The Parable of the Chicken House: Charles S. Peirce, Complex/Dynamic Systems, and Environmental Science

Jesse James Thomas

Religious Studies Department, San Diego State University, San Diego CA 92182, USA

Abstract: This paper describes how scientist-philosopher Charles S. Peirce (1839-1914) develops theories that lead eventually to contemporary complex/dynamic systems. In both Peirce and complexity theory, possible bridges appear between analogical/reductionist representations and metaphorical/creative symbols. In complex/dynamic terms, Peirce's scientific theories become a conceptual egg that hatches a century later in complex systems, which is relevant in turn to environmental science and engineering.

Key words: Semiotics, complex/dynamic systems, sub-agential state, coupling, epigenetic landscape, self-organization, multicausality.

1. Introduction

This paper introduces Charles S. Peirce (1839-1913), the scientist-philosopher whose contributions include Pragmatism, Modern logic, and Semiotics. The case made here is that he also helped set the stage for current *Complex/Dynamic Systems* (*Dynamic* is added here because of its recent use in life sciences, which will be obvious as the paper progresses). Given such growth, and the many definitions of complex systems, the approach here is to allow the reader's own definition to emerge and/or re-emerge during the paper. As new terms become common usage, the capitals and/or italics are removed quickly or slowly, depending on the term.

The case made in this paper is that both Peirce and complex systems lie somewhere between the analogical/mechanical/precise definitions of traditional science and the metaphorical/emotive/ambiguous definitions of art. For Descartes, who many consider the 17th century founder of modern science, the egg is an imitative machine. For the current poet Alice Fulton: "Within the latent marrow of the egg, the amber waves—is where its vantage lies".

Corresponding author: Jesse James Thomas, Ph.D., research field: methodologies for life sciences.

2. Activity

Before unpacking Peirce, whose name is pronounced "Purse" due to the reversal of vowels of Pierce, it is important first to introduce quickly someone who lived six centuries before Peirce. John Duns Scotus (1265-1398) was given the moniker "dunce" because he supposedly failed to understand the classical debate between the *Idealists* and the *Nominalists*. The Idealists believed the world as experienced consists of mere shadows cast by the "real" world of eternal ideals, too abstract to be experienced directly. The Nominalists believed "truths" are only words whose meanings disappear quickly.

According to "Dunce" Scotus, and to Peirce after him, both positions are inadequate. *The "real" world of empirical experience is quite capable of explaining itself, and in terms that are far more than momentary.* As Peirce puts it: "*Here and Now* is the phrase forever on the lips of Duns Scotus" [1]. Peirce considers that the classic debate was settled long ago by the supposed dunce.

By Peirce's time, nature had become the center of virtually everything in the laws, representations, and analogies of science, but also in the feelings, symbols, and metaphors of art. Science and art were different,

but they got along fairly well. Then, a generation before Peirce, Charles Darwin (1809-1882) provided a frame that could potentially draw scientific analogy and artistic metaphor together. Darwin's specimens provided precise analogies from widespread times and locations, and the voyage of *The Beagle* was a metaphorical saga of discovery. The argument being made here, however, is that it took a century of evolutionary processing, beginning with Peirce's attempts to correct Darwin, to reach the resolution that Complex Systems eventually provide.

Peirce saw long before complexity theory that Darwin's description of "survival of the fittest" was flawed. *Survival of the fittest was not primarily a matter of survival of the fit competitively but the building of a fluid organization in which a new species could fit.*

Peirce's approach is crystallized in his often quoted *Pragmatic Maxim*: "Consider what effects which might conceivably have bearings we conceive the object of our conception to have. The conception of those effects are the whole of our conception of the object" [2]. Notice here that Peirce uses "effects" twice in this quote, which is the emphasis here in part 1: activity.

Things are known not by what they are in and of themselves but by their *effects*. Even a rock can roll down a hill. For Peirce something that has no *effects* has no meaning either in nature or consciousness. "We expected one thing or took it for granted and had an image in our minds, but experience forces this into the background and compels us to think differently" [3].

