing about protoplasm, mind, and evolution, all of whom published work in *Open*

10. For another 1891 summary of his evolutionary cosmology, see Peirce to Christine Ladd-Franklin, August 29, 1891 (Peirce Papers, L237; published in Peirce 1931–60, 8:316–18). I will give paragraph numbers when citing the *Collected Papers* (i.e., Peirce 1931–60). On the Schellingian roots of the idea of matter as extinct or effete mind, see n. 49 below.

11. At the time, 'naturalist' meant what we mean today by 'natural scientist' (Whitney 1889–91, 4:3942, s.v. "naturalist"). For reasons given below (see n. 24), I disagree with Heidelberger's (2004, 268–71) claim that Peirce's metaphysics was influenced by the views of Gustav Fechner.

Court in the late 1880s: the American paleontologist Edward Drinker Cope most importantly, but also the French psychologist Alfred Binet (in translation), the Scottish physiologist-philosopher Edmund Montgomery (then living in Texas), and Paul Carus (the editor of *Open Court*). Even if Peirce was familiar with Haeckel's ideas, he primarily encountered them as interpreted by these other authors.[12]

Ernst Haeckel: From Protoplasm to Hylozoism

Cope had been discussing protoplasm, consciousness, and evolution since the mid-1870s. But why did these topics travel together in the first place? As Daniel Liu (2017) has shown, during the 1840s and 1850s naturalists began to argue that the substance inside cells was not merely passive matter from which living things were formed but was itself alive (see also Mendelsohn 2003). This shift was accompanied by a new role for simple microscopic organisms, which became "provocative objects" and "exemplary cells" in physiology and zoology (Schloegel and Schmidgen 2002, 618; Reynolds 2008). Rhizopods, in particular—a group that included the Foraminifera and Radiolaria as well as several other amoeboid taxa—were the subject of new research in the 1850s and 1860s. These creatures were seen as especially interesting, since the homogeneous jelly of their active bodies exhibited all the heterogeneous phenomena of life. As Max Schultze (1854, 7–8) wrote in his short work on the Foraminifera, "The movements of these beings appear voluntary, but specific organs of motion and sensation are not yet differentiated." He was echoed by the English physiologist William Benjamin Carpenter (1862, vii–viii) in his own book on the topic:

> The Physiologist has here a case in which those vital operations which he is accustomed to see carried on by an elaborate apparatus, are performed without any special instruments whatever, a little particle of apparently homogeneous jelly changing itself into a greater variety of forms than the fabled Proteus, laying hold of its food without members, swallowing it without a mouth, digesting it without a stomach, appropriating its nutritious material without absorbent vessels or a circulating system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves, propagating itself without genital apparatus.[13]

12. Cope and Montgomery are both discussed in the chapter on "speculative biology" in Schneider's *History of American Philosophy* (1946, 359–65).

13. As Reynolds (2008, 315–16) has noted, Carpenter (1865, vii, 134–47; 1874, 41–43) drew on his rhizopod research in some of his influential physiology textbooks.

This protean jelly, although it had previously been called the *sarcode* (from the Greek *sarx*, flesh/body), had been identified in the 1850s with what botanists called *protoplasm* (from the Greek *prōtos*, first, and *plasma*, something formed/molded) and thus with the contents of all living cells.[14] Schultze (1860, 298) summarized its essential role in an 1860 article: "Protoplasm is the most important substance of the cell: in it are concentrated the functions of the cell; in it are manifest, in particular, all the chemical and morphological changes that characterize the different phases of cell life."

Protoplasm also occupied an important place in discussions of evolution. Ernst Haeckel, who became Darwin's most famous German follower, quoted Schultze's article in his own work on rhizopods, embracing the idea that all cells contain protoplasm (Haeckel 1861, 7; 1862, 93–96).[15] Then in his two-volume *Generelle Morphologie* of 1866—described on the title page as "justified by the theory of descent reformed by Charles Darwin"—Haeckel (1866, 1:136) separated out a group of naked amoeboid organisms, calling them the *Monera* (from the Greek *monērēs*, solitary/simple): "The Monera stand . . . on the boundary between living and non-living natural bodies. They live, but without organs of life; all the phenomena of life, nutrition and reproduction, movement and irritability, here seem to flow immediately from formless organic material."[16] "All organisms," Haeckel declared later in the book, "are ultimately descendants of such autogenous Monera, evolved in sequence by divergence of character through natural selection." Thus, the Monera, which he described as "completely structureless and homogeneous bits of plasm," were our own most distant ancestors (2:419). Haeckel showed no reticence in making any of these claims—one American commentator compared Darwin's rhetorical strategy to careful siege warfare and Haeckel's to an impetuous cavalry charge (Coues 1879, 429).[17]

What about consciousness? It was agreed that rhizopods, and even moners, exhibited "all the phenomena of life," including irritability—that is, responsiveness to stimulus. Haeckel (1862, 160) had pointed out in his monograph on the

14. For more on the identification of sarcode and protoplasm, see Geison (1969) and Liu (2017). Liu suggests that the original use of the term 'protoplasm' may have been inspired by *protoplastus*, "a Catholic liturgical term that referred to Adam, and which could be translated as 'first formed' or 'first creation'" (894 n. 4).

15. On Haeckel's embrace of Darwinism in the early 1860s, see Di Gregorio (2005, 74–98), Gliboff (2008, 156–70), and Richards (2008, 63–75, 94–104).

16. Haeckel (1866, 1:135–36) distinguished between cytodes (lacking a nucleus) and cells (possessing a nucleus); the Monera were cytodes that were free living.

17. Haeckel made similar points in his more popular *Natürliche Schöpfungsgeschichte* (1870) and *Anthropogenie* (1874), both of which were translated into English in the late 1870s (1876b, 1:183–86, 2:61–67, 278; 1879a, 1:179–81, 2:43–48). In one of his *Century Dictionary* entries, Peirce quoted Rollo Ogden contrasting the "patiently inductive" Darwin with the "general theorizings" of Spencer and Haeckel (Ogden 1889, 754; quoted in Whitney 1889–91, 6:6278, s.v. "theorizing").

Radiolaria that it was often difficult to distinguish between mere irritability and conscious sensation: "Where is the objectively perceptible boundary between sensation [*Empfindung*] and irritability [*Reizbarkeit*]? From what can we conclude that the stimulus [*Reiz*], which elicits a reaction, has really attained to consciousness?" Later, in a monograph on the Monera, Haeckel (1868, 82–83) again broached the issue: "Individual phenomena of movement seem to reveal the power of distinct *sensation*, just as they do a definite *will*; and ultimately one could even attribute an actual *soul* or so-called *Geist* [mind/spirit] to these little living lumps of mucous, just as well as to humans and other true animals." But although they seemed to possess all of these capacities, Haeckel explicitly denied that microorganisms were conscious. In 1862, he wrote that "*sensation*, or a reaction to external stimuli accompanied by consciousness, has not been observed as yet in any radiolarian, or even any rhizopod" (1862, 128). As he put it in the second edition of his *History of Creation*, the psychic activity of these organisms "manifests itself in their *irritability*, that is, in the movements and other changes which take place in consequence of mechanical, electrical, and chemical irritation [*Reiz*] of their contractile protoplasm. Consciousness and the capability of will and thought are probably wanting" (1876b, 2:68–69; translated from Haeckel 1870, 392–93). Thus, although the behavior of moners and other primitive organisms betrays some kind of psychic life, grounded in the responsiveness of protoplasm, this does not extend to conscious awareness or sensation—or so Haeckel argued in the 1860s.

A few years later, however, beginning in the mid-1870s, Haeckel began to attribute conscious sensation to matter itself, endorsing a kind of hylozoistic monism.[18] Having already asserted in his *Anthropogenie* (1874, 381) that every part of a moner is both "irritable and sensitive," in an 1876 pamphlet he attributed sensation to protoplasm as such (1883, 222; translated from Haeckel 1876a, 23). Then he went even further, declaring that "the movements of atoms which must occur in the formation and decomposition of every chemical compound, are only explicable if we impute to them sensation and will" (1883, 231; translated from Haeckel 1876a, 38). Haeckel repeated these bold claims the next year: "Single, detached particles of protoplasm have sensation and movement," and ultimately "every atom has sensation and the power of movement" (1883, 286, 296; translated from Haeckel 1877b, 13, 23). To support this idea of "atom-souls," Haeckel cited Johann Carl Friedrich Zöllner (1872, 320–21), an astrophysicist who speculated that we would ascribe sensation to matter if

18. Hylozoism, from the Greek *hylē*, matter, and *zōē*, life, is the belief that matter is alive. Hylozoistic monism is thus the belief that there is fundamentally only one kind of substance in the universe: living matter.

we could only observe its reactions at the molecular level, and Gustav Tschermak (1876, 240), a mineralogist who suggested that "the drive to form the manifold from the simple, the life-drive, the organization-drive, is already present in matter." Haeckel (1878b, 58) summarized his new account of the psychic life of protoplasm: "Far from believing in a crude, soulless matter, after the manner of our adversaries, we must rather suppose that the first elements of soul-life are in all living matter, in all protoplasm: desire and aversion, the simple forms of sensation; attraction and repulsion, the simple forms of motion" (translation modified from Haeckel 1883, 173).[19] Thus, according to these later speculations of Haeckel, protoplasm actually desires certain things in its environment—a proposal that prompted the American psychologist Granville Stanley Hall, who had already summarized Haeckel's position in the New York weekly the *Nation* (Hall 1879, 180), to comment that "studies in general biology tend to make even the best and most empirical investigators speculative, fantastic, and transcendental" (Hall 1880, 365).

