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Abstract: I have segregated the fascinating personal story of Charles Peirce and his views to this appendix. Peirce's "architectonic" provides a nexus of logic, signs and the universal categories to give us the tools we need to see Peirce's big picture, dominated by what he called pragmatism. In Peirce's cosmogony, the primitives of chance (Firstness), law (Secondness) and habit (Thirdness) can explain everything from the emergence of time and space to the emergence of matter, life and then cognition.

Peirce's deepest contributions were in mathematical logic, where he pioneered many new areas. Peirce considered his work on the logic of numbers and the analysis of the infinite as major contributions. I detail significant resources from which you may learn more about Peirce, either directly from his voluminous writings, or as interpreted by others.

APPENDIX A:

PERSPECTIVES ON PEIRCE

Charles Sanders Peirce (1839-1914), pronounced ‘purse,’ was an American logician, scientist, mathematician, and philosopher of the first rank. His profound insights and writings spanned a half-century, and cover topics ranging from the nature of knowledge and epistemology to metaphysics and cosmology. Well-known in the Americas and Europe early in his career, his foibles, and challenges to social orthodoxies, led to a precipitous decline in his fortunes, such that he died nearly penniless and unable to publish. Still, Peirce had a deep influence on many leading thinkers of his time, and as transcription and publishing of his voluminous writings moves to completion, an influence that will continue for generations.

My first attraction to Peirce began with my professional interests in the semantic Web.¹ My earliest exposure to the semantic Web kept drawing my attention to questions of symbolic knowledge representation (KR). Like the genetic language of DNA in biology, my thought has been that there must be better (more ‘truthful’) ways of representing knowledge and information in digital form. My sense is that syntax or specific language is not the key, but that the basic building blocks of grammar and primitives hold that key. We further need a set of primitives well suited to natural language understanding, since humanity embodies so much of its cultural information in text. Structured data, such as from databases, is not an appropriate starting point; we critically need means to represent natural language. In Peirce, I have found the guide for those interests.

I have maintained throughout this book that Peirce is the greatest thinker ever in the realm of knowledge representation. Yet, KR, as a term of art, was not a phrase used in Peirce’s time. Granted, Peirce wrote much on relations and representation (via his semiotic theory of signs) and provided many insights on the nature of information and knowledge, but he never used the specific phrase of ‘knowledge representation.’ He never attempted to categorize knowledge such as what we have undertaken with the KBpedia Knowledge Ontology (KKO), though he did make multiple attempts to classify the ‘sciences’ (fields of study in today’s parlance). While Peirce had more than a glimmer of an idea that reasoning machines might someday be a reality, there was no need within his time to attempt to provide the specific representational framework for doing so.

Because of his influence — and his nearly constant presence throughout this book — I wanted to share what I have learned about Peirce the person, the polymath, the philosopher, and as a polestar guiding new directions in KR. I hope to convey a bit of the perspective about why you, too, should study Peirce, and help add to the interpretation of his fecund mind. I conclude this appendix with suggested resources you may find helpful to study this most remarkable human thinker.

PEIRCE, THE PERSON

Charles S. Peirce was born into privilege in 1839 and was brought up among the intellectual elite in Cambridge, Massachusetts. His father, [Benjamin Peirce](#), was a professor at Harvard and one of the prominent mathematicians of the 1800s. Charles received a first-rate education, including much personal tutoring by his father, and was given preference and sinecures at a young age, mainly through his father's connections.

Trained as a chemist at Harvard's Lawrence Scientific School where he graduated *summa cum laude* in 1863, Peirce was able to secure a deferment with his father's assistance from serving in the Civil War. Peirce was a working scientist for most of his employed career at the [Coast and Geodetic Survey](#), then perhaps the premier US government research facility, on gravitational differences around the globe, based on meticulous measurements using pendulums, often of Peirce's innovative designs. His early writings in the mid-1860s in areas of logic and metaphysics received wide acclaim. He was frustrated in securing a teaching position at Harvard,* but eventually became a lecturer at Johns Hopkins University, which was innovating in American graduate education, from 1879 to 1884, when he was summarily dismissed under unclear clouds of scandal. He subsequently had sporadic engagements in various entrepreneurial activities and wrote and translated articles for hire, but never had a permanent position again. His last decades were spent writing at his Milford, Pennsylvania home, [Arisbe](#), which itself was in various stages of construction and disrepair based on vacillating, but declining financial fortunes. By his death in 1914, he and his second wife, [Juliette](#), were essentially penniless, having been sustained in part due to loans and charity from friends and family, orchestrated by his brother, [James](#), himself a Harvard mathematician, and his life-long friend, [William James](#). Peirce had no children.

In a stellar biography, Brent often refers to Peirce as a dandy in his earlier years.² Playing on the pronunciation of his name, two of Peirce's favorite self-descriptions were that he had 'Peirce-istence' and 'Peirce-everence.' He was certainly an iconoclast, and also flaunted society's conventions, living with Juliette before marriage and after being abandoned by his first wife, [Zina](#). Peirce was a prodigious writer and very hard worker over fifty years, but was cavalier, if not unethical, in the abuse of his positions and public funds. He was reportedly a user of morphine and cocaine, os-

* In fact, due to enmity at Harvard, Peirce was barred from lecturing on campus for thirty years, only relaxed when Peirce was in his 60's.

tensibly for neuralgia, but a factor that may have contributed to his sometimes perplexing inconstancies. Peirce often pursued his intellectual interests at the expense of his paid responsibilities. He created powerful enemies that ultimately kept him from securing a professorship at a leading university, which he and his family believed his birthright. He made poor decisions concerning money and finances, often disastrous ones, and died virtually penniless, with no fame and little notoriety. Still, Peirce befriended and influenced many of the leading thinkers of his time, including William James, Josiah Royce, John Dewey and Oliver Wendell Holmes.

After Peirce's death, Harvard was scandalous in how it (mis-) handled his donated papers and restricted access for many years to his unpublished writings,* a continuation of the vendetta brought by Charles W. Eliot, the longstanding Harvard president. His supposed supporter and family friend, Simon Newcomb, routinely undercut Peirce. Thankfully, within two decades of his death, anthologies were published, and his reputation and stature began to grow. The understanding of his insights and accomplishments continues to grow as researchers study and release his voluminous unpublished writings. Peirce's reputation now is the highest it has ever been in the hundred years since his death, growing, and surely greatly exceeds whatever fame he saw during life.

Peirce was often the first to acknowledge how he changed his views, with one set of quotes from early 1908 showing how his thinking about the nature of signs had changed over the prior two or three years.⁴ That example is but a small snapshot of the changes Peirce made to his sign theories over time, or of his acknowledgments that his views on one matter or another had changed.

Of course, it is not surprising that an active writing career, often encompassing many drafts, conducted over a half of a century, would see changes and evolution in thinking.[†] Most Peircean scholars acknowledge changes in Peirce's views over time, particularly from his early writings in the 1860s to those after the turn of the century and up until his death in 1914. Where Peirce did undergo major changes or refinements in understanding, Peirce himself was often the first to explain those changes. Many scholars have looked to specific papers or events to understand this evolution in thinking. Max Fisch divided Peirce's philosophy development into three periods: 1) the Cambridge period (1851-1870); 2) the cosmopolitan period (1870-1887); and 3) the Arisbe period (1887-1914).⁶ Murphey split Peirce's development into four phases: 1) the Kantian phase (1857-1866); 2) three syllogistic figures (1867-1870); 3) the logic of relations (1879-1884); and 4) quantification and set theory (1884-1914).⁷ Brent has a different split more akin to Peirce's external and economic fortunes.² Parker tends to split his analysis of Peirce into early and mature phases.⁸ It is a common theme of major scholars of Peirce to note these various changes and evolutions. Some of this analysis asserts breakpoints and real transitions in Peirce's thinking. Others tend to

* See further Nathan Houser, "The Fortunes and Misfortunes of the Peirce Papers."³

† Peirce's lifetime writings have been estimated at 100,000 pages, and Case has estimated that as many as three-quarters of his writings still wait transcription.⁵ I doubt this estimate, but in any case, discovery of new entire manuscripts is unlikely, since untranscribed pages seem to constitute mostly drafts of prior manuscripts.

see a more gradual evolution or maturation of thinking. Some of the arguments bolster whatever particular thesis the author is putting forward. Such is the nature of scholarship.