The context for this is *Tychism*, "absolute chance—pure tychism" [4]. *Chance* in Peirce is called *Chaos* in complex systems. Nature does not consist of mechanical constructions. It is an evolutionary process, evolving new things that never existed before. In complex systems, especially life sciences, this is often called *Dynamics*. What for Peirce is a *Thing* for complexity theory is an *Agent*. A *Thing*, like an *Agent*, can be personal or impersonal, abstract or real. It is all

a matter of activity, effects, and differences. Everything is *active*.

For Peirce, as Things *become* definable, they become *Signs*. "A sign is something that stands to somebody for something in some respect or capacity. Linguistically, a sign could be as simple as a word or as complex as a scientific theory. It addresses somebody" [5]. A Sign is therefore known not by what it is in and of itself, but by its *effects*. In Complex Systems, an *Agent* may be so active and complex that due to *Causal Spread*, it may not yet be identifiable, and is known *only* by its obvious *effects*, thereby, becoming an *Efficacious Sub-Agential State*, a term suggested by Wheeler [6].

For Peirce, a thing made into a *Sign* becomes a *Representamen*, which he describes as far more fluid than a "representation", just as an *Interpretant* (effect on its user) is more fluid than an "interpretation". Linguistically, as stated above, a sign could be as simple as a word or as complex as a scientific theory. But if nothing *at all* is there (*something is there* even in sub-agential states), Peirce would say it means *nothing* and is meant for *nobody*. The complexity of signs will be dealt with in *Semiotics*, the "organization" of signs in Part 3, but the emphasis here is that signs are dynamic rather than static. They are *evolutionary*.

Meanings are ultimately fluid rather than static. If there are no effects, there is no meaning. Nothing is static. Even effects have effects. It may of course be *useful* to consider things as static for special purposes, but sooner or later, static definitions need to be revised. Scientific results are fluid components in an evolutionary flow. The *Pragmatic Maxim* holds that actions and their signs *become* meaningful as they have effects, in consciousness as *purposes*. But neither results nor purposes can escape their inherent fluidity. In terms of complexity theory, they are *dynamic*, meaning here *active*.

Interpretants are therefore evolutionary, not reductionist. In Peirce's approach, the reductionist

causes of traditional science may not be all that accurate, given the active world in which they are embedded. In nature things change. What was an egg one is a baby chicken the next.

Peirce's *Pragmatism* is therefore focused on *momentarily* definable causes, even if the *moment* lasts in a few cases for centuries, and on clearly *useful* results within that time frame, but given evolving and often unique circumstances, that too shall pass. To Peirce the evolving world is forever different. And it is evolutionary process that ultimately decides what *works* and what does not. To him, the supposed Laws of nature's operation are *Tendencies* rather than *Rules*, because everything is always surrounded by *Chance* (*Chaos*). But these surroundings are the closest thing imaginable to nothing at all simply because they are *as yet* undefinable, but they are nevertheless *there*.

A proverbial puzzle asks which came first, the chicken or the egg. That puzzle today is considered solved by simple genetic considerations. The egg comes *before* the chicken, because the fertilized egg genetically would have been laid by a proto-chicken rather than a chicken. Evolution is always *active*, creating something new.

3. Interactivity

A second important factor needs to be treated before approaching Peirce's semiotics; the *Interactivity* of action. Recall Peirce's *Pragmatic Maxim*: "Consider what effects which might conceivably have bearings we conceive the object of our conception to have. The conceptions of those effects are the whole of our conception of the object" [2]. The focus here is on the word *Bearings*. *Bearings* mean two things: (1) *Organization*, but before considering organization (the next part of this paper), it is important to discuss and (2) the *Interactivity* that makes organization possible.

The term "bearings" suggests context, which leads to Peirce's *Synechism*. As Peirce explains: "I have proposed to make *synechism* the tendency to regard

everything as continuous" [7]. But "continuous" is not self-explanatory. Continuity requires not only *action* but *interaction*. A living thing may appear to be active, but without interactivity, it cannot survive. Whether it is food and drink needed for physical survival, or new information needed for the development of a new hypothesis, without interaction things, it will die. In complex systems this interaction is known as *Coupling*.

