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Glenn Harlan Reynolds

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Essay

***110** CHAOS AND THE COURT

Glenn Harlan Reynolds [FNa]

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Professor Laurence Tribe has recently made some interesting observations on the usefulness of analogies from the physical sciences in understanding constitutional law and the role of the Supreme Court. [FN1] Tribe's observations are made more valuable by his good sense in not pushing them too far: he does not suggest that constitutional law is "just like" quantum mechanics, or that lawyers can derive concrete legal answers from the paradigms of modern physics. Rather, he suggests that just as classical constitutional thought was strongly influenced by Newtonian paradigms of clockwork precision, regularity, and objectivity, [FN2] so modern constitutional thought might gain from an appreciation of post-Newtonian concepts like "observer effects" and the ability of objects to influence one another at a distance by distorting the very fabric of the space they occupy.

Tribe makes a number of interesting points, but he does not discuss one aspect of modern science that seems particularly applicable to current constitutional debate. That aspect is "chaos" theory, invented by mathematicians and widely used by scientists, which has to do with the discovery that even seemingly

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simple and determinate systems are capable of displaying apparently random-and genuinely unpredictable-behavior. [FN3] Chaos theory, which deals with "orderly disorder created by simple processes," [FN4] may be an especially useful source of analogy because it suggests an important parallel between constitutional scholarship and modern physics-the degree to which both are engaged in a quest for "grand theories" that will explain events without contradictions or messy uncertainties. [FN5] And the lessons of chaos theory suggest that, difficult as such an effort might be for physicists, it is ***111** likely to be much tougher for lawyers. The reason, as we will see, is that lawyers generally demand more from our theories than do scientists nowadays; [FN6] we try too hard to find theories that predict outcomes, and we despair unnecessarily when such efforts fail. Worse yet, we do these things largely out of a misguided effort to be "scientific," when scientists themselves have managed to come to terms with uncertainty, and even to put it to work.

To make this clear, it is worth backing up a bit and providing a rudimentary explanation of what chaos theory is all about.

Simply put, chaos theory describes the manner in which even very simple systems can behave in unpredictable ways in response to two kinds of factors: extreme sensitivity to initial conditions-for example, when a person misses a bus that runs every ten minutes and for that reason misses a train that runs every hour; and recursion-the feeding back of previous outcomes into the determination of the next set of results. One of the simplest examples of chaos in a physical system is a dripping faucet, and its regular-but-not-really drip. When a drop forms at the end of a faucet, it begins to sag downward. At a certain point (determined in part by shape, size, and downward velocity), most of the drop detaches and falls down; the rest springs back upward as a result of the released weight. The timing and character of the next drip depend on how this springiness relates to the steadily increasing weight of the water remaining on the faucet: if a drop starts its life heading down, it will break off sooner; if it starts out on the rebound, it will last a bit longer. So the behavior of each drop depends in part on that of the drop before it, which in turn depends on that of the previous drop, and so on. In short, the irregularity disguises a good deal of complexity. Instead of a regular, mechanical process, the dripping faucet turns out to be wonderfully complex, with each drip's formation shaped by prior drops.

Under classical physics, predicting the intervals between drips was seen as straightforward and determinate-know the velocity of the water, its surface tension, and so on, and you can always predict when each drop will fall. In the real world, the result is startlingly different. As scientist Robert Shaw has discovered, the complexity of the system confounds efforts at prediction. [FN7] Yet, although the dripping seems random, it follows certain patterns such that-although each drop is unpredictable-***112** the overall pattern of dripping turns out to be structured and coherent. That is, though no one can predict when the next drop will fall, a phase-space graph showing the distribution of drops over time will reveal the sort of intricate, yet predictable structure we see in the multidimensional fractal graphics generated by chaos

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researchers. And though no one can predict where on the graph the next data point will fall, it is possible to predict what the graph will look like when many such points have been plotted. The structure of the graph is predictable, even though no single drip is. [FN8]

This structure is the characteristic that distinguishes "chaos" from mere randomness. Chaos, as used by scientists, means order masquerading as randomness-unpredictable, yes, but by no means unstructured. [FN9] Scientists exploring chaos theory have found this phenomenon to exist in all sorts of settings, from the collisions of a few molecules trapped in a vacuum jar, [FN10] to the Great Red Spot of Jupiter, [FN11] to the rhythm of the human heartbeat. [FN12] For our purposes, the point is that in the physical world, determining what will happen when turns out to be a lot tougher than it looks. The problem is not simply one of accumulating enough data and accurate-enough statements of physical law. Even where the interactions are very well understood and the applicable laws are quite accurate and clear, results in specific cases can be impossible to predict-although overall patterns are discernible.