For me, I take a pragmatic view of these changes. First, some of Peirce's earliest writings, particular his 1867 "On a New List of Categories,"⁹ but also mid-career ones, are amazingly insightful and thought-provoking. Tremendous value resides in these earlier writings, often infused with genius. Peirce, after all, was in the prime of his powers. Sure, I can see where some points have evolved, or prior assertions or terminology have changed, but Peirce is also good at flagging those areas he sees as having been important and earlier in error. I, therefore, tend to rely most on his later writings, when a hard life lived, maturity and experience added wisdom and perspective to his thoughts. I tend to see his later changes more as nuanced or mature, rather than radical breaks with prior writings. I see tremendous continuity and consistency of worldview in Peirce over time.¹⁰

Peirce considered himself foremost as a scientist, who probed and questioned premises with logic and purpose. Peirce's critical attention and refinement of the scientific method places him in the top tier of philosophers of science. Peirce believed all questions lend themselves to scrutiny and logical analysis. Among the myriad of possibilities available to us for inquiry as scientists, Peirce's methods help point to those options most likely to yield fruit within limited time and resources, the essence of his philosophy of pragmatism. The universal categories provide us with a constant and consistent framework for representing, analyzing and organizing knowledge.

Though many intellectual giants of history were recognized as such in their own times — Newton, Einstein, Darwin, and Aristotle, come to mind — all of us like the story of the genius unjustly ignored in his lifetime. In science, famous examples include Copernicus, Galileo, Wegener, and Mendel. Charles Sanders Peirce belongs in this pantheon as well, a possible outcome I think he realized himself. The failure of his grant application to the Carnegie Institution in 1903 to synthesize his life's work, supported no less by Andrew Carnegie and Teddy Roosevelt, was Peirce's last attempt at broad-scale recognition. Ill, in poverty, and shunned by the establishment of his time, Peirce worked feverishly in his last years to get down on paper as much as he could, pretty much laboring alone and in obscurity. We are still plumbing these handwritten papers, gaining new insights and perspectives of what we think we know about Peirce's philosophy and perspectives.

Philosophers, logicians, scholars, and laypersons study Peirce as a passion, many for a living. Though Peirce was neglected by many during the heyday of analytical philosophy throughout the 20th century, that is rapidly changing. Walker Percy and Umberto Eco were two noted writers who have studied Peirce closely and written on him. The reason for Peirce's ascendancy, I think, is precisely due to the Internet, with then ties to knowledge representation and artificial intelligence. Peircean views are directly relevant to those topics. His writings in logic, semiosis (signs), pragmatics, existential graphs, classification, and how to classify are among the most direct of this relevancy.

However, relevant does not mean agreed upon, and researchers understand

Peirce through their own lenses, as the idea of Peirce's Thirdness affirms. Given Peirce's own constant questioning and revision of his theories, plus the fragmented nature of the written record he left behind, I think it fair to assert that we will never come to understand Peirce's 'truth' fully. Peirce was a man of complexity, unlikely to be fully plumbed. On the other hand, I also think we are only still beginning to understand how Peirce's insights can inform our understanding of the world.

PEIRCE, THE PHILOSOPHER

Peirce did not view himself as a philosopher but as a scientist and logician. These distinctions are mere shadings in Peirce's philosophy, one that places high stock on truth, logic, representation, and the scientific method. Much of Peirce's philosophy figures prominently in the main body of this book, specifically in the role of semiosis and sign-making (*Chapter 2*); his universal categories, 'truth' and fallibility, and categorization (*Chapter 6*); logic of relations and logic types (*Chapters 7 and 8*); the role of natural classes (*Chapters 5 and 10*); and pragmatism (*Chapter 14*). Here, however, I want to highlight the more cross-cutting aspects of Peirce's philosophy, not so directly related to KR, but also essential to understand his worldview.

Peirce's Architectonic

Peirce's *architectonic*, a word applied to the worldview for certain influential philosophers such as Kant or Aristotle, is built around the structure of all human knowledge. The pivotal elements of Peirce's architectonic are his universal categories, as manifested in logic, and evaluated through the pragmatic maxim. Peirce organized his classifications of science into disciplines using this system, in which he also embedded such topics as ethics, esthetics (his spelling), philosophy, and metaphysics, in addition to the classical sciences and humanities. Peirce evolved his classification of the sciences considerably over time. Beverly Kent conducted a thorough analysis in 1987, much based on unpublished manuscripts at the time, that documents at least 20 different classifications over the period of 1866 to 1903 (the last, final one called the 'perennial'), with minor ones in between.¹¹ The three main branches of Peirce's perennial classification are mathematics, cenoscopy (philosophy) and idioscopy (the special sciences of traditional science and the humanities). Peirce believed that we should place philosophy within this systematic account of knowledge as science, and adopted the idea of the architectonic from the philosopher he idealized the most, Immanuel Kant. Peirce increasingly relied on this structural sense and the irreducible universal categories in most all of his later thinking.

Logic, as defined by Peirce, is only another name for semiotic. (1897, CP 2.227) The clear thread through Peirce's writings is the respect and attention he gives to the primacy of logic, but also the role of community in deciding belief and terminology. Though, as a normative science (along with ethics and esthetics), logic is not the center root of his categorization of science, Peirce still bases all of his major arguments and insights on logic. Those insights include ones about the role and principles of

logic itself.

“I do not, for my part, regard the usages of language as forming a satisfactory basis for logical doctrine. Logic, for me, is the study of the essential conditions to which signs must conform in order to function as such. How the constitution of the human mind may compel men to think is not the question; and the appeal to language appears to me to be made (and logicians generally do make it; in particular their doctrine of the copula appears to rest solely upon this), it would seem they ought to survey human languages generally and not confine themselves to the small and extremely peculiar group of Aryan speech.” (NEM 4:243)

Via the classification of the sciences, Peirce attempts to organize and relate all aspects of knowledge and inquiry, and via the logic of semiosis, Peirce provides a way to think about and represent that knowledge. Peirce subsumes these considerations under the irreducible foundation of the universal categories, though Peirce placed the study of these categories within phenomenology, another branch of philosophy. (Thus, phenomenology, normative science, and metaphysics provide the three branches of cenoscopy, or philosophy.) Peirce is also clear about these same groundings for his pragmatism. In a 1902 letter to William James, Peirce stated:

“[M]y three categories, ... in their psychological aspect, appear as Feeling, Reaction, Thought. I have advanced my understanding of these categories much since Cambridge days; and can now put them in a much clearer light and more convincingly. The true nature of pragmatism cannot be understood without them.” (1902, CP 8.256)

Though we can see the universal categories subsuming logic, semiosis, and pragmatism, we can also see a tight nexus between all of the concepts. For example, Ika, in an overlooked doctoral thesis, provides lengthy analysis that places Peirce’s universal categories at the foundation of his pragmatism:¹²

“... it can be said that Peirce’s general philosophical project was most fundamentally concerned with some kind of *methodological* quest; a quest that seeks to establish the most fundamental categories that are both logically and metaphysically presupposed in any inquiry. The categories are logical presuppositions in the sense that they are principles or norms to be necessarily followed in the process of inquiry. They are also metaphysical presuppositions in the sense that Peirce rightly regarded them as reflections or representations of reality. Peirce’s unique brand of pragmatism, with its blend of logical rigour, practical orientation and realist metaphysical foundations was the end result of his methodological quest.” (p. 23)

which also ties into the idea and importance of logic:

“According to his classification of the sciences, metaphysics depends on logic for its fundamental principles, and logic depends on metaphysics for the data on which to operate. Although this relation of inter-dependence between metaphysics and logic is useful for determining certain aspects of his overall philosophical position, it is too rigid to account for another sense in which logic is dependent on metaphysics for Peirce, namely, that the whole end or intention of logic is contained within metaphysics.”¹² (p. 139)

but also recognizes that the categories subsume semiosis, providing the more general tenets:

“While Peirce appears to be preoccupied with his theory of signs, and sees sign and sign-action in every phenomenon, he did not seek to reduce reality to a semiotic system, where the real would be construed as only that which is sign-like. For Peirce, such a reductionist view of reality would result either in a dismissal of metaphysics or require that metaphysics be reducible to logic.... both these views are inconsistent with Peirce’s overall philosophical position, which recognises the distinction between the logical and the real as important.”¹² (p. 152)

We stride into a world with an uncertain future. We need to act and make decisions in the face of that uncertainty. We evaluate that world by the three logical methods of deduction, induction, and abduction. Peirce’s architectonic provides a nexus of logic, signs and the universal categories to give us the tools we need to move forward, what Peirce calls pragmatism:

“Pragmatism ... had been designed and constructed ... architectonically. Just as a civil engineer, before erecting a bridge, a ship, or a house, will think of the different properties of all materials, and will use no iron, stone, or cement, that has not been subjected to tests; and will put them together in ways minutely considered, so, in constructing the doctrine of pragmatism the properties of all indecomposable concepts were examined and the ways in which they could be compounded. Then the purpose of the proposed doctrine having been analyzed, it was constructed out of the appropriate concepts so as to fulfill that purpose. In this way, the truth of it was proved.” (1905, CP 5.5)

We can thus understand Peirce’s *architectonic* as the building blocks that go into constructing our structure of knowledge. How we go about thinking about these building blocks and then applying them to a given problem at hand, such as capturing a domain or inquiring where we have doubt, is what I refer to as a *mindset*. The universal categories are foundational to either of these two meanings.

Chance, Existents, and Continuity: Real

The three universal categories, as noted, are appropriately studied under the phenomenology section of the cenoscopic (philosophic) branch of the sciences. Though we earlier, in *Table 6-2*, listed many examples of Firstness, Secondness, and Thirdness, let’s single out some phenomenological aspects of these categories that Peirce emphasized in his writings. These three aspects are absolute chance for Firstness; actual, existing individuals for Secondness; and continuity for Thirdness. In some ways, these concepts are firsts among equals given their prominence in Peirce’s thinking. If a grounding exists for the three universal categories, these may be it.

Chance

The fount of Peirce’s universal category of Firstness is absolute chance. Peirce

brings two remarkable insights about chance in his writings. The first insight, now somewhat prosaic but new for its time, was the importance of probability to many problems. The results, for many problems, are not absolute, but probable across a distribution of possible outcomes. It is essential to sample randomly, or by chance, to test these probabilities. Peirce was an early explicator about random sampling and statistics. Indeterminant problems are common, and an understanding of chance and probabilities is the only tractable way to assess them.

The second remarkable insight is more fundamental, and perhaps even more critical. It is what Peirce called *tychism*. Peirce was an early supporter of Darwin's theory of evolution and understood the role of variation. Peirce was first exposed to the ideas of evolution at least since the time of the Metaphysical Club, under the strong influence of friend and fellow club member, Chauncey Wright. Peirce's probability studies also enabled him to see that our world was one of 'surprising facts.' A completely random world would signal no variety. Absolute chance must, therefore, be leading to variants that cause us to inspect and understand emerging properties. Chance is itself offering up variants, some which have the character of persistence because of their stronger probability to be reinforced. These forces of chance give our world the variety and diversity it possesses. Laws and habits lead to regularities that both tend to perpetuate themselves as generalities, but also flash surprising variation that causes us to take stock and categorize and generalize anew.

In Peirce's *cosmogony*, these primitives of chance (Firstness), law (Secondness) and habit (Thirdness) can explain everything from the emergence of time and space to the emergence of matter, life and then cognition. Though it is true that Thirdness (continuity) is the more synthesizing concept, the role of chance alone to drive this entire reality suggests its essential character.¹³ Tychism is thus a philosophical doctrine that absolute chance is real and operative in the world, and it is the source of irregularity and variety and the underlying force of evolution.

Chance alone could be the variant that led to the minute differences arising during the Big Bang, which is posited to have led to matter and its structure. Chance is what enabled self-perpetuating life to emerge from inanimate matter. Chance is how forms of life could symbolically capture these variations via cognition and language. While all of this may now seem inevitable — though unexpected in how manifested — Peirce would maintain they are events arising from chance. Perhaps most events have a cause, but the fundamental ones result from chance. 'Surprising facts,' a favorite phrase of Peirce, mean the world is unpredictable and ultimately probabilistic. The limits of Cartesian logic, the 0s and 1s, are likely never achievable. Reality is shaded and nuanced.

When Peirce began putting forth these ideas, specifically in his *Popular Science* series in 1878 in "On the Nature,"¹⁴ these were radical ideas. At the time of these publications, science was still decades away from quantum mechanics and the Heisenberg uncertainty principle. Moreover, even though Einstein (in) famously said that "God doesn't play dice with the world,"¹⁵ Einstein himself, and his unsettling of Newtonian physics, were still three decades away. These examples are but a few of where Peirce had insight and prescience well in advance of later supporting science.

The reason for such insights, Peirce would say, and I would agree, is not that he was somehow miraculously able to see the future. But, through the rigorous application of logic, Peirce was able to see the requisite primitives of existence. As he wrote,

“The endless variety in the world has not been created by law. It is not of the nature of uniformity to originate variation, nor of law to beget circumstance. When we gaze upon the multifariousness of nature we are looking straight into the face of a living spontaneity. A day’s ramble in the country ought to bring that home to us.” (1887, CP 6.553)

Peirce posited five reasons to believe in the reality (objective existence) of absolute chance:⁷ 1) mechanical forces cannot explain growth and complexity in nature; 2) the sheer variety of nature; 3) uniformity develops from some state of determinacy; 4) no empirical evidence supports determinism; and 5) we can draw verifiable consequences from the hypothesis of chance. (from 1892, CP 6.58-62)

Existents

Existents are what is actual, what exists, and consists of events and entities. Everything that exists is an individual and has an identity. Existents reside entirely in Secondness. “... existence (not reality) and individuality are essentially the same thing.” (1901, CP 3.613) Existents have the nature of ‘haecceity,’ the idea of ‘thisness’ from the Latin, that gives them their particular uniqueness and identity.

Existents are thus an instantiation, something actual with identity, in comparison to the possibilities or qualities of Firstness, and in contrast to the generalities or continuities of Thirdness.* Existents embody qualities as found in Firstness, and may be generalized or related to continuous collections as found in Thirdness. Existents have some limits that bound their thisness, or haecceity, in either space (entities) or time (events). They exist whether we think them to do so or not. In Peirce’s semiosis, actual existents are sinsigns.¹⁶ We may indicate existents (via an index) as an object. Existents are real, but reality is not limited to them. Secondness is the most straightforward of the universal categories.

Continuity

Synechism, which Peirce equated to continuity,¹⁷ is the notion that space, time, and law are continuous and form an essential Thirdness of reality in contrast to existing things and possibilities. Peirce notes that continuity is one of “the most difficult, the most important, the most worth study of all philosophical ideas.” (1893, MS 717; NEM 4:310) I tend to agree.