In Peirce, interconnectivity leads to his *Logic of Relations* and his *Continuous Predicate*. It is safe in any case to define *Synechism* in terms of the "fluid interaction" that is basic to his *continuity*, because continuity is impossible without those two components. Together, they made for the continuity of the proverbial rock rolling down a hill. Everything is interconnected ultimately with everything else. It is like the "small world" idea that everyone is only a few relationships away from everyone else in one's culture. Everybody knows somebody who knows somebody, etc., till it gets back to the original somebody fairly quickly. According to Peirce, no *Synechist* should ever say: "I am altogether myself and not at all you" [8].

In nature and in everyday experience, interactivity leads spontaneously to the development of *Habit*. Nature does not think and then act, it "thinks" *as* it acts, which is a different kind of process from reflective deliberation. It often defies ordinary rationality. Its own methods of establishing new *habits* are often beyond ordinary reasoning.

Wherever it is found: "Habit is a generalizing tendency; it causes actions in the future to follow some generalization of past actions and this tendency is itself something capable of similar generalizations, and thus, it is self-generative" [9]. Peirce may not realize how "dispersed" this "self-generative" process may be in complex systems, but he is obviously moving in that direction. Evolutionary change as described in complex systems can be incredibly complex, but both Peirce and complexity theory emerge out of what Peirce calls *Chance* and complex

systems call *Chaos*.

Traditional logic, like arithmetic, is determined by rules that are developed independently of any concrete applications, as in arithmetic. For Peirce, however, logic, to be considered in more detail later, has evolutionary roots. The reverse is not true in traditional logic. *Evolution is not designed to read textbooks on logic*, and until Peirce, logicians had few language skills to enable them to read the textbook that nature indirectly presents, so that logic can learn from nature. Peirce strives to do that by teaching logicians some of the needed language skills not only to understand nature but consciousness.

Reductionism, the tool of the standard science of his day, is very useful in its own way, but it provides no help in understanding evolutionary reality. It misses the *dynamic* quality of nature when trying to analyze either the development of new species or any other evolutionary processes in either nature or everyday life. Here whatever issue is at stake is changing *the very shape (Gestalt) of things*. In Gestalt understanding of perception, small changes in the image of a zero can suddenly make it the image of an egg. It is also surprising, of course, when watching an incubating egg to see a fluffy little chick hatch from the egg.

Nature, like everything new, evolves by organizing things into forever moving *Habits*, often in great detail and complexity. *What is happening in a fertilized egg from the chicken house is happening slowly or quickly everywhere else* (in every *State Space* as it is called in complex systems). When psychological habits achieve some permanence and complexity, it might be proper sometimes to call them *Nests*, and speak of *Nesting Habits*, like marriage and children. Habits of course include not only living but non-living spaces. After all, even rocks have a *habit* of rolling down hills.

Concerning eggs, it requires two chickens, hen and rooster, to make a fertilized egg. Consider the tale *D'Alembert's Dream* [10] by Denis Diderot (1596-1650), a contemporary of Descartes, who used

the egg to advance his own ideas, which resemble those of Peirce a century later and complex systems a century after Peirce. Diderot describes the fascination of how the little creature inside the fertilized shell moves slowly through its life processes, making its way to the outside world, including an observer hearing the little creature peeping inside the eggshell before breaking through it and able to walk around and flutter its wings in the world of "pain and pleasure" (notice this phrase later in Part 4). Then Diderot asks his friend: "Can you imagine with Descartes that this is nothing but an imitative machine? If so, even the smallest children will make fun of you, and philosophers will tell you that if this is a machine, you're another" [11].

4. Semiotics (Conception)

Before treating Peirce's Semiotics, it is important to emphasize his term *Conception* rather than the traditional term "organization". Note its importance in his *Pragmatic Maxim*: "Consider what effects which might *conceivably* have bearings we *conceive* the object of our *conception* to have. The *conception* of those effects is the whole of our *conception* of the object" [2]. The italics have been added here *five* different times of *Conception* and its derivatives. Peirce's emphasis focuses on the biological and linguistic process of Conception as a *productive* process. For Peirce Conception is an *organic* process, not a static matter of "organization" like adding two and two to get four.