In 1890, Peirce encountered a version of these views in the opening essay of Paul Carus's book *Fundamental Problems*, a collection of pieces previously published in *Open Court*. Echoing both Haeckel and Cope but citing Binet, whose book *The Psychic Life of Micro-Organisms* (1889) had just been published by Open Court, Carus (1889a, 9; 1889b, 1431) declared that "sensation is a psychical phenomenon. When a moner is affected by and responds to irritations, it behaves in such a way as to leave no doubt that there is on a small scale and in a very simple condition the self-same power at work which we feel active in our consciousness. Like ourselves, the moner is a sentient being, a creature that is endowed with feeling." In a review of Carus's book for the *Nation*, Peirce (1890d, 119) highlighted a passage from this same essay that anticipated his own discussion of protoplasm: "The appearance of the phenomena of sensation, will be found to depend upon a special form in which the molecules of protoplasma combine and disintegrate" (Carus 1889a, 10–11). Thus, by 1890, Peirce had joined the Open Court conversation about moners and the protoplasmic basis of sensation.[20]

19. Haeckel made similar points in Haeckel (1879b, chap. 4; translated from 1878a, chap. 4). Peirce quoted the English translation of Haeckel's *Anthropogenie* in some of his *Century Dictionary* entries, but he does not seem to have been familiar with any of the later texts (Whitney 1889–91, 4:3834, s.v. "monistic"; 5:5840, s.v. "spirit"). For more on Haeckel's 1870s "cellular psychology," see Schloegel and Schmidgen (2002, 622–25) and Brain (2008, 214–17; 2015, 53–57).

20. Later in the same essay, Carus mentioned the German physiologist Ewald Hering, whose claim that "every organized being of our present time is the product of the unconscious memory of organized matter" had influenced Haeckel (Hering 1887, 170; translated from Hering 1870, 273; cited in Haeckel 1876a, 40–41). Carus was also familiar with the views of Cope, who had written about "the mind of the amoeba" in *Open Court* (1887a, 358).

Edward Drinker Cope: From Protoplasm to Archaesthetism

Peirce was indirectly familiar with Haeckel's hylozoistic monism: he had cited Montgomery's description of it in the *Century Dictionary*, and Carus—after reading the aforementioned review of *Fundamental Problems*—had sent Peirce an essay arguing that all natural processes are "animated with the elementary germs of psychic life" (Montgomery 1887c, 65–66; Whitney 1889–91, 3:2943, s.v. "hylozoistic"; Carus 1890a, 2426).[21] But Cope's speculations are even more important for our story, as they seem to have had a greater impact on Peirce's metaphysics. Although Peirce does not mention Cope in any of his *Monist* articles, he was certainly familiar with his views: Cope contributed, along with Peirce, to an 1887 issue of the *Christian Register* that assembled scientists' opinions of immortality (Barrows 1887b); several of Peirce's many entries for the *Century Dictionary*, whose first three volumes (A–L) appeared in 1889, included references to Cope's work (Whitney 1889–91, 2:1541, s.v. "departure"; 3:2673, s.v. "habit"; 3:2883, s.v. "horizon"); Peirce (1890c), part of the *New York Times* debate about Spencer, referred to Cope—"whose book is famous"—as one of America's great generalizers (the book in question was *The Origin of the Fittest*, an 1887 collection of Cope's earlier articles); and finally, in his review of the first issue of the *Monist* (which contained an article by Cope), Peirce (1890b) joked that although he "sometimes abandons the English language for the jargon of biology," Cope is "always distinguished by a clear style."[22]

Unlike Carus, Binet, and Montgomery, Cope developed his theory of "metaphysical evolution" independently of Haeckel's hylozoism. The main tenets of Cope's theory were presented in three essays, all of which were collected in *The Origin of the Fittest*: "Consciousness in Evolution," published in 1875; "On

21. On August 3, 1890, Carus sent Peirce a copy of "Feeling and Motion" (1890a) and also referred him to "the Montgomery controversy of recent date" (Peirce Papers, L77). This controversy included Carus's description of his view as "hylozoism" in Carus (1890b, 2466). Haeckel (1892, 486) later published an English overview of his monism in which he declared, "I regard *all* matter as *ensouled*, that is to say as endowed with *feeling* (pleasure and pain) and with *motion*." Although Peirce probably read this article, it appeared too late to have been the source of his claim that "protoplasm feels"; and in November 1893, Peirce (1893, 394) was still counting the "Haeckelites" among those "who inscribe Materialistic Monism upon their banners."

22. Max Fisch used internal evidence to attribute this *Nation* review to Peirce (see Peirce 1982–, 8:544). Many of Cope's neologisms were included in the *Century Dictionary*, and the entries for 'archesthetism' and 'metesthetism'—on which more below—were written by Peirce himself (Whitney 1889–91, 1:295, s.v. "archesthetism"; 1:474, s.v. "bathmism"; 1:854, s.v. "catagenesis"; 1:947, s.v. "chemism"; 2:2011, s.v. "esthetophore"; 3:3289, s.v. "kinetogenesis"; 4:3739, s.v. "metesthetism"). Those definitions that Peirce did not write were probably the work of Elliott Coues, the designated editorial contributor for general zoology and biology (Whitney 1889–91, 1:iii).

Archaesthetism," published in 1882; and "Catagenesis; or, Creation by Retrograde Metamorphosis of Energy," published in 1884. Cope (1875, 565; 1887b, 394–95) declared in the first of these essays, based on a February 1874 lecture, that rhizopods possessed—or had possessed at some point in their evolutionary history—conscious sensation:

> The lowest form of consciousness is common sensibility; and judging by the resemblance between our own experience and that of the higher animals, the lowest of animals also are not devoid of this quality. The structureless jelly of Rhizopods, such as Amoebas, Gromias, etc., evidently selects its food with regard to its nutritious qualities, in most instances preferring diatoms and desmids to sand and other innutritious substances. Its acquisitions in knowledge of articles of food can only be accounted for on the hypothesis of original, pleasurable or painful, consciousness of the effects of external and internal contact with these substances, and retention of the impression in unconsciousness. The impression reviving on the recurring of a similar contact, the substance is accepted or rejected as the former sensations were pleasurable or painful. And this is not incredible, if, as the researches indicate, the structure of the protoplasm of these creatures is of the same type as that of the bioplastic bodies of the gray tissue of the brain.

Who inspired Cope's interest in the minds of microorganisms, if not Haeckel? He may have been drawing on conversations with his former mentor Joseph Leidy, another Philadelphia paleontologist, who had recently been presenting work on freshwater rhizopods to Cope and others at the Academy of Natural Sciences. Whatever its exact provenance, Cope's claim that rhizopods experience pleasure and pain was presented just before Haeckel's and was thus an independent hypothesis based on the same empirical research.[23]

One of the boldest theoretical moves in Cope's 1875 essay was the claim that consciousness is not a result but a cause of evolution: evolution tends to-

23. Cope's *Origin of the Fittest* (1887b) appeared late in December 1886 and was reviewed by the British zoologist Alfred Russel Wallace in the *Nation* on February 10, 1887 (Wallace 1887). For Leidy's studies of rhizopods, see *Proceedings of the Academy of Natural Sciences of Philadelphia* (1874, 13–15, 77–79, 86–88, 155–57, 166–68, 225–27) and Leidy (1879). Cope regularly attended and presented at the Academy of Natural Sciences meetings, and he later cited Leidy's 1879 volume (Cope 1887a, 359). For more on the Leidy-Cope relationship, see Rainger (1992) and Davidson (1997, 20–22).

ward unconsciousness and automatism and not toward consciousness.[24] Thus, Cope was convinced that a rhizopod's ability to select its preferred food was originally the result of conscious experience, even though such behavior might now be unconscious. This evolution from consciousness to automatism was made possible by "the property of protoplasm to organize machinery which shall work automatically in the absence of consciousness" and was related to what Cope called "the doctrine of the unspecialized" (1875, 566, 569; 1887b, 395–96, 398). According to this doctrine, generalized types—adaptable and without "mechanical peculiarities in their structure"—are ancestral to more specialized types (1875, 400; 1887b, 571). Cope (1875, 572; 1887b, 401) applied this doctrine of the unspecialized to mental evolution as well: "The greater the proportion of unconscious automatism of habits, the less the power of adaptation. . . . The greater the degree of consciousness of stimulus, the greater will be the degree of adaptability to new relations, and to such constant rousing the unspecialized mind is always open." He argued that it was reasonable to apply the terms 'unspecialized' and 'undecided' "to the molecular condition of protoplasm" and speculated that "unknown forms of matter" might present "the essentially unspecialized condition of protoplasm, without some of its physical features" (1875, 574; 1887b, 403). Thus, consciousness may even have preceded protoplasm.[25]

A few years later, Cope (1882, 467; 1887b, 419) began using the term 'archaesthetism' (from the Greek *archē*, beginning, and *aisthēsis*, sensation) to refer to this "hypothesis of the primitive and creative function of consciousness." He argued for archaesthetism as follows: adaptive response, and thus progressive evolution, requires a "generalized *dynamic* condition" of matter; "wherever this generalized condition exists, consciousness will be present"; thus, consciousness existed at the beginning of evolution and has been its main driver (1882, 467; 1887b, 419). Cope (1882, 460–61; 1887b, 412) supported his second premise by claiming that living beings differ from the nonliving in that "their actions have some definite reference to their well being or pleasure, or their preservation from

24. Heidelberger (2004, 268–71) has noted that the German physicist-psychologist Gustav Fechner held a similar view and has argued that Fechner influenced Peirce's evolutionary metaphysics on this point and others. However, although Peirce cited and engaged with Fechner's *Elements of Psychophysics*, there is no evidence that he was familiar with those works of Fechner (the *Zend-Avesta* [1851, 1:459–60] and the *Einige Ideen* [1873, 12–25]) that seem to anticipate Peirce's metaphysics. For two examples of Peirce's engagement with Fechner's psychology, see Peirce (1877) and Peirce and Jastrow (1884). Peirce (1892c, 2) does mention (in passing) Fechner's 1855 defense of atomism, but any parallels between the 1870s ideas of Fechner and the 1890s ideas of Peirce are probably due to the fact that Fechner (1873, 14, 74; 1879, 7, 248–52) was by then responding directly to Haeckel's research.

