The Crying of Lot 49 and C. S. Peirce's Theory of Self-Organization

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The possible relevance of the unusual names Oedipa, Thurn and Taxis, and Pierce Inverarity to themes in *The Crying of Lot 49* has intrigued Pynchon critics since the novel's publication. Oedipa's name, many agree, points to her role as a solver of riddles, after Oedipus, who answered the riddle of the Sphinx. The historical postal family Thurn and Taxis has been investigated, but nothing particularly significant about the name itself has been found. Regarding a Pierce/Peirce link, in "a novel so concerned with signs and the processes of signification," John Johnston observes, "Pierce's name evokes the name of the American founder of semiotics, C. S. Peirce" (52, 56). In fact, evidence suggests that all three names are linked to one another through C. S. Peirce (1839–1914)—not necessarily his semiotics, but his less well-known theory of self-organization. The way each name functions can be understood in relation to what I consider the main question of the novel: What is responsible for organization that emerges out of an essentially anarchic world, a world without a centralized source of direction?

Self-Organization and Teleology

Self-organization has received much critical attention in the sciences and in philosophy since the early nineties when the study of nonlinear dynamics entered the mainstream under the name "complexity sciences." C. S. Peirce's theory can be considered a predecessor of these newer theories,[2] which provide simple models with which we can more easily recognize the Peircean elements in *Lot 49*. The sciences of complexity define self-organizing phenomena as systems composed of stochastically interacting parts that spontaneously produce structurally complex wholes. Due to nonlinear relations in the interaction of the parts, the whole is more than the sum of the parts: it cannot be described reductively. The complex outcome of low-level mechanistic behavior seems to require additional guidance. Weather systems, such as tornadoes, are self-organizing, as are economic systems in free-trade environments, but self-organization is a property generally associated with biological organisms. As Kant writes,

> [E]very part [of an organism] is thought as *owing* its presence to the *agency* of all the remaining parts, and also as existing *for the sake of the others* and of the whole, that is as an instrument, or organ. . . . [T]he part must be an organ *producing* the other parts—each, consequently, reciprocally producing the others. . . . Only under these conditions and upon these terms can such a product be an *organized* and *self-organized being*, and, as such, be called a *physical end*. (§65)

Kant argues that, since the interactions of parts of a complex system are stochastic (individually determined but not directly correlated as a group), they must owe their self-organization to *telos*, the universal laws that govern the functional relations among parts and wholes. Any discussion of self-organization inevitably entails teleology, the study of the appearance of inherent design. As James P. Crutchfield notes, even contemporary descriptions of the phenomenon continue to use the term *self*-organization, attributing a teleological "self," a consciously directing self, to a system that simply, albeit surprisingly, "organizes" according to the underlying dynamical constraints operating in a nonlinear system (480).

Teleological behavior is commonly misunderstood today as a *linear* phenomenon. J. Hillis Miller claims that a linear narrative "tends to organize itself or to be organized in a causal chain" and follows an "inevitable sequence" according to a "*telos*, *arche*, or ground" (18). Derrida critiques the notion of telic order insofar as it derives from "a linked chain of determinations from the center" (960). He equates the center with both *arche* and *telos*. Given that the understanding of teleology as linear contradicts the way teleologists have thought of their own work and the way self-organization is understood today in physics, some clarification is needed to avoid confusion about my use of this concept. While teleology is partly concerned with developmental stages of increasing complexity, the transition from one stage to the next is not linear. Each new stage is surprisingly more complex than reductive analysis of the initial conditions implies. The idea that teleological or goal-directed activity is linear may derive from late–nineteenth- and twentieth-century analytic philosophers who, in direct contrast to early–nineteenth-century teleologists, tried to fit telic behavior into a reductionist paradigm. As Lowell Nissen has demonstrated in analyzing the seminal literature, this cannot be done.[3]

In this essay, *telos* is to be understood as follows: A teleological explanation is necessary only if a purpose is fulfilled in a way that could not have been predicted by analyzing the initial conditions or the starting point that led to the goal; in retrospect, however, it appears as if each stage in the process were a condition for the advantageous or

more complex property, quality or event that eventually emerged. This is the very situation that nonlinear-dynamics theorists now explain: they claim that self-organizing systems, while completely deterministic, are irreducible and hence unpredictable because effective factors (for example, function and context) unaccounted for in the system's initial measure of energy are later generated by the dynamics, the interactions of the parts and the whole. Thus one may say that these complex systems are capable of spontaneous increase in complexity, or progressive behavior. At the same time, however, the degree of unpredictability is constrained by the dynamics that govern the system as a whole. Behavior, then, is directed as well as original. Only nonlinear feedback results in an act that could be considered intentional, that is, determined and yet free (see Alexander).