Although he does occasionally use the term "organization" in his writing, he clearly assumes the organic meaning of *conception*. If this is not understood, any description of his Semiotics will get off to the wrong start. Consider the following as a valid paraphrase of Peirce: *The conception of interactive effects makes for the whole of Semiotics, which is itself a conception that consists of an infinite number of component conceptions. The point is to conceive of conception as an active process.*

Semiotics for Peirce is linguistically defined as a flow toward forever *new* definitions. As suggested earlier, what Peirce calls a *representamen* is therefore more than a traditional “representation”, just as the sign’s *interpretant* is *more* than a traditional “interpretation”. *Semiotics for Peirce refers to the complex nature of how language, like nature, brings together organic strands that constitute the originality that emerges in language.*

But this requires a few more comments about *Habits* before turning to *Semiotics* proper.

Peirce tries seriously to understand how nature organizes *Chance* (*Chaos*) into new ways that work efficiently. Such processes can be found not only in nature but in everyday life in the *inevitable* development of *Habits*. As Peirce describes it: “The stream that wears a bed for itself is forming a habit” [12]. Nature in this sense is a *conceptualizing* process. “It appears in the work of bees, of crystals, and throughout the purely physical world thought develops there” [13]. In nature, what happens first occurs spontaneously and then habitually.

Conscious habits may also occur spontaneously, as in developing a taste for a new food, like pasta with pesto sauce, a mere sample of which can quite “accidentally” lead to its becoming a *habit* in one’s current diet. Although a hypothesis may also occur spontaneously as a “bright idea”, however, developing a the careful formulations of a hypothesis usually requires reflective thought, which is rather different from the way nature and everyday consciousness “organize” things.

While nature does not appear to *think*, it can be extremely complex in its formulations, as in the development of a new evolutionary species. This often boggles the minds of scientists trying to understand nature’s slippery attempts to develop such species and achieve what in complex systems is a *grip* that in Peirce’s terms *works*. In Darwin’s terms, this requires competition. in Peirce’s and complex systems terms, this requires organization (*conceptualizing*). In almost

everyone’s terms, it requires time and achieving a good *fit*.

This introduction now makes it possible to deal properly with the content of Peirce’s *Semiotics*. For Peirce *all* signs, not just logic, fall into three (and only three) *Categories: Firstness, Secondness, and Thirdness*. There is no forth category. These three categories are found everywhere in nature’s evolutionary processes and in human consciousness, including logic (hopefully), science (hopefully), language (usually), and everyday life and nature (always). Everything described to this point falls into one or another or a combination of these categories.

Briefly, *Firstness* is the spontaneous dynamics of creativity, wherever it is found. This dynamics is part of every evolutionary process, which produces the *Secondness* of *facticity*, the orderly concreteness that makes it possible to define and analyze things. *Thirdness* refers to the generalizations into which signs *fit* (or don’t) in the larger semiotic (or ecological) frame.

Within *Firstness*, *Abduction* is a new *logical* term that he adds alongside the traditional *Deduction* and *Induction*. *Abduction* adds *chaos, chance, and unpredictability* to the logical frame. *Abduction*, he insists, is *part of*, not just a *preliminary to*, logic. Neither nature nor logic can be understood without *Firstness*. *Abduction* is *Firstness* for Logic. It should be *part* of logic, just as it is of nature, not an addendum to it. For Peirce, *Abduction* makes *probability* the best that logic can do concerning predictability. *Tendency* and *Probability* are the most that can be said about *anything*, including supposed Natural Laws.

Within *Secondness*, *Deduction* is categorially separated from both *Induction* (*Thirdness*) and *Abduction* (*Firstness*), neither of which is as mechanical as what occurs on the *Deductive* tables at a pool hall. No matter happens within the players, every action on the table (supposing it is perfectly level, etc.) is mechanical and predictable, and the obvious deductibles of the game makes Descartes’

ghost very happy. (However, meteorologists play a much more complex game with clouds and the weather. That will be considered in Part 4.)