In law, a similar situation obtains, but we don't fully realize it yet. Like the drop on the end of its faucet, a legal principle tends to expand to its logical limits, and then break off, to be replaced by a new one. [FN13] Yet unlike scientists, who have learned better, most legal scholars still expect to be able to predict when and how that will happen [FN14]-and consider any theory that will not do so inadequate.

***113** The importance of predictable judicial outcomes to the Law and Economics movement is fairly obvious, but this sort of thinking does not stop there. Robert Bork's constitutional jurisprudence, for example, is based on the perceived need for judges to be constrained to a limited range of "correct" outcomes, in order to prevent the judicial branch from interfering with decisions properly arrived at by the political majority. Bork thus demands a powerful predictive ability as the test of legitimacy for constitutional theory. [FN15] Many on the Left seem to agree. Even those seemingly nonlinear thinkers, the Critical Legal Studies scholars, draw heavily on Marxist doctrine, which (at least in its traditional varieties) is as doggedly deterministic and "scientific" in the old sense as any thinking to come out of the nineteenth century. [FN16] And other legal scholars, both within and without the Critical Legal Studies camp, have argued that, because legal principles do not yield predictable results, they are therefore of little value. [FN17] This is an approach that embraces deterministic thinking even as it denies the possibility of its success, and thus yields an unnecessarily bleak, even nihilistic, conclusion. [FN18]

The absurdity of expecting exact predictions in law becomes clear when we compare the complexity and indeterminacy of the Supreme Court to the mechanical certitude of the still-unpredictable dripping faucet. Like the drops on the faucet, each decision by the Supreme ***114** Court is affected by the one that came before. But the Court is far more complex. There is only one faucet; there are nine justices on the Supreme Court. The faucet follows a well-defined set of physical laws; the Supreme Court justices, being human, are very unlikely to share identical views even if they nominally adhere to the same theory of constitutional

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interpretation. And, of course, the judicial system as a whole is far more complex, and interactive, than just the Supreme Court-yet the Supreme Court is certainly too complex on its own for anyone to predict results reliably, as court-watchers learn each year to their chagrin. [FN19]

Despite this unpredictability, the actions of the Supreme Court are not random. Just as there is structure within chaos, so there is pattern of sorts within the actions of the Court [FN20]-pattern that itself reflects recursion and sensitivity to initial conditions, and that exists on both large and small scales. On a small scale, each year's decisions affect the disposition of new cases in the pipeline, affect the decisions of parties to settle or hold out, and affect the decisions of lawyers deciding whether to file suit at all. And, of course, they affect the way in which subsequent cases coming before the Court are argued and addressed. Each of these effects may have an enormous impact on the outcome of a case later in the process-say, when the case reaches (or fails to reach) the Supreme Court.

On a larger scale, over time, the Court's decisions on many important issues have a strong effect on politics; politics affect elections; elections affect who is appointed to the Court, which affects the Court's decisions; and so on. The Court has in its history seesawed from a "natural rights" position, to a highly formalist position, to one recognizing unenumerated positive rights, to one expanding enumerated rights, to (maybe) a highly formalist position again. Not cycles, perhaps, but epicycles. [FN21] The result is, in fact, a very orderly sort of disorder indeed, and at several levels. Such a process certainly makes it unlikely that the Court will ever reach a truly "final" answer to very many questions that come before it, though most theories of constitutional interpretation seem grounded in the assumption that such answers exist.

An interesting question is whether this lack of "finality" is bad. I ***115** don't mean in terms of results (I certainly disagree with those at times), but in terms of its overall effect on the nation. It is at least possible that an inherently fluctuating judicial system is a good thing in a larger sense, by injecting a sort of "wild card" function into our governmental system as a whole. I would like to suggest, at any rate, that there are two kinds of potential payoffs: political and economic.

Politically, the fluidity of the Supreme Court's jurisprudence means that no coalition is set in stone over time, and that people are often pressed to become involved in politics in order to protect their interests, even when the judicial system has already spoken. In this sense, the Court's involvement in major questions promotes political involvement over the long term-rather than inhibiting it, as James Bradley Thayer suggested [FN22]-something illustrated by (for example) the revitalization of the pro-choice side of the abortion debate in recent years.