“Now if we are to accept the common sense idea of continuity (after correcting its vagueness and fixing it to mean something) we must either say that a continuous line contains no points or we must say that the principle of excluded middle does not hold of these points. The principle of excluded middle only applies to an individual (for it is

* Peirce sometimes also refers to relations between two existent objects as also being *existent*.

not true that 'Any man is wise' nor that 'Any man is not wise'). But places, being mere possibles without actual existence, are not individuals. Hence a point or indivisible place really does not exist unless there actually be something there to mark it, which, if there is, interrupts the continuity.... On the whole, therefore, I think we must say that continuity is the relation of the parts of an unbroken space or time.... The precise definition is still in doubt; but Kant's definition, that a continuum is that of which every part has itself parts of the same kind, seems to be correct. This must not be confounded (as Kant himself confounded it) with infinite divisibility, but implies that a line, for example, contains no points until the continuity is broken by marking the points. In accordance with this it seems necessary to say that a continuum, where it is continuous and unbroken, contains no definite parts; that its parts are created in the act of defining them and the precise definition of them breaks the continuity.... Breaking grains of sand more and more will only make the sand more broken. It will not weld the grains into unbroken continuity." (1902, CP 6.168)

Peirce clearly excludes individuals from continuity; indeed, they are disruptions to it. The principle of excluded middle also does not apply, since we are also dealing with generalities. He illustrates these ideas in multiple passages with the idea of points on a continuous line, such as this next example:

"A true continuum is something whose possibilities of determination no multitude of individuals can exhaust. Thus, no collection of points placed upon a truly continuous line can fill the line so as to leave no room for others, although that collection had a point for every value towards which numbers, endlessly continued into the decimal places, could approximate; nor if it contained a point for every possible permutation of all such values. It would be in the general spirit of synechism to hold that time ought to be supposed truly continuous in that sense." (1902, CP 6.170)

We can not distinguish things without making the line discontinuous. If something is inexplicable, it cannot be continuous:

"... synechism amounts to the principle that inexplicabilities are not to be considered as possible explanations; that whatever is supposed to be ultimate is supposed to be inexplicable; that continuity is the absence of ultimate parts in that which is divisible; and that the form under which alone anything can be understood is the form of generality, which is the same thing as continuity." (1902, CP 6.173)

We now begin to see the intimate connection between continuity and generality. "True generality is, in fact, nothing but a rudimentary form of true continuity. Continuity is nothing but perfect generality of a law of relationship." (1902, CP 6.172) We can also relate continuity to the concepts of regularity:

"That continuity is only a variation of regularity, or, if we please so to regard it, that regularity is only a special case of continuity, will appear below, when we come to analyze the conception of continuity. It is already quite plain that any continuum we can think of is perfectly regular in its way as far as its continuity extends. No doubt, a line may be say an arc of a circle up to a certain point and beyond that point it may be straight. Then it is in one sense continuous and without a break, while in another sense, it does not all follow one law. But in so far as it is continuous, it everywhere fol-

lows a law; that is, the same thing is true of every portion of it; while in the sense in which it is irregular its continuity is broken. In short, the idea of continuity is the idea of a homogeneity, or sameness, which is a regularity. On the other hand, just as a continuous line is one which affords room for any multitude of points, no matter how great, so all regularity affords scope for any multitude of variant particulars; so that the idea [of] continuity is an extension of the idea of regularity. Regularity implies generality; and generality is an intellectual relation essentially the same as significance, as is shown by the contention of the nominalists that all generals are names. Even if generals have a being independent of actual thought, their being consists in their being possible objects of thought whereby particulars can be thought. Now that which brings another thing before the mind is a representation; so that generality and regularity are essentially the same as significance. Thus, continuity, regularity, and significance are essentially the same idea with merely subsidiary differences. That this element is found in experience is shown by the fact that all experience involves time. Now the flow of time is conceived as continuous. No matter whether this continuity is a datum of sense, or a quasi-hypothesis imported by the mind into experience, or even an illusion; in any case it remains a direct experience. For experience is not what analysis discovers but the raw material upon which analysis works. This element then is an element of direct experience.” (1908, CP 7.535)

At one point, Peirce claims that “continuity represents Thirdness almost to perfection,” (CP 1.337) and Haack notes that abductive reasoning is the preferred logic for positing continuities.¹⁸ Peirce relates his concept of time to continuity (CP 6.132), and claims his ideas about fallibility are grounded in it:

“The principle of continuity is the idea of fallibilism objectified. For fallibilism is the doctrine that our knowledge is never absolute but always swims, as it were, in a continuum of uncertainty and of indeterminacy. Now the doctrine of continuity is that all things so swim in continua.” (1897, CP 1.171)

Peirce notes that classifying and typing things are also grounded in continuity:

“... it will be found everywhere that the idea of continuity is a powerful aid to the formation of true and fruitful conceptions. By means of it, the greatest differences are broken down and resolved into differences of degree, and the incessant application of it is of the greatest value in broadening our conceptions.” (1878, CP 2.645)

We thus see that Peirce’s conception of continuity is a metaphysical theory as well as a methodological principle. Peirce and others have noted that the presence of continuity is not a construct of the human mind, but is part of reality.¹⁹

What is Real

Peirce grew over his working life to believe that all of these universal categories were real, and not merely figments of the human mind. “If I *truly know* anything, that which I know must be *real*.” (EP 2:181) Fisch dated this transition to about 1897²⁰ when Peirce accepted the reality of the category of Firstness, *i.e.*, of possibility, in addition to his then acceptance of the reality of the categories of Thirdness and Sec-

ondness, becoming what Fisch called a ‘three-category realist.’* In Peirce’s words:

“‘Truth is the conformity of a representation to its object,’ says Kant. One might make this statement more explicit; but for our present purpose it may pass. It is nearly correct, so far as it is intelligible. Only, what is that ‘object’ which serves to define truth? Why it is the *reality*: it is of such a nature as to be independent of representations of it, so that, taking any individual sign or any individual collection of signs (such, for example, as all the ideas that ever enter into a given man's head) there is some character which that thing possesses, whether that sign or any of the signs of that collection represents the thing as possessing that character or not. Very good: now only tell me what it means to say that an object possesses a character, and I shall be satisfied. But even now, in advance of our study of definition, [we can] sufficiently see that we can only reach a conception of the less known through the more known, and that consequently the only meaning which we can attach to the phrase that a thing ‘has a character’ is that something is *true* of it. So there we are, after threading the passages of this labyrinth, already thrown out at that very conception of truth at which we entered it. Indeed, when one comes to consider it, how futile it was to imagine that we were to clear up the idea of *truth* by the more occult idea of *reality!*” (1902, CP 1.578)

Reality, for Peirce, is that which has character independent of what we might think about it in our minds. It rejects the Cartesian mind-body duality. The measures of a character of a thing arise from its disruptions in continuity. These disruptions arise from evolving design and absolute chance.

Leaning Into Pragmatism

In a probabilistic world, which it is, we see lines of evidence everywhere for inferring various aspects of the world, now and into the future. The truth is, as Peirce often makes clear, only the here and now is knowable; what might come next (into the future) is a probability. The stronger, or more definitive, means of inference, deduction, and induction, can never apply to the future. I am not sure Peirce understood that his formulation of abductive reasoning was the needed pathway here, but it is also true that abductive reasoning is the only path to new knowledge or novelty. We must make practical choices in our limited time. From Ika’s dissertation:¹²

“The point is that pragmatism as a logical maxim is set to serve the assertion that there are real things; for without that assertion, pragmatism would be a meaningless enterprise, no matter how hard we think of it as only a logical principle. In his classification of the sciences, Peirce describes logic as the science of the category of Secondness, and metaphysics as the science of Thirdness. His whole point is that the sciences are just as closely related to one another as are the three categories. That is, according to his theory of categories, Secondness is meaningful because of the Thirdness it involves. Similarly, pragmatism as a logical maxim would simply remain meaningless if it did not involve metaphysics.”¹² (p. 149)

The future is not given. The future may be changed via action, or via chance.

* h/t to Jon Alan Schmidt; also see EP 2:186-195.

Some future conditions are more favorable to me as an entity in the present than other future conditions. The choice of next actions among many possible next actions should be guided, in Peirce's view, by pragmatic considerations for three reasons. One, not all alternatives may be tested simultaneously. Two, some alternatives are more likely instrumental than others. Three, any alternative has its own unique set of actions and steps, what might be called costs. Peirce developed the pragmatic maxim to provide guidance for what we should attend to next, and how.

PEIRCE, THE POLYMATH

C.S. Peirce was a man of many capabilities and many accomplishments. His contributions spanned all three of the sciences of discovery (as he named them) — mathematics, cenoscopy, and idioscopy — previously discussed. Peirce's advances in mathematics, logic, the physical sciences, and the scientific method are legion. He was the first to develop a theory of signs (semiosis), is the acknowledged 'father' of American pragmatism, developed diagrammatic ways to represent logic via existential graphs, and explicated a new kind of inference, abductive reasoning. He made contributions to linguistics, the categorization of the sciences, geodesy, and topology. His precise work on physical measures with pendulums and in chemistry led him to make advances in probability, statistics, and instrument errors. He was a realist and understood the limits to truth. His advances appear grounded in a relentless questioning of premises and a rigorous application of logic to the most basic questions. These quests led him to a fundamental cosmogony built around the irreducible and universal categories of Firstness, Secondness, and Thirdness.