Within Thirdness, *Induction*, like *Abduction*, is more vague than *Deduction*, but for somewhat different reasons. *Induction* concerns generalizations, locating things within their surroundings, which frequently, according to both Peirce and complex systems, have *fuzzy* edges, unless those edges are defined *very* precisely, which ignores *Abduction*, for whatever reasons. Since reality is dynamic, generalizations, except in such places as pool tables, are usually *at least a little fuzzy*. Unfortunately, generalizations have to try to take into account *what will happen next*, and that always has some fuzziness (Firstness) about it.

Scientifically, logically, and in habits generally, Firstness and Thirdness tend to escape the precision of pure Secondness. Without the fluidity of Firstness, the scientific generalizations of Thirdness become too rigid and cannot grip the real meaning of evolutionary change. Secondness (*Deduction*) has an important place even within complexity theory, especially in niches and feedback loops, which may be reductive and *representational* within their defined and prescribed limits. But in Thirdness, he attempts to provide conceptions that transcend reductive representations.

His triads describe many fields. As he summarizes them: “In psychology Feeling is First, Sense of reaction Second, General conception Third, or mediation. In biology, the idea of arbitrary sporting is First, heredity is Second, the process whereby the accidental characters become fixed is Third. Chaos is First, Law is Second, the tendency to take habits is Third. Mind is First, Matter is Second, Evolution is Third” [14]. As he summarizes them later: “Thus the tendency of habit would be started, and from this, with the other principles of evolution, the regularities of the universe would be evolved” [15].

He does not include in these two summaries the icons, indexes, and symbols basic to Semiotics, but his

elaborations reach 66 different subtypes of signs, the enumeration of which goes far beyond present purposes. Their complexities may not match in detail the complexity of complex systems today, but Peirce’s conceptions have several resemblances that are interesting.

5. Even Clocks are Clouds

Peirce obviously did not develop anything comparable to “dispersed” *self-organization* and *multi-causality* in complex systems, but he does provide some hints of such things.

(1) According to the philosopher of science Karl Popper, Peirce was the first to anticipate *Indeterminacy Theory*. “So far as I know Peirce was the first post-Newtonian physicist and philosopher to dare to adopt the view that to some degree *all clocks are clouds* (rather than the reverse in Newton and in Descartes); in effect that only clouds exist, though clouds of very different degrees of cloudiness” [16]. “In effect” in this quote may make it sound as if Popper is paraphrasing, but Peirce does specifically use the phrase that even “clocks are clouds” [17]. Peirce supports this with considerable experimental evidence from his extensive work with pendulums. Incidentally, Popper also believes Peirce anticipates *Quantum Theory*, which again transcends present purposes.

(2) Peirce also moves toward a conception of *Multicausality* in his work with *Composite Photography*, blending several individual photographs into a single photograph that incorporates differences in lighting, sizes of images, focus, and pixels per square inch from several photographs into a single image. His method is a rational and reflective process rather than the spontaneous process often found in evolutionary change, but it is still literally *multi-causal*. Hookway, an articulate interpreter of Peirce, describes Peirce’s extensive pursuits in this area in some detail [18]. Hookway sees this as Peirce’s efforts to find a convincing proof for his

Pragmatic Maxim, which is discussed earlier. Here the emphasis, however, is on Peirce's hint of multicausality in complex/dynamic systems.

(3) With his efforts to fine-tune semiotics, realizing that a picture can replace a thousand words, Peirce develops what he calls *existential graphs*. These graphs are two dimensional, accustomed as he was to two-dimensional pages and illustrations, but they hint at the picturesque three-dimensional *epigenetic landscapes* of recent geneticist C. H. Waddington. The latter depict genetic changes within a fertilized egg as balls rolling slowly or quickly downhill, depending on pitch, depth, and breadth of valleys confronted. The ball meets occasional separations and re-merging of these valleys, resembling a stream leading toward a river [19]. Peirce himself often utilizes the image of an evolutionary stream, but not in such vivid images. Such evolutionary models in any case make it unsurprising that computer scientists, like logicians before them, are now trying to learn from evolutionary processes how better to do information processing, an effort that began with Brooks and others in 1991 [20].

(4) Finally, Peirce himself in his later work, in some disagreement with his earlier descriptions of hypothesis confirmation, claims that a working hypothesis may occasionally be verified by *instinct* alone that is "independent of any kind of evidence" [21]. This may be a saving grace for complex/dynamic systems practitioners unable to achieve a clear and detailed verification of a hypothesis in a field like the aforementioned *efficacious sub-agential states*, where *multi-causal effects* are obvious, yet *all* the causes are not identifiable with either available or even possible data, given current technology.