The economic impact may be even more important. Nobel economist Mancur Olson has written of a key danger to democracies: the development of a web of special interests that-by protecting existing economic interests-prevents economic growth, technological innovation, and remedies for stagnation. [FN23] In

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stirring things up periodically (say in the swing from Lochner [FN24] to Wickard v. Filburn [FN25] to Nollan [FN26]) through the very way its structure and methods promote change, the American judicial system may tend to counteract politically inspired stagnation of the sort that Olson fears, making long-term pacts among interest groups inherently unstable. Imagine, for example, the effect that Rutan v. Republican Party of Illinois, [FN27] the Supreme Court's recent decision abolishing patronage hiring practices, will have on local politics (and probably local government purchasing and contracting) across the nation.

Thus, quite possibly, the "chaotic" nature of the judicial system may mean that stagnation through special-interest domination is unlikely over the long term, as periodic shifts by the Supreme Court lead to the periodic need to renegotiate political/economic alliances. The payoff from this could be significant in maintaining political and economic flexibility.

I don't know whether the Framers had this sort of thing in mind, or whether it is a happy accident of our system of judicial review. In fact, ***116** I'm not certain that the analogy that I point up here is a valid one, and I am certainly not suggesting that the Supreme Court "really is" chaotic in the same sense that a physical system might be. That would push the point too far. But I do think that the matter is worth looking into further, and that the whole idea of chaos theory calls into question the need for-or even the practical possibility of-theories of interpretation aimed at predicting results in particular cases. After all, if we can't predict the behavior of a dripping faucet, we should surely be humble about our ability to make predictions concerning any system that has people in it. Instead of trying so hard to predict outcomes, perhaps, like the scientists, we should think harder about the order that lies behind the apparent randomness. I am confident that if we think about these ideas, we will learn some interesting things indeed. [FN28]

And even if we don't actually learn anything new, some thinking about chaos theory and other aspects of the new sciences may do us good simply by clearing away some cobwebby ideas from our collective intellectual attic. In spite of the efforts of the Legal Realists, much of legal thinking is still undergirded by efforts to make law "scientific"-and the idea of "science" that lies behind those efforts remains thoroughly rooted in a nineteenth century linear determinism that has in fact been significantly abandoned by scientists today.

***117** The real world, as scientists have learned, is far more complex than nineteenth century doctrines allow for, and the answers are often not as clear as we would wish. But the complexities of the real world also allow for a kind of beauty and deep structure that more simplistic approaches cannot comprehend. Scientists already realize this:

> As one physicist put it: "Relativity eliminated the Newtonian illusion of absolute space and time; quantum theory eliminated the Newtonian dream of a controllable measurement process; and chaos eliminates the Laplacian fantasy of deterministic predictability." ... The simplest systems are now seen to create extraordinarily difficult problems of predictability. Yet order arises spontaneously in those

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systems-chaos and order together. Only a new kind of science could begin to cross the great gulf .... [FN29]

Perhaps in time we can develop a new kind of legal science, one that recognizes the relationship among legal institutions, legal rules, and the structures of law that they generate. [FN30] Rules need not constrain results with clockwork precision, but may be useful even so-not as barriers to change, but as sources, and shapers, of change. And even if we are unable to accomplish that Herculean task, we can at least recognize that the old Newtonian and Laplacian models that have influenced our thought for so long are now regarded as "illusion," "dream," and "fantasy" on their home turf. In realizing that, we may achieve the freedom to discover new models all our own, and we will at the very least gain freedom from outdated models, borrowed from other disciplines, that have since been significantly abandoned by their creators.

Tribe's article was subtitled "What Lawyers can Learn from Modern Physics." Perhaps this one should be subtitled, "What Lawyers can Unlearn with Help from Modern Mathematics." In the search for truth, after all, unlearning can be as important as learning, and often proves much more difficult. But it is generally worth the effort.

[FNa] Associate Professor of Law, University of Tennessee. B.A., University of Tennessee, 1982; J.D., Yale Law School, 1985. I would like to thank Fran Ansley, Tom Eisele, Rob Merges, Peter Morgan, Charlie Silver, and mathematician Carl Wagner for some useful discussions and insights.

[FN1]. Tribe, The Curvature of Constitutional Space: What Lawyers Can Learn from Modern Physics, 103 Harv. L. Rev. 1 (1989).

[FN2]. See, e.g., M. Kammen, A Machine That Would Go of Itself: The Constitution in American Culture 17-22 (1986) (prominence of machine imagery in constitutionalism from the time of Jefferson to that of Holmes and Woodrow Wilson).