One of the best general introductions to Peirce's lifelong accomplishments is provided in the hard-to-find "Introductory Note" by Max Fisch to Chapter 2 of Thomas Sebeok's 1981 book, *Play of Musement*.²¹ For those keenly interested in Peirce's life and accomplishments, this obscure paper is worth tracking down. One thing we do know is that Peirce was a classifier throughout his life. His classifications range from the foundations of cosmology to phenomena, relations, natural classes, sciences and knowledge, signs and knowledge representation, logic, and mathematics. In keeping with that spirit, I, too, will classify Peirce's accomplishments according to the sciences of discovery.

Mathematics

Peirce's father, Benjamin, was a noted mathematician, and Charles grew up being tutored and challenged in math, including mathematical games. Peirce made substantial contributions to the field of mathematics in many areas throughout his working career, though he did admit to backing away from rigorous mathematical problems late in his life.

Peirce's deepest and broadest contributions were in mathematical logic, where he pioneered many new areas.²² Putnam provides a good overview of Peirce's many intellectual contributions to logic²³ We have already noted his explication of the third

mode of logical reasoning, abductive logic, and his invention of the notation and rigor of existential graphs. The term ‘first-order logic’ is due to Peirce. He was a keen student and critic of the leading logicians of his era, De Morgan, Boole, Schröder, and Venn. Peirce considered his work on the logic of numbers and the analysis of the infinite as being one of his major mathematical contributions.² Peirce also referenced a three-valued logic, many methods for which he had already developed.²⁴ We can also point to a second major area of contributions in probability theory, then known as the Doctrine of Chances. (1878, CP 2.645-66) He explicated important ideas in randomness and sampling and analytic methods. We have already seen how important probability and continuity were to Peirce’s metaphysics.

In his earlier years, Peirce developed a calculus founded on the actualness of infinity and infinitesimals. He suggested a cardinal arithmetic for infinite numbers, years before any work by Cantor (who completed his dissertation in 1867) and without access to Bolzano’s 1851 work. In 1880–81, he showed how to do Boolean algebra via a repeated and sufficient single binary operation.

In 1881 he set out the axiomatization of natural number arithmetic, a few years before Dedekind and Peano. In the same paper, Peirce gave, years before Dedekind, the first purely cardinal definition of a finite set. In that same year of 1881, Peirce provided the first successful axiom system for the natural numbers. Soon after, he distinguished between first-order and second-order quantification. In the same paper, he set out what can be read as the first (primitive) axiomatic set theory, anticipating Zermelo by about two decades. He also made contributions in the areas of finite differences and linear associative algebra.²⁵

Peirce was intrigued with the ideas of geometric or notational expressions of algebra, often regarding notions of continuity. He was an explicator of some of the earliest foundations of topology, and his invention of existential graphs is a direct expression of this interest. Peirce is the inventor of the quincuncial projection of the sphere. He also claimed a proof that only four colors are needed to color a spheroidal map (the so-called ‘four-color problem’).

Peirce was also the first to apply statistical methods to comparative biography,² and he also applied his mathematical approaches to what is today known as political economy and econometrics. In 1880 Peirce was elected as a member of the London Mathematical Society.

Cenoscopia

A prior section and many references throughout this book deal with Peirce’s contributions to the science of cenoscopia, or philosophy, which are legion, including his co-founding of the Metaphysical Club in Cambridge in 1872. I only want to add one further point here, and it relates to the idea of the ‘highest good,’ or summum bonum. Peirce sees striving for the summum bonum as moving toward the perfection of Thirdness of continuity or generality by the process of evolution:

“... the pragmatist does not make the *summum bonum* to more consist in action, but

makes it to consist in that process of evolution whereby the existent comes more and more to embody those generals which were just now said to be *destined*, which is what we strive to express in calling them *reasonable*. In its higher stages, evolution takes place more and more largely through self-control, and this gives the pragmatist a sort of justification for making the rational purport to be general.” (1905, CP 5.433)

In his sciences of discovery, Peirce places esthetics and ethics with logic as the three normative sciences, with their dependence on one another:

“My own view in 1877 was crude. Even when I gave my Cambridge lectures [1898] I had not really got to the bottom of it or seen the unity of the whole thing. It was not until after that that I obtained the proof that logic must be founded on ethics, of which it is a higher development. Even then, I was for some time so stupid as not to see that ethics rests in the same manner on a foundation of esthetics...” (1910, CP 8.235)

Regarding which, Peirce elaborates further on the definition of esthetics and its relations to the *summum bonum*:

“Esthetics is the science of ideals, or of that which is objectively admirable without any ulterior reason. I am not well acquainted with this science; but it ought to repose on phenomenology. Ethics, or the science of right and wrong, must appeal to Esthetics for aid in determining the *summum bonum*. It is the theory of self-controlled, or deliberate, conduct. Logic is the theory of self-controlled, or deliberate, thought; and as such, must appeal to ethics for its principles. It also depends upon phenomenology and upon mathematics.” (1900, CP 1.191)

Peirce alludes to what is goodness, the esthetics to which ethics impels action as the governing principle of logic, in many areas throughout his writings.²⁶ His ideals of looking to the community to help guide inquiry and adjudicate truth are also grounded in his practical ethics. We can see an esthetic core to the ethics that govern Peirce’s overall philosophy.

Idioscopy

In the area of the special sciences, that is, the standard sciences plus the humanities (nature and mind) that Peirce termed the *idioscope*, Peirce’s contributions occur in three different areas. The first area, and most prolific, were Peirce’s contributions as a scientist. The second area was as an inventor. The last area of contributions come from Peirce’s special skills as a person, a humanist.

Scientist

For most of his employed life, apart from his teaching at Johns Hopkins and the piecework that constituted much of his later employment, Peirce was a practicing physical scientist. He made notable contributions in geodesy, astronomy, metrology, and chemistry. As a practicing scientist, Peirce gained much appreciation for the difficulty and lack of precision and repeatability in measurements. He understood the

importance of accurate tools and measurement standards for capturing small differences. These first-hand experiences contributed greatly to his views on probabilities and the role and significance of the scientific method.

Geodesy was a primary responsibility for Peirce during his more than three-decades-long employment at the U.S. Coast and Geodetic Survey, as introduced previously. He proposed using the wavelength of sodium light as a means to measure the length of pendulums more accurately, anticipating the metric standard by many decades. These studies also helped improve our understanding and calculation of the exact shape of the earth.²²

Peirce made many contributions to astronomy, including computations of theoretical astronomy, stellar observations, and theories of error. He was among the first to propose (correctly) that the Milky Way forms a disc, and did pioneering work on the magnitude of stars in the Milky Way.² The only full-length book authored solely by Peirce during his lifetime was an 181-page monograph in 1878, *Photometric Researches*, on the applications of spectrographic methods to astronomy.²⁷

In many areas, various researchers have noted Peirce's foresight in his scientific endeavors. For example, Ilya Prigogine claimed Peirce's "Design and Chance" article, written in 1884, with its view of time and the second law of thermodynamics, anticipated the 'new physics' of the 20th century. We note other areas for which Peirce foresaw or alluded to future science or discoveries throughout this book. Peirce was elected as a Fellow of the American Academy of Arts and Sciences in 1867, and a member of the National Academy of Sciences in 1877.

Inventor

Besides inventions such as map projections, semiotics, and pendulum design mentioned elsewhere, Peirce was also a prolific developer of notations and classical inventions. In notations, his existential graphs certainly stand out. However, he was also an inventor of the Peirce arrow symbol for the logical 'neither nor,' also called the Quine dagger (NOR), and its NAND complement, the Sheffer stroke. Peirce also created a unique method of iconic handwriting, which he dubbed 'Art Chirography.'