25. For more on Cope's evolutionary views, see Bowler (1977; 1983, chap. 6); Laurent (1979); Moore (1979, 146–52); Davidson (1997, chap. 8); Ulett (2014a, chap. 3; 2014b).

injury or pain, and are varied with circumstances as they arise." He also invoked more familiar neo-Lamarckian points about directed variation and use/disuse: "If the law of modification of structure by use and effort be true, it is evident that consciousness or sensibility must play an important part in evolution" (1882, 460; 1887b, 412). As Cope (1884, 241; 1887b, 425) summarized, the hypothesis of archaesthetism "maintains that consciousness as well as life preceded organism, and has been the *primum mobile* in the creation of organic structure."

Never afraid of neologisms, Cope (1884) then introduced the term 'catagenesis' (from the Greek *kata-*, downwards, and *genesis*, origin) to refer to "the process of creation by the retrograde metamorphosis of energy." Cope believed that all forms of energy had "originated in the process of running-down or specialization from the primitive energy," which he linked to evolution from consciousness to automatism (243; 1887b, 433). He had already made a similar point in 1875: "Consciousness constitutes then the only apparently initial point of motion with which we are acquainted. If so, we are at liberty to search for the origin of the physical forces in consciousness, as well as the vital; their present unconscious condition being possibly due, as in the case of the vital, to automatism" (1875, 574–75; 1887b, 403–4). According to Cope (1884, 243; 1887b, 435), organisms evolve from generalized to specialized types, and the same may be true for energy: "If the inorganic forces are the products of a primitive condition of energy which had the essential characteristics of vital energy, it has been by a process of specialization." Thus, chemical and physical forces, for Cope, could be results of the specialization of vital forces—of an evolution away from adaptability and toward complete automatism.[26]

Cope repeated all of these claims in his contribution to a symposium on science and immortality in the *Christian Register*. He presented "three sources of evidence" supporting the claim "that mind does or can, within certain limits, dominate matter, or direct its movements" (1887d, 212; 1887e, 34–35). First, echoing his comments about rhizopod behavior (quoted above), he argued that animals, as well as the primitive forms of plants, exhibited movements that must have "been previously learned by a process of education, and this process requires consciousness"—he gave as an example "the selection of food by the lowest animals" (1887d, 212; 1887e, 36–37). Second, he argued in standard neo-Lamarckian fashion that consciousness biases variation toward useful characters and thus influences "the direction of organic evolution" (1887d, 212; 1887e,

26. For the rest of the article, I will cite only *The Origin of the Fittest* (Cope 1887b) when quoting articles collected there.

37). Third, he repeated his suggestion that "automatic energies may be cast off, so to speak, from the conscious source" and claimed that the chief characteristic of vital energy "is that it bears the stamp of consciousness" (1887d, 212; 1887e, 39–40).[27] He also again speculated that although protoplasm was currently "the only substance which is known to us to live and be conscious," the first protoplasm must have been produced by "vital energy," which would at that stage have been "a property of some physical basis not protoplasm." Cope (1887d, 212–13; 1887e, 39–41) saw this as "evidence of primitive consciousness before the days of protoplasm." In the reprinted version, he added that "a physical basis of consciousness other than protoplasm is the essential of a belief in a Supreme Mind, and in the persistence of human consciousness" (1887e, 41). In other words, archaesthetism provides indirect support to both theism and the immortality of the soul.[28]

As mentioned above, Peirce (1887a, 73; 1887b, 214) also contributed to this symposium, criticizing Spencer's mechanistic account of evolution. The editor Samuel Barrows (1887a, 110–11; 1887c, 209) linked Peirce and Cope in his opening comments: "Dr. Cope and Prof. Peirce do not hesitate to grapple athletically with the logical problems involved in the relations of mind to matter. They both take strong and well-fortified ground against the mechanical or automatic philosophy." Thus, contemporaries saw parallels between the evolutionary worldviews of Peirce and Cope.

Protoplasm: "Man's Glassy Essence"

Peirce first wrote about protoplasm roughly 5 months after the *Christian Register* discussion and about a year after the publication of *The Origin of the Fittest*. Although the timing is suggestive, and despite the shared critique of mechanism identified by Barrows, this initial foray into protoplasm research was not obviously influenced by Cope's theories. In an unpublished chapter, Peirce (1982–, 6:193) argued that protoplasm provided a link between physiology and psychology: "The three fundamental functions of the nervous system, namely, 1st, the excitation of cells, 2nd, the transfer of excitation over fibres, 3rd, the fixing of definite tendencies under the influence of habit, are plainly due to three properties of the protoplasm or life-slime itself. Protoplasm has its active and its passive condition, its active state is transferred from one part of it to another, and it also

27. In the reprinted version (Cope 1887e), "the conscious source" is replaced by "a vital source."

28. Cope made related points in a pamphlet that appeared the same year and that led to a debate in *Open Court* with Edmund Montgomery (Cope 1887a, 1887f; Montgomery 1887b).

exhibits the phenomena of habit."[29] The only source cited by Peirce was Michael Foster's *Text Book of Physiology*, from which he took his list of protoplasm's properties: "contractility, irritability, automatism, nutrition, metabolism, respiration, and reproduction." According to Peirce, these could "all be summed up under the heads of sensibility, motion, and growth" (6:193–95; cf. Foster 1879, 1–3).[30] As in later work (discussed below), Peirce went on to speculate about the physical basis of these properties of protoplasm, giving special attention to growth and habit.

A few years later, however, Cope's influence became more pronounced. As we have seen, Peirce had been developing his account of the laws of nature as products of evolution since at least 1884. But around 1890, he began to combine this view with one that looked a lot like Cope's archaesthetism. It is no coincidence that Peirce actually wrote the entry for 'archesthetism' in the first volume—published in 1889—of the *Century Dictionary*, using Cope's own words: "The hypothesis of the primitive creative function of consciousness; the hypothesis that consciousness, considered as an attribute of matter, is primitive and a cause of evolution" (Whitney 1889–91, 1:295–96).[31] Although Peirce rejected the monism of Cope and others, which he saw as a kind of materialism, in 1890 he began defending archaesthetism without naming it as such: "The only possible way of explaining the connection of body and soul is to make matter effete mind, or mind which has become thoroughly under the dominion of habit, till consciousness and spontaneity are almost extinct" (1982–, 8:22). Like Cope, Peirce linked this original mind to life and feeling: "The free is living; the immediately living is *feeling*. Feeling, then, is assumed as a starting-point; but feeling uncoordinated" (6:393). Peirce also connected feeling and protoplasm, although he was critical of an unnamed philosopher—perhaps Cope or Carus—who declared that "~~consciousness~~ feeling is an ultimate property of protoplasm" without explaining why (8:87).[32] Although Peirce called his view idealism, a position that Cope explicitly rejected, his description of it recalled Cope's catagenesis: "Idealism regards the psychical mode of activity as the fundamental and universal one, of which the

29. The chapter in question, Peirce's "The Triad in Physiology" from *A Guess at the Riddle* (Peirce Papers, MS 909), was written between November 1887 and March 1888 (Peirce 1982–, 6:596–97).

30. Note that Foster, as he explained in a footnote, used 'automatic' to denote "an action of a body, the causes of which appear to lie in the body itself." Foster and Peirce (unlike Cope) were thus using 'automatism' as a synonym of 'spontaneity'. For more on Foster and protoplasm, see Reynolds (2008, 321–24).

31. 'Archaesthetism', Cope's preferred spelling, refers the *Century Dictionary* reader to 'archesthetism'. Although some of Peirce's other entries cited *The Origin of the Fittest*, here he cited the original publication, i.e., Cope (1882, 467, 469).

32. The unpublished manuscripts quoted in this paragraph (collected in Peirce 1982–) are all dated to 1890. I have restored the word 'consciousness', struck out by Peirce, which was removed in the published version of MS 956 (1982–, 8:568).

physical mode is a specialization" (Peirce 1890b, 326).[33] Peirce's evolutionary cosmology, as summarized in the closing passage (quoted above) of "The Architecture of Theories," was fundamentally archaesthetic, beginning with mind and ending with law: "A chaos of unpersonalised feeling" gradually acquires habits, finally evolving "all the regularities of the universe" (Peirce 1891a, 176).[34]

In the second essay of his *Monist* series, "The Doctrine of Necessity Examined," Peirce (1892a, 333) again criticized the mechanistic, necessitarian outlook of Spencer and others, claiming that chance—"pure spontaneity and life"—must be admitted "as a character of the universe." According to Peirce, this "chance-spontaneity" is the "agency by which the complexity and diversity of things can be increased" (333, 335). He argued that the findings of astronomy, biology, geology, paleontology, and history all demonstrated that "the main fact is growth and increasing complexity"; thus, we should not locate such complexity at the beginning of cosmic evolutionary history but consider it a result of evolution (333).[35]

The physiologist-philosopher Edmund Montgomery, who had debated Cope in *Open Court* 5 years earlier, wrote to Peirce on May 9, 1892, praising "The Doctrine of Necessity Examined" soon after it appeared (Peirce Papers, L297; 1982–, 8:402).[36] Peirce already knew something of Montgomery's work: Montgomery had published a series of articles on protoplasm in *Popular Science Monthly*, which appeared shortly after Peirce's own series (Montgomery 1878); Peirce's entry for 'hylozoistic' in the *Century Dictionary* had cited an essay by Montgomery in *Open Court* (Whitney 1889–91, 3:2943, s.v. "hylozoistic"; citing Montgomery 1887c, 65); and on August 3, 1890, Carus had directed Peirce to his recent debate with Montgomery, also in *Open Court* (Peirce Papers, L77).[37] In his letter, Montgomery told Peirce that he had found evidence against the doctrine of necessity in his own scientific research: "Protoplasmic studies have long ago convinced me that specific modes of reaction on the part of bodies are of far greater

33. Peirce (1890e, 493) criticized monists who "make mind a specialization of matter." For Cope's rejection of idealism, see Cope (1887c, 528–29; 1887f, 6–9; 1888).

34. Peirce and Cope thus both endorsed a form of panpsychism. Although Seager and Allen-Hermanson (2010) do not mention Peirce or Cope, they point out that Haeckel was credited with the "evolutionary continuity argument for panpsychism."