[FN3]. J. Gleick, Chaos: Making a New Science 250-51 (1987).

[FN4]. Id. at 266.

[FN5]. Compare S. Hawking, A Brief History of Time 165-69 (1988) (discussing "grand theory" efforts in physics) with M. Tushnet, Red, White and Blue: A Critical Analysis of Constitutional Law (1988) (discussing "grand theory" efforts in law).

[FN6]. See, e.g., Brush, Prediction and Theory Evaluation: The Case of Light Bending, 246 Science 1124 (1989).

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[FN7]. The "dripping faucet" discussion, and all else about chaos theory here, is from J. Gleick, supra note 3, at 262-67. For a more technical (and much longer) account, see R. Shaw, The Dripping Faucet as a Model Chaotic System (1984); Shaw, Strange Attractors, Chaotic Behavior, and Information Theory, 36a Zeitschrift für Naturforschung 80 (1981). Gleick's book remains by far the best treatment of this topic for nontechnical readers; for a much more technical treatment aimed at engineers and scientists, see H. Stewart & J. Thompson, Nonlinear Dynamics and Chaos (1986).

[FN8]. See J. Gleick, supra note 3, at 266:

> In three dimensions, especially, the patterns emerged, resembling loopy trails of smoke left by an out-of-control sky-writing plane. Shaw was able to match plots of the experimental data with data produced by his analog computer model, the main difference being that the real data was always fuzzier, smeared out by noise. Even so, the structure was unmistakable.

[FN9]. See id. at 266-67 ("Truly random data remains spread out in an undefined mess. But chaos-deterministic and patterned-pulls the data into visible shapes. Of all the possible pathways of disorder, nature favors just a few.").

[FN10]. Id. at 202-09.

[FN11]. Id. at 53-56.

[FN12]. Id. at 280-84.

[FN13]. Cf. B. Cardozo, The Nature of the Judicial Process 51 (1921) (legal principle expands to the limit of its logic).

[FN14]. See, e.g., Clark, The Interdisciplinary Study of Legal Evolution, 90 Yale L.J. 1238, 1238 (1981) (arguing for interdisciplinary study of legal evolution "to understand, to predict, and to influence changes in legal rules and in the institutions that they shape"); Posner, Volume One of the Journal of Legal Studies: An Afterword, 1 J. Legal Stud. 437, 437 (1972) (goal of legal studies is "to make precise, objective, and systematic observations of how the legal system operates in fact and to discover and explain the recurrent patterns in the observations-the 'laws' of the system").

[FN15]. R. Bork, The Tempting of America: The Political Seduction of the Law 140-41 (1990). For more on Bork's theories, see Posner, Bork and Beethoven, 42 Stan. L. Rev. 1365 (1990); Reynolds, Sex, Lies and Jurisprudence: Robert Bork, Griswold, and the Philosophy of Original Understanding, 24 Ga. L. Rev. 1045 (1990).

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[FN16]. For a discussion of Critical Legal Studies' roots in two different kinds of Marxism-the "critical" and "scientific" wings-see Note, 'Round and 'Round the Bramble Bush: From Legal Realism to Critical Legal Scholarship, 95 Harv. L. Rev. 1669, 1677 & n.58 (1982); see also A. Gouldner, The Two Marxisms 38-40 (1980) (proposing and explaining the "critical"-"scientific" dichotomy). Of course, the diverse character of the Critical Legal Studies movement makes all generalizations a bit iffy. See generally Hutchinson & Monahan, Law, Politics, and the Critical Legal Scholars: The Unfolding Drama of American Legal Thought, 36 Stan. L. Rev. 199, 220-22 (1984); Schlegel, Notes Toward an Intimate, Opinionated, and Affectionate History of the Conference on Critical Legal Studies, 36 Stan. L. Rev. 391, 398-408 (1984) (all discussing relationship between Critical Legal Studies and the varieties of Marxism); Sparer, Fundamental Human Rights, Legal Entitlements, and the Social Struggle: A Friendly Critique of the Critical Legal Studies Movement, 36 Stan. L. Rev. 509, 527-52 (1984).

[FN17]. See Singer, The Player and the Cards: Nihilism and Legal Theory, 94 Yale L.J. 1, 4 n.8 (1984) (discussing nihilism and rationalism and their influence on legal theory). But see Note, The Scientific Model in Law, 75 Geo. L.J. 1967, 1984-86 (1987) (rejecting argument that scientific analogy to law fails because of indeterminacy of legal results).