In 1892, Peirce developed an electrolytic bleaching process for wood pulp. A few years later, he also invented an acetylene lamp generator, also later tied into a hydroelectric project, that was competing with Edison's electric light. At this same time, after his dismissal from Hopkins, he also conducted stress engineering analysis for what would eventually become the George Washington Bridge in New York City.²²

His strengths in logic and his inventive mind also foreshadowed the modern computer era. Some claim that he invented the electronic switching-circuit computer.²² In 1886, he saw that Boolean calculations could be carried out via electrical switches, anticipating Claude Shannon by more than 50 years. He also wrote on Charles Babbage and posited the use of electricity and logic gates for reasoning machines.²⁸

Humanist, as Person

Along with his student Joseph Jastrow at Hopkins, Peirce was one of the first experimental psychologists in the United States, pioneering experimental studies in 'subliminal' perception. He had definite views on the concept of higher academic education as a pursuit of collective research, an approach that he embodied in the *Studies in Logic* in 1893, a collection of essays by Peirce and his students. He wrote over three hundred book reviews for the *Nation* magazine, and wrote a textbook in elementary mathematics, unpublished in his lifetime, that Carolyn Eisele painstakingly re-created in the *New Elements of Mathematics* series.^{29 30 24 25} For many years, Peirce documented individual studies of great men. (1900, CP 7.256) He proposed the *Logotheca* as an updated replacement for *Roget's Thesaurus*.

Peircean ideas have been influential in linguistics, specifically in the fields of cognitive linguistics, diachronic linguistics, linguistic semantics and pragmatics, and text linguistics, most driven by his semiotic insights.³¹ Peircean ideas have also informed computational approaches to linguistics³² and language parsing³³ (see also Chapter 16). He produced an important work on pronunciation of Shakespearean English.²² Peirce was also an avid book collector and adviser to the New York Public Library for the purchase of scientific books.² As will be noted in the next section, Peirce was an accomplished lexicographer, specializing in definitions of technical topics. He also was a translator, sometimes for hire, in Greek, Latin, French and German.

According to Brent,² Peirce was a practiced actor, belonging to many amateur acting groups, and his wife, Juliette, was reportedly an actress of some ability. He was lauded at times as a storyteller, orator and debater, teacher, and lecturer, though other occasional reports characterize certain of his lectures as rambling, unintelligible, or dislocated. Peirce even knew card tricks and practiced occasional magic tricks. He was very much interested in mazes and games and published a series in *The Monist* on "Amazing Mazes" later in his life. As a hobby and because of family illnesses, Peirce was also well versed in the history and theory of medicine.

AN OBSESSION WITH TERMINOLOGY

Though Peirce frequently railed against *nominalism*, arguing instead for a realistic view of the world, he also was very attuned to names, labels, and definitions. He sought the 'correct' way to label his constructs. As one instance, at various times, Peirce called abductive reasoning *hypothesis*, *abduction*, *presumption*, and *retroduction*. He also called the methodetic *speculative rhetoric*, *general rhetoric*, *formal rhetoric*, and *objective logic*. Such changing names were not uncommon with Peirce.

In his lifetime, Peirce both enjoyed and made money as a lexicographer defining terms. He personally wrote 6,000 entries for the 12-volume *Century Dictionary*,³⁴ and oversaw a total of 16,000 entries where he had primary responsibility in such areas as logic, mathematics, mechanics, measurement, philosophy, astronomy, and universities.²² Peirce held that the understanding of a language symbol is a process of shared consensus among its community of users; he was loathe to use common terms

for his constructs. Indeed, when one of his terms, pragmatism, was adopted by William James who gave it a different spin and interpretation, Peirce disavowed his earlier term and replaced it with the term *pragmaticism*.

“So then, the writer [Peirce], finds his bantling ‘pragmatism’ so promoted, feels that it is the time to kiss his child good-bye and relinquish it to its higher destiny; while to serve the precise purpose of expressing the original definition, he begs to announce the birth of the word ‘pragmaticism’, which is ugly enough to be safe from kidnap-pers.” (pp 165-166)³⁵

Peirce should have realized that understandability holds sway over individualized perspective. He was silly to argue with James about the term pragmatism, as James was doing so much to promote awareness of Peirce’s ideas.

agapism	coenoscropy	interpretant	phaneroscopy	semeiotic
anancasticism	cyclosy	legisign	pragmatic definition	sinsign
apeiry	dicent	medisense	pragmaticism	speculative rhetoric
antethics	entelechy	methodetic	precession	stechotic
architectonic	fallibilism	objective idealism	qualisign	synechism
axiagastics	hylozoism	percipuum	representamen	transuasion
ceno-pythagorean	hypostatic abstraction	periphraxy	retroduction	tychasticism
chorisy	idioscopy	phaneron	rheme	tychism

Table A-1: Examples of Obscure Peirce Terminology

This penchant for ‘ugly’ terms was not uncommon for Peirce. As examples, Table A-1 above presents some terminology from Peirce’s writings. Changing and ‘ugly’ terminology is but the first of the difficulties in reading and understanding Peirce. His evolution as a thinker, plus the interpretations of those who study Peirce, also complicate matters. A real point about interpretation, I think, is to try to get past his sometimes off-putting terminology. Mostly what is hard to understand are terms you may be encountering for the first time.

I can appreciate Peirce’s preference for precision in how he described things. I can also understand scholars sometimes concentrating more on literalness than meaning. But the use of obfusatory terms or concentrating on labels over the conceptual is a mistake. When looking for a precise expression of new ideas I try to harken to key Peircean terms and concepts, but I sometimes find that alternative descriptions within Peirce’s writings better communicate to modern sensibilities. Concepts attempt to embody ideas, and while it is useful to express those concepts with clear, precise and correct terminology, it is the idea that is real, not the label. In Peirce’s worldview, the label is only an index. I concur. In the semantic Web, we sometimes refer to this as ‘things, not strings.’

PEIRCE, THE POLESTAR

That we live in an age of information and new technologies and new developments is a truth evident to all. These developments lead to a constant barrage of new information, often leading to new or revised assertions ('facts'). What we believe and how we interpret that information is what we call knowledge. New facts connect to or change our understanding of old 'facts'; those connections, too, are a source of new knowledge. Our: 1) powers of observation and learning and discovery; 2) interactions and consensus-building with communities; and 3) the methods of scientific inquiry, all cause us to test, refine and sometimes revise or discard what we thought were prior truths. Knowledge is thus dynamic, continually growing, and subject to revision.

What I call a Peircean *mindset* can help inform answers to new problems, problems that Peirce did not directly address himself. Indeed, the problems that set this context are machine learning and natural language understanding, all driven by computers and electronic data unimagined in Peirce's day. Because my views come from my own context, something that Peirce held as an essence of Thirdness, I cannot say that I *base* my views on Peirce's views. Who knows if he would endorse my views more than a century after his death? However, my take on these matters is the result of much reading, thought, repeat reading and study of Peirce's writings. So while I can not say I *base* my views on Peirce, I can certainly say that he *guides* me.

Peirce's universal categories of Firstness, Secondness, and Thirdness provide the mindset for how to think about and organize knowledge. The tasks of defining and organizing knowledge demand that we bring meaning, context, and perspective to the task. I believe Peirce's universal categories and what they imply offer the next adaptive climb upward for knowledge representation. The overarching framework of Peirce's philosophy — his architectonic — is grounded in these categories. As a scientist and logician, Peirce applied this mindset in pragmatic and testable ways. These methods, indeed the scientific method itself, further guide how and where to apply this mindset in ways that are economical and promise the most knowledge among all of the possible paths of inquiry.

Peirce's fierce realism, his belief in reality beyond our minds, and his insistence that this reality is subject to inquiry and the fixation of belief leading ever closer to truth are distinctly different from the mind-body duality put forward by Descartes. Richard Bernstein in a recent book,³⁶ called this viewpoint a sea change:

"Pragmatism begins with a radical critique of Cartesianism. In one fell swoop, Peirce seeks to demolish the inter-related motifs that constitute Cartesianism [mind-body duality; primacy of personal experience; doubt as a starting condition; there are incontrovertible truths to be discovered] We can view the development of pragmatism from Peirce until its recent resurgence as developing and refining this fundamental change of philosophical orientation — this sea change. A unifying theme in all the classical pragmatists as well as their successors is the development of a philosophical orientation that replaced Cartesianism (in all its varieties)." (pp 18-19)

Our real world is always changing, continually unfolding. Our real world is viewed

by all of us differently, based on background, predilection, perspective, and context. What we think we know about the world today is subject to inquiry and new insights. New factors are arising to shift what we think we know about ourselves and our place in the world.