According to Kantian philosophy, telic systems are purposeful, that is, designed in such a way as to create and then to sustain the whole by sometimes resisting change and sometimes adapting to it. Retrospectively, behavior seems goal-directed, progressive, creative, autonomous or intentional. Most important in regard to an analysis of *Lot 49*, according to a strict understanding of teleology, the design of telic systems is inherent, given in the dynamical interactions of the parts, not imposed arbitrarily from without by a designer.

In Pynchon's novel, *telos* appears as the counterforce to entropy. By definition, all telic systems are anti-entropic or far from equilibrium. Any self-organized system will eventually begin to expend more energy than it takes in, and it will no longer be able to maintain its organized structure, slowly becoming as disorganized as its environment. Although self-organized systems eventually do expire, it is nevertheless nothing short of miraculous that organization arises in the first place from disorganization. Given the second law of thermodynamics, which states that disorder is more likely than order, the occurrence of spontaneous organization in our (presumably closed) universe is truly surprising. The mysterious appearance of order out of chaos, investigated perennially by teleologists, is also investigated by Pynchon.

The debate over teleological phenomena has historically taken several forms: for example, argument-from-design teleology, Aristotelian/Kantian teleology and a pseudo-teleology commonly known as Providence. These competing theories of the origins of design-like structure are sources of tension in *Lot 49*. I will return to the subject of Providence a bit later; first I will look at orthodox teleologies.

Proponents of the argument from design[4] contend that apparent design in nature proves the existence of a supernatural designer, external to the universe, who is able to look ahead, plan and program events according to his ideas of fitness, harmony, cooperation and

perfection. After setting his universe in motion according to his laws, the designer left it to run on its own, maintaining itself through checks and balances like a fully independent telic system. If one wanted to stress the notion of a timeless designer, one would say his telic laws are given beyond the material universe rather than before time. But the important consideration here is that, in this form of teleology, the existence of telic laws leads to the supposition of a Lawgiver. Argument-from-design teleology, which I associate below with Thomas Aquinas, locates the source of the laws somewhere outside the system in which they function.

Aristotelian/Kantian teleologists argue that inherent design (that is, pattern/orderliness) in biological systems and in the universe as a whole is created by internal automatic principles. These teleologists believe that a nonphysical cosmic intention is immanent in physical interactions of the parts of the system itself. They posit an internal set of constraints implying not a rational creator but a rational universe.[5]

C. S. Peirce and Norbert Wiener on Self-Organization

C. S. Peirce is related to the Aristotelian/Kantian group of teleologists, but he went a step further. He provided the first naturalistic answer to the question of the origin of supposed internal automatic principles. Aristotle and Kant had left the origin of *telos* unexplained in their teleology/physics and dealt with it in their metaphysics instead.

Like many other readers of Pynchon, I had long suspected that C. S. Peirce was implicated in *Lot 49*. When Louis Menand pointed out recently that Peirce's obsession with the phenomena of self-organization was actually an obsession with the Maxwell's demon problem (189–99), I resolved to investigate the possible link more carefully. Peirce believed the demon's effects were produced by a sorting mechanism comparable to Darwin's mechanism of natural selection. He generalized natural selection and applied it to the laws of physics. Dealing strictly with the way mathematical probabilities interact over time, Peirce's notion of selection does not depend on any kind of Darwinian fitness but on the fact that chances narrow themselves as systems engage in feedback.