[FN18]. See Singer, supra note 17. Rationalists, Singer notes, believe that rational foundations are both necessary and possible in formulating legitimate ethical systems. Nihilists, he says, believe that such foundations are necessary, but not possible. Thus, "[n]ihilism is only a partial rejection of rationalism .... [A] nihilist would argue that a rational foundation is necessary to sustain values but that no such foundation exists or can be identified. This sort of nihilism leads directly to psychological feelings of impotence and despair ...." Id.

[FN19]. Cf. Kornhauser & Sager, Unpacking the Court, 96 Yale L.J. 82, 83 (1986) (theory of adjudication should account for complex group decision-making processes in multijudge courts); Leff, Economic Analysis of Law: Some Realism About Nominalism, 60 Va. L. Rev. 451, 476 (1974) ("'If a state of affairs is the product of n variables, and you have knowledge of or control over less than n variables, if you think you know what's going to happen when you vary "your" variables, you're a booby.'").

[FN20]. Erwin Chemerinsky hints at this. Chemerinsky, The Supreme Court, 1988 Term-Foreword: The Vanishing Constitution, 103 Harv. L. Rev. 43, 61-74 (1989).

[FN21]. Some scholars link this shift directly to the political effects of Court decisions in much the fashion I have suggested. See Ansley, Stirring the Ashes: Race, Class, and the Future of Civil Rights Scholarship, 74 Cornell L. Rev. 993, 1031-35 (1990).

[FN22]. J. Thayer, John Marshall 103-07 (1901) (too-easy resort to judicial review will "dwarf the political

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capacity of the people").

[FN23]. M. Olson, The Rise and Decline of Nations: Economic Growth, Stagflation and Social Rigidities (1982). For a clear and insightful review of Olson's work, see Schuck, Review Essay: The Politics of Economic Growth, 2 Yale L. & Pol'y Rev. 359 (1984).

[FN24]. Lochner v. New York, 198 U.S. 45 (1905).

[FN25]. Wickard v. Filburn, 317 U.S. 111 (1942).

[FN26]. Nollan v. California Coastal Comm'n, 483 U.S. 825 (1987).

[FN27]. 110 S. Ct. 2729, 2735 (1990).

[FN28]. Such analysis is a project for another day and another article. However, here is one thought that I find intriguing: Chaos researchers have come to the conclusion that chaotic processes are-despite, or more properly because of, their unpredictability-more stable than linear processes. As Gleick summarizes:

> [P]hysiologists have also [begun] to see chaos as health. It has long been understood that nonlinearity in feedback processes serves to regulate and control. Simply put, a linear process, given a slight nudge, tends to remain slightly off track. A nonlinear process, given the same nudge, tends to return to its starting point....
>
> With all such control phenomena, a critical issue is robustness: how well can a system withstand small jolts. Equally critical in biological systems is flexibility: how well can a system function over a range of frequencies. A locking-in to a single mode can be enslavement, preventing a system from adapting to change. Organisms must respond to circumstances that vary rapidly and unpredictably; no heartbeat or respiratory rhythm can be locked into the strict periodicities of the simplest physical models, and the same is true of the subtler rhythms of the rest of the body.

J. Gleick, supra note 3, at 292-93. Of course, courts are not themselves living creatures, but they are complex dynamic systems, so that many of these considerations of robustness and flexibility apply to them, as to biological systems. If that is true, it seems to me that we have additional reason to beware of theories of adjudication that would enforce a rigid and linear system on the courts, since such a system might well lead to instability on the part of the judicial system, and thus perhaps of the political system as a whole. Cf. Waldrop, Spontaneous Order, Evolution, and Life, 247 Science 1543, 1545 (1990) ("[E]volution drives living systems to a critical point halfway between these two extremes, where they can maintain a vital mix of stability and change.... Langton calls this hypothetical point 'the edge of chaos,' and suggests that it may be a fundamental characteristic of any complex dynamical system ....").

[FN29]. J. Gleick, supra note 3, at 6-8. The physicist quoted is Joseph Ford.

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[FN30]. Cf. Clark, supra note 14, at 1242-56 (discussing growth and survival of legal rules in common law courts); Llewellyn, The Constitution as an Institution, 34 Colum. L. Rev. 1, 3 (1934) (discussing American Constitution not as document but as living institution). See generally C. Black, Structure and Relationship in Constitutional Law (1969) (analyzing constitutional law questions by drawing inferences from structures and relationships created by Constitution).

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