How I interpret Peirce, and why he has become a polestar in my thinking about knowledge representation, embraces three perspectives. First, given the breadth of Peirce's insights, I try to read as much by him and about his writings by others as I can. This exposure helps set a fertile milieu, useful to interpretation and critical judgment. Second, despite my awe of Peirce's genius, I do not treat his writings as gospel. Were he alive today, I do not doubt that the massive increase in knowledge and information since his day would cause him to alter his viewpoints — perhaps substantially so in some areas. Third, no similar reason compels us to shy away from questioning any of Peirce's assertions. Nonetheless, given Peirce's immense powers of logic, one better be well prepared with evidence and sound reasoning before undertaking such a challenge.

RESOURCES ABOUT PEIRCE

Slowly at first, and then growing after the publication of the *Collected Papers*,* a legion of researchers and academics have labored to preserve, understand and explicate Peirce's insights. Virtually every author and name mentioned in this book has played such a role, with hundreds more, some more active than those cited, contributing their part. I share in this section some of my preferences and personal selections for useful resources about Peirce.

My first recommendation to begin learning about Peirce is to start with Wikipedia. Its English entry on [Charles Sanders Peirce](#) is quite good and rather complete. An [entire category](#) is dedicated to Peirce on Wikipedia, with some 40 articles listed. I think the articles on [semiosis](#), [abductive reasoning](#), and [pragmatism](#) are some of the better ones. Unfortunately, the article on Peirce's [universal categories](#) is pretty weak. To compensate, however, the [Wikipedia Peirce bibliography](#) is an excellent reference source.

Peirce is hardly easy to read, and most of what others write about him is also pretty dense. Though those seasoned in Peirce studies might find it covering standard ground, the 2013 Cornelis de Waal guide to Peirce²² is an accessible introduction to Peirce and his contributions. I no longer consult it for facts or details, but as an intro, it is helpful and a relatively quick read. If this piques your interest, then it is probably worth your time to start exploring Peirce in more depth. I also like de Waal's labeling of the 'doctrine of the categories.'

After introductions, it is best to study Peirce in his own words. The earliest known compilation of Peirce's writings was by Cohen in 1923,³⁷ nearly a decade after Peirce's

* The jumbled nature of the original *Collected Papers* means they should be used with caution, since they have no chronology. Many contemporary Peirce scholars now tend to date by year the passages they quote in order to overcome this problem.

death and is both a good intro and starting compilation. An even better starting compilation is that of Buchler.³⁸ However, I did not start with either of these nor with de Waal, because my initial research discovered that searchable PDF versions of the first ‘complete’ compilations of Peirce’s writings could be obtained for free online.³⁹ The *Complete Papers* are available online in a version easier to read than the PDF versions, and which you can search.⁴⁰ The problem with these CP sources, however, is that the editorial order of CP is not chronological, gaps exist because of the sources initially chosen, and the formatting and editorial decisions are not equal to later standards. The online version is better for learning and reading purposes, but the lack of editorial oversight hurts CP irrespective of format. (A prior CD library is also no longer available.³⁴)

Of course, many editors have compiled Peirce’s writings. In mathematics, you likely want to focus on the fantastic four-volume series from Eisele,⁴¹ which can often be found for free online. As a non-mathematician, I found Volume 4 the most useful. For my interests in logic and knowledge representation, I have found *Vol 1 of The Essential Peirce*⁴² the best single compilation of relevant writings. In fact, you can re-assemble the entire contents of EP (as it is abbreviated) from free, online PDFs, and I have, but that also means you lose the fantastic Nathan Houser introduction and the excellent packaging and portability of an actual paperback book. Many other compilations are also available (see the various bibliographic sources).

I almost uniformly find the introductions by the editors of these compilations provide useful insights about Peirce. The introductions often weave in relevant personal details to help evaluate Peirce as a person. The editors bring a perspective and context to Peirce’s accomplishments since they offer an external vantage. Under the category of editorial compilations, I especially like Nathan Houser’s introduction to EP. However, from different perspectives, the intros by both Brent and Murphey (see below) helped bring him alive to me.

After this kind of a dive into Peirce’s writings, again usefully supported by the editor’s intros, I find I want a big picture of Peirce, which covers his motivations, circumstances, discoveries, and maturation. I suspect these are the hardest of the books about Peirce to write. It requires a breadth of familiarity and a deep understanding of (at least what the author thinks are) Peirce’s intentions. There also are variants of this approach, focusing on specific slices (such as religion⁴³) or particular concepts or academic perspectives.

The online Arisbe, the Peirce Gateway,* lists some 210 books published on Peirce and related topics since 1995 or so, with 114 published since 2006 alone. The site further lists 357 doctoral dissertations about Peirce, most in the last few decades. Note, many of these sources are not in English since Peirce is studied worldwide, with a strong following in Latin America, especially Brazil and Colombia. The Arisbe site is helpful in that most entries include at least a paragraph of description, and often with links to more extended online excerpts. Arisbe is a good resource should specific topics pique your interest while studying Peirce.

Amongst the comprehensive studies covering the entirety of Peirce’s life work, I

* <http://www.iupui.edu/~arisbe/>

will mention two. The first is the book from Kelly Parker in 1998⁸ that focuses on Peirce's emphasis on continuity (synechism). Parker writes well, is lucid, and has an excellent notes section. The second compilation, and one of my favorite Peirce reads, is the earlier 1993 book by Murphey⁷ on the development of Peirce's philosophy. Some other scholars, notably Hillary Putnam, have suggested that Murphey's interpretations are often controversial. Murphey did, indeed, change some of his opinions of Peirce, especially about continuity, in the second edition. However, I find Murphey's analysis of the phases of Peirce's developments to conform to my sense. The latter section of his book is excellent. I find it strange that many other general recommendations for Peirce readings tend to overlook this book. Perhaps a bit of this neglect came from Putnam's early comments, but Murphey is one of the resources I most often consult.

When first learning about Peirce, it is striking how dominant semiosis and his theory of signs (and logic) pervade many of the resources. These are critical Peircean topics, but I find that it took me a while to probe beyond these topics into others I find even more fascinating. I have focused on Peirce's universal categories of Firstness, Secondness, and Thirdness. I have also been studying abductive reasoning, language grammars, the link between logic and mathematics, and how Peirce's views dovetail into current topics in topology and category theory. About these last topics, I recommend Fernando Zalamea.⁴⁴ Zalamea's scholarship is quite advanced, and I do not recommend as a starting point, but after some exposure to Peirce, I like the synthetic view that Zalamea brings to the table. His scholarship shows that Peirce continues to produce major insights for modern logic and mathematics.

Biographies are another useful source. Louis Menand won a Pulitzer prize for his recounting of the birth of pragmatism in the US.⁴⁵ He told the story through the lens of the major participants in the Metaphysical Club, really more of an informal grouping of intellectuals. William James, Chauncey Wright, and Oliver Wendall Holmes figured prominently in that group, but none perhaps more so than Peirce. (Peirce and James were lifelong friends, but Peirce tremendously respected Wright for his insight and intellect, and they were very close friends; Wright, unfortunately, died young at 45.) What is great about this book is that the author frames the movement to pragmatism through the prism of slavery and abolition, the Civil War, and rapid intellectual and technological change. This perspective makes for an excellent read because it does such a marvelous job of placing Peirce into the context of his times, as well as providing equivalently fascinating looks at his very accomplished colleagues. However, this is not the single book to read if you want to probe deeply into Peirce's theories and worldview.