The theory of self-organization usually identified with *Lot 49* is Norbert Wiener's theory of cybernetic self-organization.[6] In the introduction to *Slow Learner*, Pynchon acknowledges Wiener's influence (14) and thus, in effect, discourages the search for additional or competing influences. Wiener coined the term cybernetics based on the Greek *kubernetes*, which means steersman and is also the source

of our word governor. This is an apt appellation because a self-organizing system does appear to have a self that governs it. In Maxwell's terms, such a self is called a "pointsman for flying molecules" (qtd. in Leff and Rex 39). Maxwell's pointsman was later dubbed "Maxwell's demon."

The main thrust of Wiener's work was to critique the supposed efficiency and practicality of a constantly interfering centralized control —a demon, if you will—that watches over and organizes a system according to a predetermined plan. He argued that feedback and distributed systems work better because they function intelligently in their environments by interacting with their surroundings and adjusting themselves accordingly. For example, a heating system controlled by a thermostat is more efficient than one that has to be manually adjusted as the temperature changes. Note that Wiener dealt with "intelligent" or "intentional" machines built by humans. His self-organizing machines can run on their own and maintain themselves through feedback after their designers have set them running.

Peirce, in contrast, was more interested in "design" that emerged spontaneously in nature through feedback without the help of a designer. His theory involves true automation. It requires neither designer nor Prime Mover.

Although some may consider Wiener a critic of the teleological view of the world, he, like many others, mistakenly associated teleology with the idea of a rigid plan of action imposed by an external and constantly intervening central control. Wiener appears to have believed he reinscribed the word "teleological" to fit his concept of the behavior of cybernetic machines that are programmed to adjust themselves through feedback. His theory actually has a great affinity with conventional teleology, properly understood. The most important difference is that Wiener had no concept or intuition of nonlinearity. (Kant seems to have had some suspicion of nonlinear effects.) Wiener tended to conflate antireductionist teleology (which some deist-teleologists refer to as general Providence) with special Providence. Believing in ontological emergence of either *telos* or chaos was to Wiener tantamount to believing in Manichean forces of Good and Evil (188).

According to Frank Kermode, *Lot 49* explores a question similar to the one I posed at the beginning of this essay: "Is there a hidden plot concerning an almost Manichaean conflict, which makes sense, whether evil or benign, of the randomness of the world?" (162). While Peirce would not have been interested in framing the question this way, Wiener was. His answer was no; only paranoia makes it seem so. Wiener held to reductive determinism.

Peirce was more ambitious in his approach to the problem. He sought to describe the appearance of the generative forces of good or, rather, telic order scientifically without succumbing to reductionism. According to Peirce, order is emergent, neither predetermined nor derived from Platonic essentialism; but it is in some sense objective, and it is governed by the laws of chance. Peirce did not, however, think enough about the generative forces of evil to allow him to develop a notion of deterministic chaos, which, one might say, is the other side of the coin of nonlinearity. He believed, with the Pre-Socratics, that the decaying forces of evil or, rather, the primordial chaos was nothing, in the sense that absolute undifferentiation can have no effects. Peirce imagined that the ultimate fate of the cosmos would be the reverse of heat death: everything would become more ordered or crystalline.[7] However, since nonlinear systems can generate novel randomness, such a fate is unlikely. Note that Wiener, as a reductionist, also rejected the idea of a force that could actively generate chaos. He thought disorder was due only to the predictable effects of the second law of thermodynamics.

Peirce's theory contrasts in several interesting ways relevant to *Lot 49* with Wiener's ideas about cybernetic self-organization. Peirce offered an alternative to Wiener's belief, given the second law,

> that the whole universe around us will die the heat death, in which the world shall be reduced to one vast temperature equilibrium in which nothing really new ever happens. There will be nothing left but a drab uniformity out of which we can expect only minor and insignificant local fluctuations. (31)

Peirce argued that local fluctuations were *not* insignificant because they could be spontaneously magnified over time. In fact, he thought infinitesimal irregularities appearing in the "original chaos" were the very source of all order and physical laws, which emerged in time. Peirce's hypothesis is now believed to be closer to the truth than Wiener's. Stephen Hawking, for example, has argued (drawing on Linde's chaotic-inflation hypothesis) that sufficient amplification of fluctuations in the positions and velocities of particles in the highly entropic early universe would "explain the origin of the structures we observe around us" (114).[8] According to this theory, no intelligent agent would be required to provide the design for the creation of structure or its evolution: the laws of structure would evolve spontaneously.