35. For a perceptive analysis of this essay, see Kronz and McLaughlin (2002).

36. For the Cope-Montgomery debate, see Cope (1887a, 1887c, 1888); Montgomery (1887a, 1887b); *Open Court* (1888).

37. For the Montgomery-Carus debate, see Carus (1890b); Montgomery (1890); *Open Court* (1890). For more on Montgomery, see Keeton (1950). Earlier scholars have briefly noted the similarity between the views of Peirce and Montgomery but seem to have been unaware of the actual historical connections between them (Schneider 1946, 365; Keeton 1952, 312).

consequence in nature than extrinsic mechanical causation" (Peirce Papers, L297; 1982–, 8:402).[38]

What exactly was Montgomery claiming? He had walked a fine line in several 1880s essays, criticizing the mechanical outlook but also trying to reduce life to its underlying chemistry. In an essay published in the *Index*—a weekly paper devoted to free religion, founded by Peirce's old classmate Francis Ellingwood Abbot—Montgomery (1885, 222) had argued, as in the letter to Peirce, that intrinsic forces were responsible for the phenomena of life: "Vital energy is . . . in no instance the mere transfer of some other energy furnished from external sources; but, on the contrary, the display of most peculiar, spontaneous powers, inwrought and persistently maintaining themselves in the living structures. Or, more correctly, vital energy is the display of the very powers which constitute the living structures."[39] Nevertheless, he insisted that vital activity was a product of underlying chemical activity: "The structures displaying vital phenomena are, through and through, the visible expression of an ever-flowing cycle of such specific chemical activities, constituting most highly elaborated chemical compounds" (224). Montgomery also explicitly disagreed with Haeckel, Cope, and anyone else who attributed conscious sensation to protoplasm: "The closest observation [of monera and amoeba], continued for years, has yielded me no indication that obstacles are feelingly avoided or contact with anything, however desirable, voluntarily solicited. It all seems the blind play of complex chemical activity" (318). Elsewhere, he accused philosophers like Haeckel of "smuggling a modicum of sensation into their primitive elements of reality" and declared that Cope had provided "no evidence whatever that protoplasmic individuals are at all conscious" (1886, 439; 1887b, 301).

Peirce received Montgomery's letter just as he was writing the third essay in his *Monist* series, "The Law of Mind," published in July 1892. In this essay, Peirce (1892b, 534) defended the following thesis: "There is but one law of

38. Peirce later bragged about Montgomery's support in Peirce (1892c, 1n). Montgomery's protoplasm research was inspired by Haeckel's study of microorganisms, as evidenced by a January 22, 1878, letter written to the German naturalist: "It would have been strange if I had been able to occupy myself so continuously with your darlings [i.e., moners] without daily thinking also of you." On August 3, 1878, Montgomery told Haeckel that he was eagerly awaiting the German naturalist's "Zellseelen und Seelenzellen" (1878b), which was about to be published (Edmund Montgomery and Elisabeth Ney Papers, DeGolyer Library, Southern Methodist University, box 2, folder 64). These particular letters are apparently transcripts of originals held in the Ernst-Haeckel-Haus at Friedrich-Schiller-Universität Jena (Hossfeld and Breidbach 2005, 447).

39. The *Index* was a direct ancestor of *Open Court* (Henderson 1993, 25–32). Montgomery sent some of his articles to Peirce along with his letter, but we do not know which ones; for some guesses, see Peirce (1982–, 8:402). Note that the author of "The Dual Aspect of Our Nature" is given incorrectly in the *Index* as Edward Montgomery, but it was certainly written by Edmund Montgomery and is cited as such in Montgomery (1887b, 163n).

mind, namely, that ideas tend to spread continuously and to affect certain others which stand to them in a peculiar relation of affectability. In this spreading they lose intensity, and especially the power of affecting others, but gain generality and become welded with other ideas." As we will see, Peirce connected this generalizing tendency to habit, as well as to cosmic and biological evolution. But he also linked it to the idea of continuity, arguing that feelings are spatially continuous within and even across minds. He supported this point with a short discussion of protoplasm, siding with Cope against Montgomery: "Consider a gob of protoplasm, say an amoeba or a slime-mould. . . . There is no doubt that this slime-mould, or this amoeba, or at any rate some similar mass of protoplasm feels. That is to say, it feels when it is in its excited condition" (547–48).[40] Peirce observed that feeling seemed to pass continuously from one part of the "amorphous continuum of protoplasm" to another, with the spread of excitation proving that "feeling has . . . spatial extension, as the excited state has" (548). Montgomery (1887a, 512) had written that the primary difference between his view of protoplasm and Cope's was as follows: "Cope maintains that it is consciousness . . . imparting the specific character to the motions. I, on the contrary, maintain that the motion is spontaneous and intrinsic, meaning thereby that it is effected and receives its hyper-mechanical character through specific non-mental forces inherent in the living substance itself." Peirce was in Cope's camp, although he also said that protoplasm has "*feeling*, but plainly no *personality*" (1892b, 548)—here breaking with Cope (1887b, 404; 1887e, 41), who seems to have attributed a kind of personality even to his preprotoplasmic "Supreme Mind."

The fourth essay of Peirce's series, published the following October, was titled "Man's Glassy Essence"—a reference to a speech by Isabella in Shakespeare's *Measure for Measure* but also an allusion to protoplasm, the main topic of the essay.[41] As in 1887–88, but in much greater detail, Peirce (1892c, 1) tried to illumine "the relation between the psychical and physical aspects of a substance" by offering "a molecular theory of protoplasm." His theory was ultimately a kind of hybrid of the views of Cope and Montgomery. He agreed with Cope that the

40. Peirce was here echoing Cope's (1887b, 398) claim that protoplasm is only conscious "while in a state of active transformation." Peirce had defined 'feeling' in the *Century Dictionary* as "the immediate quality of what is present to consciousness in sensation, desire, or emotion, considered apart from all activity of thought" (Whitney 1889–91, 2:2171).

41. "But man, proud man, / Drest in a little brief authority, / Most ignorant of what he's most assured,— / His glassy essence,—like an angry ape, / Plays such fantastic tricks before high Heaven, / As make the angels weep" (Shakespeare 1857–66, 3:41 [2.2.146–51]). Peirce (1982–, 5:490) owned a copy of this edition of Shakespeare's works. For a modern edition, see http://www.folgerdigitaltexts.org/?chapter=5 &play=MM ∓loc=line-2.2.146. For more on Peirce's title, see Peirce (1982–, 8:400–401).

dynamism of protoplasm was due to its "extreme instability," what Cope called its "unspecialized" and "undecided" condition; but he also agreed with Montgomery that "the molecular constitution of protoplasm" was in another way "rigorously determined or 'decided,'" since that constitution dictated one's species and to some extent even one's personal traits (Cope 1887b, 403; Montgomery 1887b, 300; Peirce 1892c, 9–10). As Peirce (1892c, 10) wrote, "The anticipation of the chemist would decidedly be that enough different chemical substances having protoplasmic characters might be formed to account, not only for the differences between nerve-slime and muscle-slime, between whale-slime and lion-slime, but also for those minuter pervasive variations which characterise different breeds and single individuals." Thus, protoplasmic differences could potentially explain variation both within and across species.

Peirce focused on the same properties of protoplasm as in 1887–88: growth, habit, and sensibility. Many of these properties stemmed from protoplasm's ability to shift quickly from a solid to a liquid state. He argued that it was the extreme complexity and instability of protoplasm that allowed this shift: any disturbance causing certain submolecules to leave their orbits and wander would set off a chain reaction, allowing many more to "wander about freely," thus producing "the usual condition of a liquid, as modern chemists understand it" (1892c, 13). In its liquid state, protoplasm could grow by absorbing food particles via diffusion. If these particles were of the right chemical species, they would be united with wandering submolecules to produce new molecules of protoplasm, "like the jack-knife whose blade and handle, after having been severally lost and replaced, were found and put together to make a new knife" (14). This process also related to habit, in that successive liquefactions of protoplasm involved the throwing out of "pretty nearly the same particles that were last drawn in." Since Peirce thought the particles would "be thrown out, too, in about the same way . . . in which they were drawn in," but not in precisely the same way, this matched the distinctive characteristic of habit: "not acting with exactitude" (15).[42]

Peirce's account of habit in protoplasm also had close affinities with the views of Cope and Montgomery. For both of these thinkers, despite their differences, it was habit—quasi-automatic but inexact repetition—that made evolution possible. Cope (1887b, 399–400) had argued that protoplasm could exhibit either consciousness or automatism, with habit being a mixture of the two; he also, as we have seen, highlighted the plasticity and "adaptability of generalized types, as to habits." Montgomery's view was an even clearer anticipation of Peirce's,

42. For simplicity, I am setting to one side the first several pages of Peirce's article, which discuss "modern molecular physics" from the standpoint of the kinetic theory developed by Rudolf Clausius and James Clerk Maxwell (Reynolds 2002, 78–80).

since it emphasized the dynamic chemical activity of protoplasm. "Life," wrote Montgomery (1885, 318), "only begins when a chemical unit comes to reintegrate itself habitually, after having undergone chemical disruption through outside influences." Evolution, in turn, is the result of slight deviations in this cycle of disruption and reintegration: "Instead of restoring with absolute precision its former integrity, the protoplasm incorporates a molecule slightly differing from the one it lost. . . . By this process of superimposed increments of molecular elaboration, the functional disintegration of the active protoplasm gains the significance of functional evolution, the functioning material assuming truly the part of an evolutional substance" (Montgomery 1880, 474). Thus, although Peirce had written about habit long before encountering the work of Cope and Montgomery, he was likely inspired by their discussions of habit in relation to protoplasm.[43]

In 1887–88, following the lead of Foster (1879, 2)—who was careful to use 'irritable' rather than 'sensible' when talking about protoplasm—Peirce (1982–, 6:195) had mentioned but neglected to discuss protoplasm's "sensibility," perhaps simply using the term as a proxy for contractility and irritability. But now, in 1892, he insisted that we know by "analogical inference" that protoplasm "not only feels but exercises all the functions of mind" (1892c, 12). Peirce had encountered this idea in Cope and Carus, and he may also have been familiar with the work of the French psychologist Alfred Binet (1888a, 1386; 1889, 114), who had stated—in essays translated in *Open Court*—that "the psychology [of the Moners] is extremely complicated, and is not contained exclusively in the laws of irritability" (translated from Binet 1888c, 222).[44] Peirce was happy to attribute feeling and consciousness to protoplasm, but he was also searching for the chemical basis of its vital activities: "If consciousness belongs to all protoplasm, by what mechanical constitution is this to be accounted for? . . . This question cannot be evaded or pooh-poohed. Protoplasm certainly does feel; and unless we are to accept a weak dualism, the property must be shown to arise from some peculiarity of the mechanical system" (1892c, 17). Peirce's answer drew on his idealism, which as we have seen was related to Cope's archaesthet-

43. For some of Peirce's earlier work on habit, see the two versions of "Thinking as Cerebration" (1982–, 4:38–46). Keeton (1952) discusses the shared antimechanism of Peirce and Montgomery but strangely does not mention their common interest in protoplasm.