6. Environmental Ethics (Perhaps)

Some scientists may balk of course at the thought that ethics has any *integral* rather than *imposed* place in science. But *if* there is an integral *state place* for ethics, Peirce seems to open one, without ever fully

developing it, in his description of how evolutionary change creates *differences* in what occurs historically, as does ethical behavior. The question, however, is whether Peirce can integrate the Firstness of feelings with the Secondness of morality. He finds it possible to integrate feelings with esthetics, which is relatively easy, but although he tries, he finds it impossible to do likewise with ethics. In fact, he dismisses categorically the "psychological" efforts of his contemporaries to develop a coherent ethics. He obviously believes "an exaggerated regard for morality is unfavorable to scientific progress" [22].

He does, however, provide a hint that this might be possible if only the Firstness of feeling could be integrated with the Secondness of ethics. But perhaps it *is* possible, as evidenced in the work of the current cognitive neuropsychologist Antonio Damasio. In *Descartes' Error: Emotional Reason and the Human Brain* [23], Damasio makes it clear that he, like Peirce, opposes Descartes' reductive view of science. And in his later book, *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain*, where he utilizes Spinoza as his primary philosophical source, he quotes in some detail Peirce's favorable comments concerning the ethics of Spinoza [24].

Damasio, like Peirce, believes that feelings have no meaning *until* incorporated into the category of emotions. However, where Peirce finds no grounds for ethics in the emotions, Damasio conceives a neuropsychological alternative. Neurological factors aside here, he notices what Peirce does not, that as feelings emerge rationally as emotions they become spontaneous feelings of happiness/sadness, acceptance/disgust, sympathy/contempt, and success/failure. The former in each of these polarities *feels* good, and the latter *feels* bad, long before someone has time to *think* about what is occurring, let alone develop an ethic from such observations. This makes it possible for Damasio to link, in effect, Peirce's Firstness with his Secondness, providing ethics with a natural and evolutionary frame.

The fly in the oatmeal here concerning Peirce, which becomes so problematic for many scientists that they either ignore the “fly” and speak only of Peirce’s other contributions to science, or dismiss Peirce altogether and never mention him, is the way Peirce seems to violate his own warning concerning ethical intrusions into science. The “fly” is Peirce’s effort to connect his theory of evolution with *Agapic* love, modeled after the Greek term for love in the New Testament, especially the Gospel of John. John believed that love is not only at the heart of ethics but cosmology, including his own primitive version of evolution.

Although Peirce (usually rudely) discards theological efforts to “explain” science, in part because they reject the place of *chance* in nature, and in part because their explanations are rigid and mechanical, he yields to temptation (so to speak) and eats the fly with the oatmeal. It does not make him sick, but the very thought of eating such a fly makes some scientists today feel very ill.

But perhaps he should be forgiven for his transgression. As a professing Christian, Peirce argues that John is actually smarter than Darwin in at least one respect. Like John, Peirce argues that collaboration, i.e., *the tie that binds*, is more important than competition in evolutionary development. If collaboration does not take place, competition is useless and results in anarchy that is antithetical to a conception of evolutionary change. *Peirce may therefore have a point; he just has a strange way to some scientists of expressing it.*

So Damasio’s origin of ethics in polarized feelings at least provides some natural *roots* for decision making, including the making of ethical decisions. Thus he keeps Peirce from pulling the rug from beneath his own feet concerning feelings. Together in any case, they provide the frame for a natural ethic, although neither of them attempts to develop an ethical system as such. In the end, Peirce and Damasio together provide evolutionary grounds for

collaboration, which in Damasio’s terms *feels* good, as any member of a winning sports team knows.

There is established evidence for Peirce and Damasio systems oriented *Game Theory*. The first requirement in order to be successful in collaborative “Prisoner’s Dilemma” games (achieving thereby Damasio’s *feelings* of success) is being “nice” (a variation of sorts of Peirce’s *Agapic* love). Melanie Mitchell reports these game theory results in *Complexity: A Guided Tour* (2009) as an illustration of evolutionary collaboration [25].