From Sameness to Variety

A system in equilibrium (at maximum entropy) is not *structured*, is on average *homogeneous* or is uniformly disorganized. However, the entropy of a system is only a statistical quantity. Due to fluctuations around equilibrium, small subsystems of molecules may exist that are by chance more similar to each other than to others in their neighborhood. These fluctuations would create local *differences*.

Peirce's exploration of self-organization opens with the question of how variety (difference) can spontaneously arise from sameness (entropy). His use of the term variety to describe difference is significant because this term is historically associated with the pre-Socratics' analysis of the problem. As Tony Tanner notes, Pierce Inverarity's name sounds like "'pierces or peers into variety'" (57). Peirce argues that primal matter (which the pre-Socratics called the *arche*) could come to exist spontaneously as fluctuations around equilibrium. These fluctuations would emerge as subsystems having some regularity compared to their more entropic surroundings. According to Peirce, "The existence of things consists in their regular behaviour" (278). Primal matter is the kind of structure or difference a Maxwell's demon could recognize. But to avoid introducing a localized director into a spontaneously organizing process, Peirce thought it better to say that the structure of primal matter would lead to self-reinforcing effects and eventually telic behavior. In contrast to Derrida, Peirce is careful to preserve a distinction between the *arche* (chance structures) and *telos* (the dynamical constraints and physical laws that emerge out of stochastic interactions of chance structures).

In "Design and Chance," using the analogy of a game of chance, Peirce demonstrates how an even distribution of elements might segregate itself spontaneously. While one throw of a single die has an equal probability of producing one, two, three, four, five or six, a sequence of two throws more often produces a sum of seven than of two. Seven is more likely because it can result from a number of combinations: one and six, six and one, two and five, five and two, three and four, and four and three. Thus not all bets are equal. To illustrate how chance has its own built-in biases that become important over time, Peirce asks his readers to imagine a million gamblers at a table:

> Each bets one dollar each time [with] an even chance of winning or losing. . . . Now it is a curious & apparently paradoxical result that although everything is supposed to happen by pure chance yet we know . . . how those million players will stand at the end of a million bets. About 10 will

> have lost $2000 or more, no one over $3000; and half of them after playing day and night for nearly a fortnight at the rate of one bet a second will stand within $300 of where they started.
>
> But now we will suppose that the dice used by the players become worn down in the course of time. Chance changes everything & chance will change that. And we will suppose that they are worn down in such a way that every time a man wins, he has a slightly better chance of winning on subsequent trials. This will make little difference in the first million bets, but its ultimate effect would be to separate the players into two classes those who had gained and those who had lost and these classes would separate themselves more and more, faster and faster. (220)

Peirce stresses that nature is forced to build on the past, further narrowing choices and increasing the biases in the game. By speculating about such feedback mechanisms, Peirce was, in effect, beginning to describe nonlinear dynamics, which complexity scientists now use to understand the kind of self-organizing phenomena Aristotle and Kant identified as telic. Peirce's theory explains order out of chaos and does not require an external intelligence to activate the mechanism that creates order. That mechanism is chance itself.

Oedipa Maas

The idea that chaos is actually the source of order rather than the enemy of order bears on the function of Oedipa Maas's name. Some attempts to interpret "Oedipa" have assumed that a postmodern reading is called for. To Chris Hall, for example, "the name Oedipa comes to signify, albeit paradoxically, postmodern dilemma." Rejecting the description of "Oedipa, like Oedipus, [as] a solver of riddles," Hall argues that "in a 'classically' ordered world, riddles are posed and have solutions; for [postmodern] Oedipa, however, riddles are posed only in fragmentary and indeterminate terms, and any solution is probably unattainable" (67). Hall seems to suppose that quantum indeterminacy makes finding solutions to riddles unlikely. But according to Peirce, the initial indeterminacy of the universe *is* the solution to the question of the origins of order. If Peirce can be linked to *Lot 49*, then Oedipa's name indicates her potential as a successful solver of the riddle of the universe, even if the novel's ending before the crying of lot 49 leaves her ultimate success in question.