44. Unlike Cope, Binet (1888b, 1235; 1889, 114) remained agnostic about whether such organisms were conscious (translated from Binet 1887, 582). Like Binet, Haeckel's student Max Verworn (1889, 155–56) attributed only "unconscious sensations" and "unconscious ideas" to microorganisms. Both Binet and Verworn were inspired by Haeckel, reviewed by Romanes in *Nature*, and published in the *Monist* (Romanes 1889; Binet 1890a; Verworn 1894; Schloegel and Schmidgen 2002, 625–33). Nevertheless, it is unlikely that Peirce had read Verworn's work by 1892, since it had not yet been widely discussed or translated into English.

ism. Protoplasm's sensibility, said Peirce, can only be explained if we "admit that physical events are but degraded or undeveloped forms of psychical events"—if we "grant that the phenomena of matter are but the result of the sensibly complete sway of habits upon mind" (18).

How was this archaesthetic idealism supposed to explain the psychic life of protoplasm? Peirce invoked the notion of accommodation to a changed environment to connect physiology and psychology, and thus habit and consciousness. He cited a passage from James Mark Baldwin's *Handbook of Psychology*: "**Law of Accommodation**. Physiologically and anatomically, accommodation means the breaking up of a habit, the widening of the organic for the reception or accommodation of a new condition. Psychologically, it means reviving consciousness, concentration of attention, voluntary control—the mental state which has its most general expression in what we know as *Interest*" (Baldwin 1891, 49; partially quoted in Peirce 1892c, 18n). Baldwin's law related accommodation, plasticity, and habit, which could be understood physiologically, to consciousness, interest, and attention, important notions in psychology.[45] Peirce (1892c, 18) argued that in protoplasm, because of its "excessively unstable condition," any unexpectedly continued stimulus would "produce startlingly large effects": namely, greater and greater "departures from regularity" and the "breaking up of habit." Since Baldwin had presented "the breaking up of a habit" as the physiological analogue of "reviving consciousness," Peirce could argue that protoplasm's ability to develop habits, but also to lose them in a "renewed fortuitous spontaneity," explained its ability to experience different intensities of feeling (18). Habit, for Peirce as for Cope, occupied the fertile middle ground between spontaneity and automatism: "Wherever chance-spontaneity is found, there, in the same proportion, feeling exists" (19).

Peirce then connected the discussion back to the previous essays in his *Monist* series. He again argued that chance and regularity were both real elements of the universe: "Diversification is the vestige of chance-spontaneity; and wherever diversity is increasing, there chance must be operative. On the other hand, wherever uniformity is increasing, habit must be operative" (1892c, 19; cf. Peirce 1892a, 333–34). He also claimed that habit—the link between "the psychical and the physical aspects" of matter—was behind the "generalising tendency" he had identified in both cosmology and psychology: "Mechanical laws are nothing but acquired habits, like all the regularities of mind, including the tendency to take habits, itself; and . . . this action of habit is nothing but gen-

45. The phenomena of consciousness, interest, and attention were central to William James's evolutionary psychology and to his critique of Herbert Spencer (Pearce, forthcoming). Peirce (1891b) had recently reviewed James's *Principles of Psychology*. On Peirce's reading of James's *Principles*, see Girel (2003) and Klein (2008).

eralisation, and generalisation is nothing but the spreading of feelings" (Peirce 1892c, 20; cf. 1891a, 176; 1892b, 549–52). Peirce argued that general ideas had a physiological basis: habitual repetition involves actions that are "analogous from a physical point of view," and there is also "an inward sense of their being analogous." The latter involves the "consciousness of a habit," a sense of similarity: "Every time one of the associated feelings recurs, there is a more or less vague sense that there are others, that it has a general character, and of about what this general character is. . . . We can hardly refuse to admit that wherever chance motions have general characters, there is a tendency for this generality to spread and to perfect itself. In that case, a general idea is a certain modification of consciousness which accompanies any regularity or general relation between chance actions" (1892c, 20). Thus, Peirce found a tendency to generalization—involving a kind of habitual feeling based on habitual actions—in physiology, psychology, and cosmology.

Peirce (1892b, 548) had declared in "The Law of Mind"—contrary to Cope's view—that protoplasm has "*feeling*, but plainly no *personality*." But in describing the physiological basis of general ideas in "Man's Glassy Essence," Peirce (1892c, 21) seemed to reopen the door to protoplasmic personality: "Every general idea has the unified living feeling of a person." This tension, however, is only apparent: just because "a person is only a particular kind of general idea," that does not mean that every general idea involves full-fledged personality (20). As he put it in the earlier essay, personality is "some kind of coordination or connection of ideas"; but more than that, "it implies a teleological harmony in ideas," producing what we call "personal character" (1892b, 556). Someone's character, according to Peirce, is "a developmental teleology"—a general idea that, while "living and conscious now," is also "determinative of acts in the future to an extent to which it is not now conscious" (556). Although character is in some sense determinative of future acts, development and growth ensure that a person does not simply act mechanically, according to "predetermined purposes" (556–57).

Peirce provided two lines of evidence in support of his notion of personality as a mere "coordination of ideas" rather than, as in the traditional view, something corresponding to each individual human soul. First, in "The Law of Mind," he cited "recent observations of double and multiple personality" (1892b, 556)—familiar from Binet's *Double Consciousness* (1890b), a series of essays originally published in *Open Court*, and from James's *Principles of Psychology* (1890, 1: 379–93, 2:613–15), which Peirce (1891b) had reviewed for the *Nation*. Second, at the end of "Man's Glassy Essence," Peirce (1892c, 21–22) argued that "there should be something like personal consciousness in bodies of men who are in intimate and intensely sympathetic communion," and he predicted that this

kind of "corporate personality" would be found in groups of like-minded Christians. Thus, even though Peirce denied personality to protoplasm, he agreed with Cope that an emphasis on feeling and spontaneity, in contrast to Spencer's "pseudo-evolutionism," would lead to "a genuine evolutionary philosophy"—one that is "so far from being antagonistic to the idea of a personal creator, that it is really inseparable from that idea" (1892b, 557). Peirce's evolutionary philosophy, like Cope's, thus purported to give indirect support to Christianity.[46]

For at least one reader of *Open Court* and the *Monist*, the similarities between the archaesthetism of Cope and the objective idealism of Peirce were evident. Montgomery, in a letter of October 5, 1892, told Peirce that "from a materialistic standpoint, Prof. Cope has expounded a somewhat similar theory. Taking the hypothesis-indulgent Ether to be the bearer of universal and supreme 'mind or consciousness,' he looks upon the arising and fixation of material compounds as a process accompanied by loss of 'mind or consciousness.' This lapsing into unconsciousness by means of organic fixation is manifest in living forms as instinct or unconscious habit." Referencing his 1887 debate in *Open Court* with Cope, Montgomery described himself as "too forcibly impressed with the laboriousness and ruthlessness of the process that leads to gradual and precarious mental development in our world" to think that the pinnacle of "mental or spiritual life" lay at the origin of evolution, followed by "a cruel and wanton fall from grace" (Peirce Papers, L297). Peirce's apparently prickly reply does not survive, but Montgomery assured him on October 21 that his "remarks were merely meant as sympathetic feelers tentatively stretched forth as a sign of the interest I am taking in your work" (Peirce Papers, L297). For Montgomery (as for Samuel Barrows, quoted above), there were obvious parallels between the views of Peirce and Cope—parallels stemming, I have suggested, from Peirce's familiarity with Cope's work and related discussions in *Open Court*.[47]

Conclusion

A closer look at the context of Peirce's *Monist* series, published in the early 1890s, reveals that it was part of a broader conversation about mind, matter, and evo-

46. Peirce was even more explicit about the support his evolutionary metaphysics gave to Christianity in "The Law of Mind [Early Try]" (1982–, 8:126). He was reassessing his relationship to religion just as he was writing the *Monist* series: see Peirce to John Wesley Brown, April 24, 1892, in Peirce (1982–, 8:lxxvi–lxxvii). For more on the relation between Peirce's metaphysical and religious ideas, see Anderson (1987).