All this of course is a mere *sketch*. However, Peirce and Damasio together provide possible roots for an evolutionary ethic. Such an ethic in turn supports environmental scientists and engineers in making ethical pronouncements *as natural scientists*. Furthermore, environmental scientists and engineers who are “nice” to their colleagues will naturally form effective teams that will result in successful *feelings* for everyone involved.

7. Conclusions

(1) Complex systems are not likely to be just another new fad that will not survive. Such thinking and experimental work is making slow but sure progress in many fields, including biology, as Camazine, et al. [26] comment: “Although self-organization and emergent properties are familiar terms in the fields of chemistry, physics, and certain areas of cellular and developmental biology (such as morphogenesis and neurobiology), much needs to be accomplished before these concepts achieve widespread acceptance and utility in other areas of biology”. However, although complex systems are new and different, it must, again, be made clear that complex systems *supplement* rather than *replace* the need for traditional science. Neither Peirce nor most complex systems theorists deny the importance of traditional science in systems, discovered or described, with distinct edges. Peirce conducted sound science utilizing traditional methodology throughout his career.

That being said, in the United States of America, the National Science Foundation makes cooperation and collaboration central in all their recommendations in several recent policy statements, including *Complex Environmental Systems: Synthesis for Earth, Life and Society in the 21st Century* [27]. Acknowledging the complexity of such an undertaking, NSF argues that current environmental problems *require* interdisciplinary collaboration, including the merging of extensive applications of data, and possible collaborations in scientific, political and social interventions as well.

If it were not for information technology, this would be impossible, in part because computers are only beginning to “think” in ways as complex as those of nature. Meanwhile what NSF calls “tipping points” for both “success and failure” (Damasio) are everywhere, as both traditional and complex systems orientations learn to collaborate in getting a “grip” on problems such as coral bleaching, which threatens to jeopardize extensive ocean ecology.

(2) Concerning the issue of analogy and metaphor, *Dynamic Systems* cognitive scientists Thelen E. and Smith L. utilize *Waddington’s epigenetic landscapes* in their model of how a young child learns to walk. A child employs an evolutionary process that requires simpler and requires less energy than a sophisticated robot “learns” to walk using meticulous programming. In commenting on their own work in child development, they coincidentally put the analogy/metaphor issue quite well: “A dynamic system is no *mere* (italics in text) metaphor. It is a *metaphor* (italics added) that turns empirical questions around by focusing attention on mechanism, the relation between stability and variability, and the process of change” [28].

In the near future, new scientific definitions of metaphor may emerge, and/or new relationships between analogy and metaphor. Time will tell.

(3) As complicated as both Peirce and complex systems may appear, they deal with everyday matters,

as illustrated in the following illustration: when writing a paper, an evolutionary agent might begin by gathering spontaneous insights that occur while reading and thinking about a paper. Eventually, piles of notes began to organize themselves, some evolutionary failures discarded in the process. At first, everything is a mess. Then the evolutionary process of *conception* begins to focus. First a general outline and then a first draft appears. Eventually, this reaches a final draft. Meanwhile, in the last stages, the paper seems to be writing itself without much effort.

Now, who or what is doing this relatively automatic writing? There are two basic alternatives, each attractive in a way. One is that all this is a slow moving but nevertheless mechanical process. The reductionist rationality involved is simply unconscious but still functioning. This makes for a “balls on a pool table” explanation. But this interpretation provides no easy justification for such things as constructing a pool hall made of pool balls, which is a creative and artistic process. So is the evolution of the pool game itself, as well as every game that is played.

Such novelties are found everywhere, including esoteric technical language. Both Peirce and *Complex/Dynamic Systems* are more than merely another *strange way of saying things*.

(4) Now, what has become of Peirce and the chicken house in all this? It comes down to this question: as someone writing over a century ago, doesn’t Peirce warrant some credit for *conceiving* all this? And, using the image of an egg one more time, perhaps what started with Peirce simply needed a century to incubate before hatching into *Complex/Dynamic Systems*—the new chick in the chicken house.

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