Circumstantial evidence supports the argument that Oedipa's name points to Peirce. Peirce's principle essay on spontaneous organization, "A Guess at the Riddle," refers explicitly to the riddle of the sphinx answered by Oedipus. Peirce requested that a drawing of the sphinx

accompany the essay in publication. Finally a connection has been found between Oedipa as a solver of riddles and the kind of riddle posed in *Lot 49*: What is the source of apparently telic order? The answer, like the answer to any good riddle, is delightfully surprising: disorder.

If *Lot 49* explores both Wiener's and Peirce's theories, then Oedipa Maas is a divided character who confronts several theories about the origins of order in the universe and the appearance of purposeful phenomena in nature. On this issue it is interesting to note Bernd Herzogenrath's suggestion that Oedipa's last name derives from Helmholtz's title *"Entropie als das Maass der Unordnung,"* which contains an unusual spelling of *Maß* (108). Herzogenrath notes that Helmholtz made the first explicit prediction of the heat death of the universe. Helmholtz is also known for having made a fatally destructive argument against German teleomechanism (that is, nineteenth-century theoretical biology derived from Kantian teleology) and its theory of self-organization (Lenoir 195–215). Years later, Helmholtz's argument was found to be incorrect, but by that time biologists were interested in Darwinism as *the* explanation of the appearance of order in the biological world, and teleomechanism, which depends on a neutral selection rather than selection based on reproductive fitness, was not revived. An altered teleomechanism has since returned (and now supplements Darwinism) as structural evolution and complexity science, and, as I suggested above, these areas of scientific inquiry have affinities with Peirce's theory of self-organization.[9] If I am right about Peirce and Herzogenrath is right about Helmholtz, Oedipa Maas's first and last names suggest she owes her existence, as all life forms do, to her complex position between the forces of *telos* and entropy.

Teleology versus Providence

A third theory of the origins of order operating in *Lot 49*, Providence, contrasts with theories of automatic self-organization. Providence is similar to teleology insofar as it also depends on a notion of reverse causation: events are thought to be caused by the purposes they eventually serve. (Teleology approaches the notion of reverse causation with a different emphasis: the behavior of any part is shaped by the irreducible context in which it functions; the preexisting laws that guide functional relations determine this interaction, and thus determine the parts.) However, special Providence relies on unnatural or supernatural intervention, which can be quite arbitrary and unpredictable. For example, in *Lot 49*, a "Hollywood [distortion] in probability" implausibly delays the death of a character "*so* he could

make a farewell speech" (43; italics added). Providence operates beyond time and space; thus it is not constrained by the laws of physics (it may not break the laws, but it is indifferent to them). Its ways are mysterious to those existing in time who cannot understand how the end can affect the beginning. Belief in Providence encourages looking at life as if it were a narrative composed by an author (outside narrative time) who reworks the various parts so they all contribute to an overall theme. "What Oedipa is doing is very like reading a book" (Kermode 163). In a world that is above normal laws of cause and effect, coincidences may indicate a different kind of causality: authorial intention. Such an attitude is fine for reading a novel, but as a way of reading life, it may be a form of paranoia. Edward Mendelson finds signs of (a demonic) Providence in Trystero, whose (potentially false) continuity manifests itself in the muted post horn that "recurs in countless settings, in children's games, in postmarks, lapel pins, tattoos, rings, scrawled on walls, doodled in notebooks—in dozens of contexts that cannot, through any secular logic, be connected" (132). Trystero as demonic Providence reflects Wiener's notion that belief in Manichean Evil is the product of paranoid delusions.

Distinguishing between merely coincidental patterns, or luck, and real self-organized patterns has always been a main concern of teleologists. Aristotle insists that *telos* guides only those events that are probable. He attempts to distinguish telic purpose (caused by inherent laws) from accidental functionality (thought to be caused by an external, superintelligent agent). In philosophy, a standard example of accidental functionality is a rock that accidentally drops onto one's desk, preventing one's papers from blowing away, thereby functioning as a paperweight. In *Physics*, Aristotle relates the story of a creditor who runs into his debtor at an opportune moment and thus is able to collect the money he is owed. Aristotle criticizes superstitious people for seeing such a lucky event as telic just because it happens to serve a purpose. He claims that telic events are only those that happen "*always* or *usually*" (2.5). In *Poetics*, he relates another story of a statue of Mitys that happens to fall and kill Mitys's murderer (9.12). Believers in Providence might regard such events as guided by divine ends, but orthodox teleologists do not.