47. Peirce's friend Josiah Royce confirmed the connection a few years later: "That nature's observable Laws might even be interpreted, from an evolutionary point of view, as nature's gradually acquired Habits, originating in a primal condition of a relatively capricious irregularity, is a conception to which several recent writers, notably Mr. Cope, and, with great philosophical ingenuity, Mr. Charles Peirce, have given considerable elaboration" (1895, 592).

lution. Although the ideas of Haeckel and Huxley probably had an indirect influence, it was the views of thinkers like Carus, Cope, and Montgomery—all frequent contributors to *Open Court* and the *Monist*—that provided the immediate context for Peirce's discussion of protoplasm. Like Cope, Peirce located mind and spontaneity at the beginning of evolution and saw physical laws and forces as the result of a tendency toward automatism; like Montgomery, Peirce attempted to understand the dynamic chemical activity underlying the behavior of protoplasm. For all of these thinkers, habit occupied the 'sweet spot' between spontaneity and law (see the diagram in Kronz and McLaughlin [2002, 204]). Thus, although Peirce's evolutionary metaphysics—featuring his account of protoplasm—may seem strange to us, it fitted smoothly into an existing set of 1880s debates. (A similar story can be told about other aspects of his metaphysics: although I have focused on protoplasm in this essay, it is notable that Cope was the leading light of American neo-Lamarckism, which helps explain Peirce's endorsement of that approach to evolution in "Evolutionary Love," the final article in his *Monist* series.)[48]

As mentioned in the introduction, Open Court also created an intellectual conduit between Germany and the United States. Protoplasm—which according to Peirce, Haeckel, Carus, and Cope was the missing link between mind and matter—was directly relevant to the controversy over whether there were some things science would never know: the *Ignorabimusstreit*. In a famous lecture of 1872, the German physiologist Emil du Bois-Reymond (1872, 18) had declared that consciousness, from "the loftiest activity of the soul" to "the first impulse of pleasure or pain, felt by the simplest being at the beginning of animal life on earth," would always remain incomprehensible and inexplicable "from material conditions." He insisted that when it came to sensation and consciousness, naturalists had to say 'ignorabimus' (we will never know) rather than the usual 'ignoramus' (we do not know). Haeckel was furious, and he told the philosopher Eduard von Hartmann in a letter that du Bois-Reymond had ignored Haeckel's own research on the Monera, which proved that even the most primitive organisms were ensouled (Darnoi 1967, 181–82). It may even have been du Bois-Reymond's lecture that prompted Haeckel's shift to hylozoistic monism, described above. Beiser (2014b, 448–49) has linked this monism to "the vital materialist tradition," arguing that "Haeckel did not develop this line of thinking, which would have brought him closer to Leibniz and the philosophy of identity of Schelling and Hegel." We can perhaps see Peirce as developing what Haeckel did not, since Peirce (1892b, 533) described his own view as "a Schelling-

48. I plan to explore Peirce's neo-Lamarckism in future work. It is also perhaps notable that Haeckel was a Lamarckian of sorts (Gliboff 2011, 46–48).

fashioned idealism which holds matter to be mere specialised and partially deadened mind."[49] Thus, the Open Court conversation demonstrates that American and German philosophers were tackling similar problems and responding to scientific developments in similar ways.

The idea that scientific research into protoplasm might have something to teach us about the nature of consciousness was embraced by many of the thinkers that Schneider's *History of American Philosophy* grouped under the rubric "Speculative Biology." Schneider (1946, 359) himself did not think much of these speculators: Montgomery showed flashes of brilliance, but Cope was "a biologist who overindulged in philosophy." This judgment may seem to have been borne out: when philosophers of biology today look to the sciences for insight into the human mind, they usually talk about nerves and games, not matter and microbes. Nevertheless, microorganisms are still used as important model systems, and some have argued—given the cognitive abilities of microbes, their evolutionary importance, and the fact that they make up 90% of the cells in our own bodies—that we need a philosophy of microbiology (Shapiro 2007; O'Malley 2014; Hutter et al. 2015; O'Malley et al. 2015). Protoplasm may not help us solve the mind-body problem, but perhaps Cope and colleagues were onto something.

Peirce's claim that "protoplasm feels" was not an embarrassing lapse of judgment or the result of a strange obsession, too bizarre to discuss in our broader accounts of Peirce's philosophy. Whether or not he abandoned his evolutionary cosmology later in life (as Short [2010] has argued), protoplasm continued to play a role in his metaphysics.[50] Ladd-Franklin thought that "Man's Glassy Essence" failed to measure up to Peirce's earlier work, but it was simply part of a different conversation—one exemplified in early issues of the *Monist*, where philosophers could rub shoulders with comparative psychologists like George John Romanes, geologists like Joseph LeConte, or physicists like Ernst Mach. The idea of the laws of nature evolving may seem odd to us now, but Mach (1891, 399) himself thought otherwise: "I might incidentally make mention of Mr. Charles S. Peirce's article 'The Architecture of Theories' in the last number of *The Monist*. . . . This author's view of the evolution of natural laws does

49. See also Peirce's 1889 description of Schelling's "objective idealism," including the claim that "matter is extinct mind," in Whitney (1889–91, 3:2974, s.v. "idealism"). Schelling (1800, 191) had famously declared that matter is "erloschene Geist" (this view was summarized in Ueberweg [1872–74, 2:218]). Carus (1888, 903) linked the *Ignorabimus* position to Spencer's unknowable, which (as noted above) was one of Peirce's bugbears.

50. There is a response to Short in Houser (2014). For some of Peirce's later discussions of protoplasm, see MS 951 (1898), in Peirce (1992, 237–41); MS 942 (no date), in Peirce (1976, 4:141); MS 427 (1902) and MS 284 (1905), in Peirce (1931–60, 1:261, 350–52); and Peirce (1906).

not strike me as so singular."[51] Peirce was not common, but he was not singular either: recovering the context of his evolutionary metaphysics teaches us that even someone as academically isolated as Peirce was part of a larger conversation.

REFERENCES

Allman, George James. 1879. "Protoplasm and Life." *Popular Science Monthly* 15:721–49.

Anderson, Douglas R. 1987. *Creativity and the Philosophy of C.S. Peirce*. Dordrecht: Martinus Nijhoff.

Atkin, Albert. 2016. *Peirce*. London: Routledge.

Baldwin, James Mark. 1891. *Handbook of Psychology: Feeling and Will*. New York: Holt.

Barrows, Samuel June. 1887a. "Notes on the Testimony." In Barrows 1887b, 101–18.

———, ed. 1887b. *Science and Immortality: The "Christian Register" Symposium, Revised and Enlarged*. Boston: Ellis.

———. 1887c. "What Does Science Say?" *Christian Register* 66:209–10.

Beiser, Frederick C. 2014a. *After Hegel: German Philosophy, 1840–1900*. Princeton, NJ: Princeton University Press.

———. 2014b. *The Genesis of Neo-Kantianism, 1796–1880*. Oxford: Oxford University Press.

Binet, Alfred. 1887. "La vie psychique des micro-organismes." *Revue philosophique de la France et de l'étranger* 24: 449–489, 582–611.

———. 1888a. "Answer to M. Ch[arles] Richet." *Open Court* 2:1386–87.

———. 1888b. "The Psychic Life of Micro-Organisms." *Open Court* 2:1127–30, 1139–42, 1151–53, 1199–1200, 1211–15, 1223–27, 1235–36.

———. 1888c. "Réponse à M. Ch[arles] Richet." *Revue philosophique de la France et de l'étranger* 25:220–24.

———. 1889. *The Psychic Life of Micro-Organisms*. Trans. Thomas McCormack. Chicago: Open Court.

———. 1890a. "The Immortality of Infusoria." *Monist* 1:21–37.

———. 1890b. *On Double Consciousness: Experimental Psychological Studies*. Chicago: Open Court.

Bowler, Peter J. 1977. "Edward Drinker Cope and the Changing Structure of Evolutionary Theory." *Isis* 68:249–65.

———. 1983. *The Eclipse of Darwinism: Anti-Darwinian Theories in the Decades around 1900*. Baltimore: Johns Hopkins University Press.

Brain, Robert Michael. 2008. "Protoplasmania: The Vibratory Organism and 'Man's Glassy Essence' in the Later 19th Century." In *Zeichen der Kraft: Wissensformationen 1800–1900*, ed. Thomas Brandstetter and Christof Windgätter, 198–227. Berlin: Kadmos.

———. 2015. *The Pulse of Modernism: Physiological Aesthetics in Fin-de-Siècle Europe*. Seattle: University of Washington Press.

51. An anonymous reviewer pointed out that the evolution of laws of nature does not seem as odd to theoretical physicists: see, e.g., Wheeler (1983) or Smolin (2004).

Brent, Joseph. 1998. *Charles Sanders Peirce: A Life*. 2nd ed. Bloomington: Indiana University Press.

Burks, Arthur W. 1996. "Peirce's Evolutionary Pragmatic Idealism." *Synthese* 106:323–72.

Carpenter, William Benjamin. 1862. *Introduction to the Study of the Foraminifera*. London: Hardwicke.

———. 1865. *A Manual of Physiology, Including Physiological Anatomy*. 4th ed. London: Churchill & Sons.

———. 1874. *Principles of Mental Physiology, with Their Applications to the Training and Discipline of the Mind, and the Study of Morbid Conditions*. London: King.

Carus, Paul. 1888. "Ignoramus and Inveniemus, Not Ignorabimus or Invenimus." *Open Court* 2:903.

———. 1889a. *Fundamental Problems: The Method of Philosophy as a Systematic Arrangement of Knowledge*. Chicago: Open Court.

———. 1889b. "Sensation and Memory." *Open Court* 2:1431–33.

———. 1890a. "Feeling and Motion." *Open Court* 4:2424–26, 2435–37.

———. 1890b. "Is Monism Untenable?" *Open Court* 4:2465–69, 2479–83.

Chicago Daily Tribune. 1920. "F. C. Russell, Old Resident, Dies, Aged 82." *Chicago Daily Tribune*, November 24.

Cope, Edward Drinker. 1875. "Consciousness in Evolution." *Penn Monthly* 6:560–75.

———. 1882. "On Archaesthetism." *American Naturalist* 16:454–69.

———. 1884. "Catagenesis; or, Creation by Retrograde Metamorphosis of Energy." *Science* 4:240–43.

———. 1887a. "Montgomery on the Theology of Evolution." *Open Court* 1:285–88, 358–61.

———. 1887b. *The Origin of the Fittest: Essays on Evolution*. New York: Appleton.

———. 1887c. "The Relation of Mind to Matter." *Open Court* 1:527–30.

———. 1887d. "[Science and Immortality]." *Christian Register* 66:212–13.

———. 1887e. "[Science and Immortality]." In Barrows 1887b, 32–42.

———. 1887f. *Theology of Evolution: A Lecture*. Philadelphia: Arnold.