My favorite biography of Peirce, whose publication is a pretty astonishing story in its own right, is Brent's life biography of C.S. Peirce.² Brent first began his biography of Peirce to answer the question of who invented the US philosophy of pragmatism, triggered by clues in a biography of Peirce's friend, William James. He completed his dissertation in 1960 and intended to publish it, but ran into permission difficulties from Harvard, which was still acting poorly about Peirce's archival papers. Brent had to drop the project and moved on to other things. Then, in 1988, Thomas Sebeok,

himself a then emerging-Peirce scholar, encountered a description of the dissertation in a footnote in another book. He was able to get the dissertation through inter-library loan and finally read it in 1990. He was astonished by what he learned and the quality of the work and set out to find Brent, whom he eventually tracked down in Washington, DC. Through Sebeok's catalyst, a publisher was found, Brent agreed to update his 30-year old dissertation, itself an effort of considerable labor, and the work was finally published in 1993. Brent provides an unvarnished and, I believe, fair look at Peirce, the person, and shows insight into his accomplishments and unique ways of thinking about the world. Brent tackled head on all of Peirce's foibles and weaknesses as well. The resulting biography is a masterpiece, what Sebeok termed a 'tragicomic thriller.' Brent himself came to believe "in philosophy [Peirce] was one of the most original thinkers and system builders of any time, and certainly the greatest philosopher the United States has ever seen." Brent came to feel 'deep affection' for his subject, despite those foibles and weaknesses. However, some Peirce scholars, such as Gary Richmond, think the biography unfair, with too much prominence given to Peirce's critics.

The Brent biography is an incredibly intelligent treatment of an incredibly intelligent man. As might be expected from a work that began as a dissertation, it is thorough and well referenced. As might not be expected from a dissertation, it is well written. Brent uses Peirce's own 'architectonic,' a term new to me then but studied by me now, a term drawn from Aristotle but modified by Kant and then Peirce, as a way of framing his treatment. Brent is also attuned to shifts in Peirce's thinking over time, a great boon to better understand the development of his theories. Since I believe others will study Peirce for centuries, along with other great thinkers of humankind, Brent's biography will be a must-include companion to Peirce's writings. As I note in the close to this article, Brent and Sebeok are but two of the hundreds of individuals who have made it their life's work and passion to understand Peirce better, to convey what he was trying to tell us, and to bring awareness of him to broader audiences. Also, a fictionalized biography of Peirce's mysterious second wife, Juliette, has some voyeuristic interest but is an unsuitable source for any reliable information about either Charles or Juliette.⁴⁶

The bulk of commentary, of course, about Peirce may be found in the academic literature. I often find when studying Peirce that a new topic (or one that finally gets my attention) will arise about which I want to learn more. As with all such topics, I first consult Wikipedia for a starting article, if one exists, to get a bit of background and then some key links and useful search terminology. However, my real focus in such investigations centers on Google Scholar. Google Scholar contains nearly 40,000 articles about or discussing Peirce, with the bulk, perhaps 70%, in English.⁴⁷ When searching Scholar, I always use "peirce" as one of my keywords and keep that search term in quotes (without the quotes, Scholar will also give you results from "pierce" since it seems to assume "peirce" is a misspelling). For papers of keen importance, I will also click the link 'Cited by xx' link on Scholar and do a secondary inspection of those to find other interesting papers that have cited the one of interest. I have assembled a complete electronic Peirce library of hundreds of documents over time in

this manner.

A society is devoted to Peirce. One may find many Web sites such as [Arisbe](#) at the [University of Indiana](#), [online forums](#) including for biosemiotics, annual conferences, and many individuals with their Web sites and writings who analyze and pronounce strong views as to what Peirce meant and how we should interpret him. I have often mentioned the influence of [John Sowa](#) in first getting me interested in Peirce, so his site (with query specific to Peirce) is a good one to include on your list. Sowa tends to focus on existential graphs, knowledge representation, logic and natural language understanding. You may also find a good source for Web writers on Peirce on the [Arisbe site](#); check out the blogroll on the left column. Of course, I, too, write not infrequently about Peirce. You may obtain my Peirce articles under my blog's [Peirce category](#). I hope the dozen or so others who often write on Peirce forgive me for not directly mentioning them. Thank you, and I hope we see more.

For broad electronic resources on Peirce, probably the best is [Arisbe](#), noted already.* Two high-quality, online philosophy sites, the [Stanford Encyclopedia of Philosophy](#) and the [Internet Encyclopedia of Philosophy](#), are often useful introductory resources when beginning to learn about a new topic. Authoritative scholars write many of the Peirce articles. A site not updated since the early 2000s, but which has some unique and high-quality articles by outside experts, is the [Digital Encyclopedia of Peirce](#). A useful site to see some different uses of specific Peircean terms is the [Commens Web site](#). The [Charles S. Peirce Project](#) was established in 1976 to continue the mission of making Peirce's writings available, started by the [Collected Papers \(CP\) project](#)³⁹ going back to the 1930s. The Project continues to produce a multi-volume chronological and critical edition of Peirce's writings. Romanini's [Minute Semeiotic Web site](#) is a fun way to explore what Peirce might have intended with his (incomplete) 66-sign schema.

Since first established by Joe Ransdall in 1993, a dedicated discussion list, [Peirce-L](#), with often lively discussion, has nearly daily activity. That link will allow you to search archives going back to 2011, and to subscribe to the list. A similar mail list exists for a group in [biosemiosis](#), another field that Peirce played no small role in helping to gestate. A useful piece of information if you study Peirce further, given that so much of his writing appeared long ago or has been transcribed or compiled by editors, is how to decipher the citation schemes. Good sources on Peirce citation standards are the [Wikipedia CSP abbreviations](#) and [Robin catalog](#) for citing papers and manuscripts. For the truly dedicated, you can help crowd-translate Peirce's unpublished manuscripts via the [SPIN project](#) co-directed by the Peirce scholar, Jeffrey Brian Downard.

Appendix Notes

1. Some material in this appendix was drawn from the author's prior articles at the [AIB::Adaptive Information](#)

* See <http://www.iupui.edu/~arisbe/faqs/whyarisb.HTM> for the [history of the term Arisbe](#) as used by Peirce for his Pennsylvania home.

PERSPECTIVES ON PEIRCE

- blog: "The Importance of Being Peirce" (Sep 2016); "Being Informed by Peirce" (Feb 2017); "How I Study C.S. Peirce" (Aug 2017); "Why I Study C.S. Peirce" (Aug 2017); "A Foundational Mindset: Firstness, Secondness, Thirdness" (Mar 2016); "How I Interpret C.S. Peirce" (Sep 2017).
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 10. I make this assertion despite major shifts in some of Peirce's positions. For instance, Max Fisch in his 1967 paper, "Peirce's Progress from Nominalism Toward Realism," in *The Monist* (vol. 51, pp. 159–178) charts Peirce's evolution from some nominalist positions in his early writings to a full-blown "three-category realist" (Fisch's phrase) by the turn of the century. Still, this evolution -- and others -- only augments Peirce's lifelong theses regarding sign-making, logic, and the universal categories.
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 15. See https://en.wikiquote.org/wiki/Albert_Einstein.
 16. Jon Alan Schmidt takes exception to this wording, noting that it entails that everything exists is a sign, which perhaps Peirce never stated in exactly this way. The quote we do have from Peirce is "that all this universe is perfused with signs, if it is not composed exclusively of signs." (1906, EP 2:394).
 17. Peirce states, "I have proposed to make *synechism* mean the tendency to regard everything as continuous." (1893, CP 7.565). He goes on to say, "I carry the doctrine so far as to maintain that continuity governs the whole domain of experience in every element of it. Accordingly, every proposition, except so far as it relates to an unattainable limit of experience (which I call the Absolute,) is to be taken with an indefinite qualification; for a proposition which has no relation whatever to experience is devoid of all meaning." (CP 7.566).
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40. You can use Google to search within the textlog.de site, even though it is in German and does not have its own search function, by using a query similar to the following: https://www.google.com/search?hl=en&as_q=peirce+abduction&as_sitesearch=www.textlog.de. Note, include 'peirce' in the request, because there are other philosopher papers on the textlog.de site. Also note this approach is tailored for English, with the example querying for "abduction"; replace your own search query in the query string.
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