Peirce distinguishes between "real thirds," feedback in self-organizing phenomena, and "accidental thirds," accidental functionalities, which he, like Aristotle, associates with superstitious reasoning. Accidental thirds introduce "an idea not contained in the data, which gives connections which they would not otherwise have had" (261). Thus it is with Oedipa when she realizes there are "coincidences blossoming . . . wherever she looked, [but] she had

nothing but a sound, a word, Trystero, to hold them together" (109). As Mendelson observes, "manifestations of the Trystero . . . are always associated in the book with the language of the sacred and with patterns of religious experience" (117). To a teleologist, the "'accidental correlation[s]'" (CL 93) that suggest intervening supernatural control are just accidents.

One of Oedipa's tasks seems to be that of distinguishing mere luck and coincidence from telic order. At one point in the narrative, she explicitly recognizes self-organization as such. A group of deaf-mute dancers, each following an idiosyncratic rhythm, spontaneously produces an organized dance:

> Each couple on the floor danced whatever was in the fellow's head: tango, two-step, bossa nova, slop. But how long, Oedipa thought, could it go on before collisions became a serious hindrance? There would have to be collisions. The only alternative was some unthinkable order of music, many rhythms, all keys at once, a choreography in which each couple meshed easy, predestined. Something they all heard with an extra sense atrophied in herself. She followed her partner's lead. . . . She was danced for half an hour before, by mysterious consensus, everybody took a break, without having felt any touch but the touch of her partner. . . . [A]n anarchist miracle. (131–32)

Oedipa thinks the orderly dance that arises out of the stochastic interactions would require too many unlikely coincidences of people taking the right steps at the right times; therefore she speculates that the emergent self-organization is somehow predetermined by law. Such speculations characterize all forms of teleology.

Thurn and Taxis and Teleology

Thurn and Taxis is a historical European postal service. But why does Pynchon refer to it and its mail carriers in *Lot 49*? First, Thurn and Taxis is linked—by a coincidence of which Pynchon may have been aware—to medieval argument-from-design teleology. Second, it is also linked through a pun to one of the most common forms of self-organization studied in twentieth-century biology.

In the Middle Ages, St. Thomas Aquinas reinterpreted Aristotelian teleology to accommodate his notion of a creator. In the Thomist view, a person's nature is a telic force, implanted by God, which guides the person in the right direction (I.103.1). The right direction for St. Thomas was toward "the light." A surprising, accidental correlation between the name of the postal service and Thomist teleology has

already been mentioned by Joseph Slade: Princess Marie von Thurn and Taxis was Rilke's patron, to whom he wrote in 1912 about El Greco's *Ascension* that the upward movement of the angels depicted in the painting seems unwilled, inevitable, unable to "help itself. This is the physics of Heaven" (qtd. in Slade 211). El Greco's angels, by nature, can only rise toward the light.

This indirect link between Marie von Thurn and Taxis and Thomist teleology is just a coincidence. However, Thomist teleology can be linked more directly, through Wiener, to Thurn and Taxis. While St. Thomas thought of *telos* as a natural tendency, particularly strong in angels, to turn toward the light, Wiener wrote extensively about phototropism and "tropism machines," which are, like angels, programmed to detect and move toward light (165). So both St. Thomas and Wiener were interested in automatons designed to act in a specific way using feedback mechanisms. And phototropism is very similar to another form of self-organization called *thermotaxis*, spontaneous movement toward heat. An evenly distributed collection of biological cells will sort itself into clusters around a heat source. If Pynchon knew of thermotaxis, there can be little doubt he intended the pun that can be made on the name of the historical postal service Thurn and Taxis, whose function was to sort mail before delivering it.