———. 1888. "Evolution and Idealism." *Open Court* 1:655–57.

Coues, Elliott. 1879. Review of *The Evolution of Man*, by Ernst Haeckel. *Nation* 29:429–30.

Darnoi, Dennis N. Kennedy. 1967. *The Unconscious and Eduard von Hartmann: A Historico-Critical Monograph*. The Hague: Martinus Nijhoff.

Davidson, Jane Pierce. 1997. *The Bone Sharp: The Life of Edward Drinker Cope*. Philadelphia: Academy of Natural Sciences.

De Caro, Mario. 2015. "Realism, Common Sense, and Science." *Monist* 98:197–214.

de Waal, Cornelius. 2013. *Peirce: A Guide for the Perplexed*. London: Bloomsbury.

Di Gregorio, Mario A. 2005. *From Here to Eternity: Ernst Haeckel and Scientific Faith*. Göttingen: Vandenhoeck & Ruprecht.

du Bois-Reymond, Emil. 1872. *Über die Grenzen des Naturerkennens: Ein Vortrag in der zweiten öffentlichen Sitzung der 45. Versammlung Deutscher Naturforscher und Ärzte zu Leipzig am 14. August 1872*. Leipzig: Veit.

Edgar, Scott. 2015. "The Physiology of the Sense Organs and Early Neo-Kantian Conceptions of Objectivity: Helmholtz, Lange, Liebmann." In *Objectivity in Science: New Perspectives from Science and Technology Studies*, ed. Falvia Padovani, Alan Richardson, and Jonathan Y. Tsou, 101–22. Cham: Springer.

Esposito, Joseph L. 1980. *Evolutionary Metaphysics: The Development of Peirce's Theory of Categories*. Athens: Ohio University Press.

Fechner, Gustav Theodor. 1851. *Zend-Avesta, oder über die Dinge des Himmels und des Jenseits*. 3 vols. Leipzig: Voß.

———. 1873. *Einige Ideen zur Schöpfungs- und Entwickelungsgeschichte der Organismen*. Leipzig: Breitkopf & Härtel.

———. 1879. *Die Tagesansicht gegenüber der Nachtansicht*. Leipzig: Breitkopf & Härtel.

Fisch, Max H. 1967. "Peirce's Progress from Nominalism to Realism." *Monist* 51:159–78.

Foster, Michael. 1879. *A Text Book of Physiology*. 3rd ed. London: Macmillan.

Geison, Gerald L. 1969. "The Protoplasmic Theory of Life and the Vitalist-Mechanist Debate." *Isis* 60:272–92.

Girel, Mathias. 2003. "The Metaphysics and Logic of Psychology: Peirce's Reading of James's 'Principles.'" *Transactions of the Charles S. Peirce Society* 39:163–203.

Gliboff, Sander. 2008. *H. G. Bronn, Ernst Haeckel, and the Origins of German Darwinism*. Cambridge, MA: MIT Press.

———. 2011. "The Golden Age of Lamarckism, 1866–1926." In *Transformations of Lamarckism: From Subtle Fluids to Molecular Biology*, ed. Snait B. Gissis and Eva Jablonka, 45–55. Cambridge, MA: MIT Press.

Haeckel, Ernst. 1861. *De Rhizopodum Finibus et Ordinibus: Dissertatio quam Rectore Academiae Magnificentissimo Serenissimo Principe ac Domino Carolo Alexandro*. Berlin: Reimer.

———. 1862. *Die Radiolarien (Rhizopoda Radiaria): Eine Monographie*. Berlin: Reimer.

———. 1866. *Generelle Morphologie der Organismen: Allgemeine Grundzüge der organischen Formen-Wissenschaft, mechanisch begründet durch die von Charles Darwin reformirte Descendenz-Theorie*. 2 vols. Berlin: Reimer.

———. 1868. "Monographie der Moneren." *Jenaische Zeitschrift für Medicin und Naturwissenschaft* 4:64–137.

———. 1870. *Natürliche Schöpfungsgeschichte: Gemeinverständliche wissenschaftliche Vorträge über die Entwickelungslehre im Allgemeinen und diejenige von Darwin, Goethe und Lamarck im Besonderen, über die Anwendung derselben auf den Ursprung des Menschen und andere damit zusammenhängende Grundfragen der Naturwissenschaft*. 2nd ed. Berlin: Reimer.

———. 1874. *Anthropogenie, oder Entwickelungsgeschichte des Menschen: Gemeinverständliche wissenschaftliche Vorträge über die Grunzüge der menschlichen Keimes- und Stammes-Geschichte*. Leipzig: Engelmann.

———. 1876a. *Die Perigenesis der Plastidule, oder die Wellenzeugung der Lebenstheilchen: Ein Versuch zur mechanischen Erklärung der elementaren Entwickelungs-Vorgänge*. Berlin: Reimer.

———. 1876b. *The History of Creation; or, The Development of the Earth and Its Inhabitants by the Action of Natural Causes*. Trans. Edwin Ray Lankester. 2 vols. London: King.

———. 1877a. "Bathybius and the Moners." *Popular Science Monthly* 11:641–52.

———. 1877b. *Die heutige Entwickelungslehre im Verhältnisse zur Gesammtwissenschaft: Vortrag in der ersten öffentlichen Sitzung der fünfzigsten Versammlung Deutscher Naturforscher und Aerzte zu München am 18. September 1877*. Stuttgart: Schweizerbart.

———. 1878a. *Freie Wissenschaft und freie Lehre: Eine Entgegnung auf Rudolf Virchow's Münchener Rede über "Die Freiheit der Wissenschaft im modernen Staat."* Stuttgart: Schweizerbart.

———. 1878b. "Zellseelen und Seelenzellen." *Deutsche Rundschau* 16:40–59.

———. 1879a. *The Evolution of Man: A Popular Exposition of the Principal Points of Human Ontogeny and Phylogeny*. 2 vols. New York: Appleton.

———. 1879b. *Freedom in Science and Teaching*. New York: Appleton.

———. 1883. *The Pedigree of Man: And Other Essays*. Trans. Edward Bibbins Aveling. London: Freethought.

———. 1892. "Our Monism: The Principles of a Consistent, Unitary World-View." *Monist* 2:481–86.

Hall, Granville Stanley. 1879. "Popular Science in Germany." *Nation* 28:179–80.

———. 1880. "The Boston Monday Lectureship." *Nation* 30:364–65.

Hausman, Carl R. 1993. *Charles S. Peirce's Evolutionary Philosophy*. Cambridge: Cambridge University Press.

Heidelberger, Michael. 2004. *Nature from Within: Gustav Theodor Fechner and His Psychophysical Worldview*. Trans. Cynthia Klohr. Pittsburgh: University of Pittsburgh Press.

Henderson, Harold. 1993. *Catalyst for Controversy: Paul Carus of Open Court*. Carbondale: Southern Illinois University Press.

Hering, Ewald. 1870. "Über das Gedächtniss als eine allgemeine Function der organisirten Materie." *Almanach der Kaiserlichen Akademie der Wissenschaften* 20:253–78.

———. 1887. "On Memory as a General Function of Organized Matter." *Open Court* 1:141–45, 169–72.

Hookway, Christopher. 1985. *Peirce*. London: Routledge & Kegan Paul.

———. 1997. "Design and Chance: The Evolution of Peirce's Evolutionary Cosmology." *Transactions of the Charles S. Peirce Society* 33:1–34.

Hossfeld, Uwe, and Olaf Breidbach. 2005. *Haeckel-Korrespondenz: Übersicht über den Briefbestand des Ernst-Haeckel-Archivs*. Berlin: Wissenschaft & Bildung.

Houser, Nathan. 2014. "The Intelligible Universe." In *Peirce and Biosemiotics: A Guess at the Riddle of Life*, ed. Vinicius Romanini and Eliseo Fernández, 9–32. Dordrecht: Springer.

Hutter, Thiago, Carine Gimbert, Frédéric Bouchard, and François-Joseph Lapointe. 2015. "Being Human Is a Gut Feeling." *Microbiome* 3:1–4.

Hutton, Sarah. 2014. "Intellectual History and the History of Philosophy." *History of European Ideas* 40:925–37.

———. 2015. *British Philosophy in the Seventeenth Century*. Oxford: Oxford University Press.

Huxley, Thomas Henry. 1869a. "On the Physical Basis of Life." *Fortnightly Review* 11:129–45.

———. 1869b. Review of *The History of Creation; or, The Development of the Earth and Its Inhabitants by the Action of Natural Causes*, by Ernst Haeckel. *Academy* 1:13–14, 40–43.

———. 1871. *Lay Sermons, Addresses, and Reviews*. New York: Appleton.

James, William. 1890. *The Principles of Psychology*. 2 vols. New York: Holt.

Keeton, Morris T. 1950. *The Philosophy of Edmund Montgomery*. Dallas: University Press in Dallas.

———. 1952. "Peirce and Montgomery." In *Studies in the Philosophy of Charles Sanders Peirce*, ed. Philip P. Wiener and Frederic H. Young, 312–24. Cambridge, MA: Harvard University Press.

Ketner, Kenneth Laine, ed. 1986. *A Comprehensive Bibliography of the Published Works of Charles Sanders Peirce, with a Bibliography of Secondary Studies*. 2nd ed. Bowling Green, OH: Philosophy Documentation Center.

Klein, Alexander. 2008. "*Divide et Impera!* William James's Pragmatist Tradition in the Philosophy of Science." *Philosophical Topics* 36:129–66.

Kronz, Frederick M., and Amy L. McLaughlin. 2002. "The Complementary Roles of Chance and Lawlike Elements in Peirce's Evolutionary Cosmology." In *Between Chance and Choice: Interdisciplinary Perspectives on Determinism*, ed. Harald Atmanspacher and Robert Bishop, 189–207. Thorverton: Imprint Academic.

Ladd-Franklin, Christine. 1895. "Hartmann's Essays." *Nation* 61:154–55.

Laurent, Goulven. 1979. "Un néo-Lamarckien Américain: Edward Drinker Cope (1840–1896)." *Revue de synthèse* 100:297–309.

Leidy, Joseph. 1879. *Report of the United States Geological Survey of the Territories*. Vol. 12, *Fresh-Water Rhizopods of North America*. Washington, DC: Government Printing Office.

Liu, Daniel. 2017. "The Cell and Protoplasm as Container, Object, and Substance, 1835–1861." *Journal of the History of Biology* 50:889–925.

Mach, Ernst. 1891. "Some Questions of Psycho-Physics: Sensations and the Elements of Reality." *Monist* 1:393–400.

Menand, Louis. 2001. *The Metaphysical Club*. New York: Farrar, Straus & Giroux.

Mendelsohn, J. Andrew. 2003. "Lives of the Cell." *Journal of the History of Biology* 36:1–37.

Montgomery, Edmund. 1878. "Monera, and the Problem of Life." *Popular Science Monthly* 13:455–60, 563–71, 677–89.

———. 1880. "The Unity of the Organic Individual." *Mind* 5:318–36, 465–89.

———. 1885. "The Dual Aspect of Our Nature." *Index* 17:199–201, 221–25, 318–20.

———. 1886. Review of "Scientific Theism," by Francis Ellingwood Abbot. *Index* 17:438–41, 450–53.

———. 1887a. "Are We Products of Mind?" *Open Court* 1:423–26, 459–61, 480–83, 512–13, 587–90, 617–20.

———. 1887b. "Cope's Theology of Evolution." *Open Court* 1:160–65, 217–20, 274–77, 300–303.

———. 1887c. "Monism in Modern Philosophy and the Agnostic Attitude of Mind." *Open Court* 1:9–11, 37–39, 65–67.

———. 1890. "The Monism of 'The Open Court' Critically Examined." *Open Court* 4:2461–65, 2476–79.

Moore, James R. 1979. *The Post-Darwinian Controversies: A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and America, 1870–1900*. Cambridge: Cambridge University Press.

Ogden, Rollo. 1889. "Evolution as Taught in a Theological Seminary." *Popular Science Monthly* 35:754–59.

O'Malley, Maureen A. 2014. *Philosophy of Microbiology*. Cambridge: Cambridge University Press.

O'Malley, Maureen A., Michael Travisano, Gregory J. Velicer, and Jessica A. Bolker. 2015. "How Do Microbial Populations and Communities Function as Model Systems?" *Quarterly Review of Biology* 90:269–93.

Open Court. 1888. "The Cope-Montgomery Discussion." *Open Court* 2:776–77.

———. 1890. "Concluding Remarks in the Discussion 'Is Monism Untenable.'" *Open Court* 4:2511–13.

Parker, Kelly A. 1998. *The Continuity of Peirce's Thought*. Nashville: Vanderbilt University Press.

Pearce, Trevor. 2014. "The Origins and Development of the Idea of Organism-Environment Interaction." In *Entangled Life: Organism and Environment in the Biological and Social Sciences*, ed. Gillian Barker, Eric Desjardins, and Trevor Pearce, 13–32. Dordrecht: Springer.

———. Forthcoming. "James and Evolution." In *The Oxford Handbook of William James*, ed. Alexander Klein. Oxford: Oxford University Press.

Peirce, Charles Sanders. 1877. "Note on the Sensation of Color." *American Journal of Science and Arts* 113:247–51.

———. 1887a. "[Science and Immortality]." In Barrows 1887b, 69–76.

———. 1887b. "[Science and Immortality]." *Christian Register* 66:214.

———. 1890a. "Herbert Spencer's Philosophy." *New York Times*, March 23.

———. 1890b. "[Notes on the First Issue of the *Monist*]." *Nation* 51:326.

———. 1890c. "'Outsider' Wants More Light." *New York Times*, April 13.

———. 1890d. Review of *Fundamental Problems: The Method of Philosophy as a Systematic Arrangement of Knowledge*, by Paul Carus. *Nation* 51:118–19.

———. 1890e. "Ribot's Psychology of Attention." *Nation* 50:492–93.

———. 1891a. "The Architecture of Theories." *Monist* 1:161–76.

———. 1891b. "James's Psychology." *Nation* 53:15, 32–33.

———. 1892a. "The Doctrine of Necessity Examined." *Monist* 2:321–37.

———. 1892b. "The Law of Mind." *Monist* 2:533–59.

———. 1892c. "Man's Glassy Essence." *Monist* 3:1–22.

———. 1893. "Ritchie's Darwin and Hegel." *Nation* 57:393–94.

———. 1906. Review of *The Dynamics of Living Matter*, by Jacques Loeb, and *Chemistry of the Proteids*, by Gustav Mann. *Nation* 83:17–18.

———. 1931–60. *Collected Papers of Charles Sanders Peirce*. 8 vols. Cambridge, MA: Harvard University Press.

———. 1976. *The New Elements of Mathematics*. 4 vols. The Hague: Mouton.

———. 1982–. *Writings of Charles S. Peirce: A Chronological Edition*. 8 vols. Bloomington: Indiana University Press.

———. 1992. *Reasoning and the Logic of Things: The Cambridge Conferences Lectures of 1898*. Cambridge, MA: Harvard University Press.

Peirce, Charles Sanders, and Joseph Jastrow. 1884. "On Small Differences of Sensation." *Memoirs of the National Academy of Sciences* 3:75–83.

Porter, Noah, ed. 1871. *Half Hours with Modern Scientists: Huxley—Barker—Stirling—Cope—Tyndall*. New Haven, CT: Chatfield.

Rainger, Ronald. 1992. "The Rise and Decline of a Science: Vertebrate Paleontology at Philadelphia's Academy of Natural Sciences, 1820–1900." *Proceedings of the American Philosophical Society* 136:1–32.

Reynolds, Andrew. 2002. *Peirce's Scientific Metaphysics: The Philosophy of Chance, Law, and Evolution*. Nashville: Vanderbilt University Press.

———. 2008. "Amoebae as Exemplary Cells: The Protean Nature of an Elementary Organism." *Journal of the History of Biology* 41:307–37.

Richards, Robert J. 2008. *The Tragic Sense of Life: Ernst Haeckel and the Struggle over Evolutionary Thought*. Chicago: University of Chicago Press.

Romanes, George John. 1889. "Psychology of Protozoa." *Nature* 40:541–42.

Rossi, Mauro, and Christine Tappolet. 2016. "Virtue, Happiness, and Well-Being." *Monist* 99:112–27.

Royce, Josiah. 1895. "Self-Consciousness, Social Consciousness, and Nature." *Philosophical Review* 4:465–85, 577–602.

Schelling, Friedrich Wilhelm Joseph. 1800. *System des transcendentalen Idealismus*. Tübingen: Cotta.

Schloegel, Judy Johns, and Henning Schmidgen. 2002. "General Physiology, Experimental Psychology, and Evolutionism: Unicellular Organisms as Objects of Psychophysiological Research, 1877–1918." *Isis* 93:614–45.

Schneider, Herbert W. 1946. *A History of American Philosophy*. New York: Columbia University Press.

Schultze, Max Sigmund. 1854. *Über den Organismus der Polythalamien (Foraminiferen), nebst Bemerkungen über die Rhizopoden im Allgemeinen*. Leipzig: Engelmann.

———. 1860. "Die Gattung Cornuspira unter den *Monothalamien* und Bemerkungen über die Organisation und Fortpflanzung der *Polythalamien*." *Archiv für Naturgeschichte* 26 (1): 287–310.

Seager, William, and Sean Allen-Hermanson. 2010. "Panpsychism." In *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta. Stanford, CA: Stanford University. https://plato.stanford.edu/archives/fall2015/entries/panpsychism/.

Shakespeare, William. 1857–66. *The Works of William Shakespeare*. 12 vols. Boston: Little, Brown.

Shapiro, J. A. 2007. "Bacteria Are Small but Not Stupid: Cognition, Natural Genetic Engineering, and Socio-Bacteriology." *Studies in History and Philosophy of Biological and Biomedical Sciences* 38:807–19.

Short, T. L. 2010. "Did Peirce Have a Cosmology?" *Transactions of the Charles S. Peirce Society* 46:521–43.

Smolin, Lee. 2004. "Cosmological Natural Selection as the Explanation for the Complexity of the Universe." *Physica A: Statistical Mechanics and Its Applications* 340:705–13.

Spencer, Herbert. 1862. *First Principles*. London: Williams & Norgate.
Sterne, Carus. 1891. "Five Souls with But a Single Thought: The Psychological Life of the Star-Fish." *Monist* 1:245–62.
Tschermak, Gustav. 1876. "Die Einheit der Entwickelung in der Natur." *Almanach der Kaiserlichen Akademie der Wissenschaften* 26:229–59.
Ueberweg, Friedrich. 1872–74. *A History of Philosophy, from Thales to the Present Time*. Trans. George Sylvester Morris. 2 vols. New York: Scribner, Armstrong.
Ulett, Mark A. 2014a. "Definitely Directed Evolution (1890–1926): The Importance of Variation in Major Evolutionary Works by Theodor Eimer, Edward Drinker Cope, and Leo Berg." PhD diss., Arizona State University.
———. 2014b. "Making the Case for Orthogenesis: The Popularization of Definitely Directed Evolution (1890–1926)." *Studies in History and Philosophy of Biological and Biomedical Sciences* 45:124–32.
Verworn, Max. 1889. *Psycho-physiologische Protisten-Studien: Experimentelle Untersuchungen*. Jena: Fischer.
———. 1894. "Modern Physiology." *Monist* 4:355–74.
Wallace, Alfred Russel. 1887. "The American School of Evolutionists." *Nation* 44:121–23.
Wheeler, John Archibald. 1983. "On Recognizing 'Law without Law.'" *American Journal of Physics* 51:398–404.
Whitney, William Dwight, ed. 1889–91. *The Century Dictionary: An Encyclopedic Lexicon of the English Language*. 6 vols. New York: Century.
Zöllner, Johann Carl Friedrich. 1872. *Über die Natur der Cometen: Beiträge zur Geschichte und Theorie der Erkenntniss*. Leipzig: Engelmann.