Thermotaxis, as well as the similar mechanism of chemotaxis, has been most widely studied not in angels but in *Dictyostelium discoideum*, a type of amoeba also known as slime mold (see Marée). Chemotaxis is the process by which individual slime-mold cells spontaneously self-organize in response to chemical signals in the environment. Slime-mold studies are numerous, and Pynchon, when a student of basic biology, likely had some introduction to slime-mold aggregation, the standard example of self-organization.[10] (Pynchon refers to slime-producing "Fungus Pygmies" in *Gravity's Rainbow* [523].[11])

At the time Pynchon wrote *Lot 49*, most biologists were convinced there must be some predetermined "founder cell" or special "pacemaker cell" that initiated the movement of other cells toward it with a chemical signal and thus governed slime-mold organization (Keller). These biologists' search for such a cell may be compared to John Nefastis's search for a demon. Other biologists, such as Evelyn Fox Keller, advocated a Peircean form of spontaneous self-organization instead, but they were the minority. (Pierce Inverarity, perhaps not incidentally in this regard, facetiously refers to himself as a "founding father" [26].)

Any slime-mold cell will produce the chemical acrasin when food becomes scarce and it is beginning to starve. Acrasin diffuses through

the medium in which slime-mold cells are suspended. When a cell detects acrasin, it moves toward the source. Starving cells near each other clump together quickly and begin drawing more cells (and even smaller clumps) toward themselves (Keller and Segel). Because acrasin goes from one cell to another throughout the medium, biologists say the cells communicate. This links self-organization with another theme of *Lot 49*: "'Communication is the key'" (105), as Nefastis tells Oedipa, for systems that self-organize.[12] Because communication among the cells occurs, an overall pattern can begin to "habituate" (to use a Peircean term) within the group. After slime-mold cells aggregate, they die, but their bodies pile up to form stalks, which release spores, which travel to other regions with possibly better food sources. The aggregating cells are teleological in the sense that they appear to sacrifice themselves *in order to* ensure the survival of the species.

In contrast to this constructive form of communication, Trystero may be seen as an anarchic, disruptive underground force of *mis*communication (using falsified and corrupted texts, and forged stamps) bent on undermining official systems. Stochasticity can result in either order or chaos, depending on the dynamics. Trystero may be a "blind, automatic anti-God" (165) opposed to Thurn and Taxis's *telos*. Sometimes it appears to be a delusion due merely to the effects of entropy (as Wiener might have argued), and sometimes it appears to be a demonic force of organized disorganization.

Before communication among slime-mold cells begins, they are evenly distributed in the spatial field. The field is symmetric: that is, approximately the same degree of disorder/order is found anywhere one looks. A maximum number of bits of information is required to describe a symmetric field. When the field begins to become differentiated, this symmetry breaks. Oedipa, we recall, "wait[s] for a symmetry of choices to break down" (181). Breaking symmetry, the field of evenly distributed slime-mold cells begins to organize into clumps. Fewer bits of information are required to describe a field that contains some structure. In other words, the entropy of the field decreases.

Just as Peirce thought primal matter formed spontaneously, self-organization begins to occur in slime mold without the direction of a special founder cell, if the initial conditions of the slime-mold cells are not perfectly equal. A random distribution of cells is highly unlikely to be perfectly random (that is, without some chance regularities or fluctuations around equilibrium). Slime-mold cells that happen to have the worst luck in their lives and reach the point of starvation sooner than others will begin producing acrasin before the others and may end up being the center around which other cells aggregate. Bad luck for particular cells is due not to a God-given less-fit nature (as a Thomist

would argue) but to the chance that they find themselves relatively close to other cells and the fact that in any high-concentration area the food will be exhausted more quickly. This explanation may bear on why Pynchon uses disenfranchised groups in *Lot 49* to represent those who are likely to self-organize—for example, through the anarchist politics of Jesús Arrabal. Unlike the old system headed by the aristocratic Thurn and Taxis family, which embodies Thomist teleology, the new Peircean system (characterized by a similarity to thermotaxis) is anarchic. The selected pacemaker cell, the leader of the new social organization, does not need to be specially programmed for that role, but can become the pacemaker by virtue of the bad luck of having begun to starve first.

The general principles underlying the self-organizing tendencies of slime mold are relevant to the tendency toward increased structural complexity of larger biological organisms and other natural systems. Slime-mold studies reveal a sorting mechanism that only seems to be organized by an intelligent force (that is, a cell with a special design that makes it produce intelligible signals drawing other cells toward it). This sorting mechanism is attributable to chance (and feedback): in the case of slime mold, to a nonuniform distribution of cells in a field; in the case of the universe, to fluctuations around equilibrium in the primordial quark soup.

The link between Pierce Inverarity and C. S. Peirce suggests that Pynchon explored an alternative to Wiener's belief in the inevitable increase of entropy. Furthermore, Pynchon might have recognized that, while Wiener's theory of self-organization describes how to build machines that work efficiently, using feedback mechanisms rather than relying on a centralized control ("'automatic as the body itself'" [CL 120]), Wiener does not theorize how spontaneous organization initially arises from chaos without some external intelligence. In this regard, Wiener's cybernetic teleology is not essentially different from Thomist teleology. Peirce's self-organization, by contrast, is explicitly leaderless.

Social and political anarchy, the theme on which Pynchon bases the denouement of *Lot 49*, is a form of stochastic behavior very like that of individual amoebae in slime-mold aggregation. Such anarchy spontaneously produces order. As Oedipa learns from Arrabal,

> "You know what a miracle is. . . . [R]evolutions break out spontaneous and leaderless, and the soul's talent for consensus allows the masses to work together without effort, automatic as the body itself. And yet, señá, if any of it should ever really happen that perfectly, I would . . . have to cry miracle. An anarchist miracle." (120)

Peirce, after Oedipus, offered a guess at the riddle, a theory of the origins of variety (difference) from sameness (entropy) that he saw as a solution to the Maxwell's demon problem. His theory names no predetermined leader, and thus supports Pynchon's theme of anarchy. The mechanisms described by Peirce's theory resemble the self-sorting mechanisms of thermotaxis, and this resemblance supports *Lot 49*'s mail-sorting/information-sorting theme. The cumulative weight of this evidence persuades us to believe that C. S. Peirce is behind Pierce Inverarity.

—Dactyl Foundation for the Arts & Humanities

Notes

[1]I thank Jewish Foundation for the Education of Women and the Dactyl Foundation for the Arts & Humanities for the financial support of this research; the Santa Fe Institute for providing me with resources and opportunity to refine my concept of teleology and intentionality; Louis Menand and Joan Richardson for introducing me to Peirce; and Jim Crutchfield for giving me some understanding of nonlinear dynamics and for helping me write an earlier version of this essay.

[2]Prigogine and Stengers name Peirce as an influence (302–03).

[3]For further analysis of teleology as a nonreductive science, see Timothy Lenoir.

[4]See Charles Bell and William Paley for two well-known examples.

[5]Kant would later add, however, that a creator might be supposed by the reflective judgment if not the determinate judgment. He thus let a creator in through the back door. I am concerned here only with the first part of his argument: behavior that appears designed does not empirically prove the existence of a designer.

[6]Martin E. Rosenberg has compared the complexity sciences to the theme of self-organization in *Gravity's Rainbow*.

[7]The fate of becoming "like a crystal" is explored in Pynchon's *V.* (340), and thus Peirce's influence may operate in that novel as well.

[8]In subtle contrast to Hawking, nonlinear-dynamics theorists tend to stress that, independent of whether the state of the early universe was characterized by quantum fluctuations or was completely uniform, other effective factors (such as function or context) unaccounted for in the measure of the energy at any moment are later generated by the dynamics. Hawking's observation seems to miss this crucial point.

[9]For an overview of structural evolution, see Crutchfield and Schuster.

[10]Pynchon expresses interest in biological self-organization in "Is It O.K. to Be a Luddite?" where he insists on the importance of "research and development in artificial intelligence, molecular biology and robotics" (41).

[11]I am not sufficiently familiar with the bright-green fungus that grows between layers of petroleum and water mentioned in *Gravity's Rainbow* to say how closely it is related to slime mold, which is usually bright yellow and found in compost heaps, but a connection seems plausible. Doubtless similar laws of self-organization apply in both cases.

[12]We might also cite a link to Wiener's idea of "communication and control" in machines, but his reductive understanding of communication and feedback does not approach the complexity necessary to describe biological processes, which are nonlinear.

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