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Chaos Theory and Strategic Thought

STEVEN R. MANN

A revolution that can change strategic thought is underway. The bitter-sweet truth is that this revolution has little to do with the “new world order” set to follow the end of the Cold War and the success of Desert Storm. The true revolution is in science, and its effects may change the pattern of both warfare and strategic thought. Yet our attention is fixed on short term international reshuffling. Absorbed by the transitory, we ignore the epochal.

Scientific advances are pushing us beyond simple Newtonian concepts and into the exotica of chaos theory and self-organized criticality. These novel lines of scientific inquiry have emerged only in the past three decades. In brief, they postulate that structure and stability lie buried within apparently random, nonlinear processes. Since scientific revolutions have so transformed conflict in the past, it is essential for US strategists to understand the changes in progress. One reason why this is important is technological: new principles yield new classes of weapons, just as basic quantum theory and special relativity ushered in nuclear devices.

A second and more fundamental reason for understanding scientific change is that our view of reality rests on scientific paradigms. The world often appears to us as an intricate, disordered place, and we search for frameworks that will make sense of it all. These frameworks derive overwhelmingly from the physical sciences, as in the 18th-century view that the motions of the celestial bodies could be compared to the works of a giant clock. Scientific advances, therefore, offer us new ways of understanding a given environment, and can suggest innovative solutions to policy dilemmas. But despite the strategic community’s hunger to grasp the technological benefits of change, it has been unable to adapt the advances to strategic thought.¹ This article will therefore touch only lightly on the hardware benefits of scientific change and focus instead on the conceptual aspects.

The strategic community's resistance to new paradigms is a tribute to the power of the current framework. The specific paradigm that permeates contemporary Western thought is best described as the Newtonian worldview. This paradigm is deterministic, linear, concerned with the predictable interaction of objects and forces, and oriented toward sequential change. This single worldview has powerfully influenced all areas of human inquiry. One commentator succinctly observes: "The other sciences accepted the mechanistic . . . views of classical physics as the correct description of reality and modeled their theories accordingly. Whenever psychologists, sociologists, or economists wanted to be scientific, they naturally turned toward the basic concepts of Newtonian physics."² As one of the social sciences, military science rests upon these same assumptions. Precisely speaking, however, it is the specific discipline of *mechanics*—the science of motion and the action of forces on bodies—that has captured our imaginations.

Why does the worldview of mechanics have such a hold on strategic thought? Part of the answer lies in the fact that military and political science truly developed as sciences in the 18th and 19th centuries, coincident with the rise of classical physics and mathematics. Einstein describes the spirit of the age:

The great achievements of mechanics in all its branches, its striking success in the development of astronomy, *the application of its ideas to problems apparently different and non-mathematical in character*, all these things contributed to the belief that it is possible to describe all natural phenomena in terms of simple forces between unalterable objects.³ [emphasis added]

There are, however, more tangible reasons. In the simplest sense, combat is mechanics. It is no surprise then that military strategy rests on a mechanistic framework. Since national strategy often borrows the metaphors of combat—peace "offensive," Cold "War," nation-building "campaign"—it is again no surprise that national strategy reflects the same bias. Politics is a continuation of war by linguistic means.

A second reason for the longstanding influence of mechanics is its accessibility. Prior to this century, physics (to include its subset mechanics) and chemistry had made relatively greater strides than other branches of science. Biological sciences were in their infancy until the latter part of the

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1800s, and the advances epitomized by Einstein's relativity theory still lay in the future. Newtonian mechanics, by way of contrast, was firmly established by the end of the 17th century.

Finally, this mechanistic worldview is reassuring, since it postulates a world of sequential change. It promises strategists that the course of events can be predicted if the underlying principles have been discovered and if the few variables involved are known. Unsurprisingly, therefore, modern theorists of war have drawn heavily and subconsciously on this mechanistic paradigm. On the level of military strategy, consider Clausewitz: the language of *On War* betrays the mechanistic underpinning: friction, mass, centers of gravity, etc. Or Jomini, who stresses the geometry of combat. Or, to take a modern example, consider this excerpt from the Defense Department's national security planning guidance: "The demise of the Cold War can be likened to a monumental shift in the tectonic plates, unleashing a host of forces that are irrevocably reshaping the strategic landscape."⁴

Once this mechanistic worldview gained currency, it never lost its grip. The resulting stasis is the unrecognized core of so many of our strategic dilemmas. The essential conservatism of the national security establishment,⁵ combined with the understandable need for caution on central issues of war and peace, has discouraged theoretical innovation. The revolution in strategy founded on a mechanistic ordering of reality has been frozen in place, and the provocative doctrines of the last century have become the confining dogmas of this one.

But is this truly a problem? Conventional wars admittedly have validated much of Clausewitz, Liddell Hart, and others of that genealogy. The so-called revolutions in warfare before 1945 have represented only changes on the mechanistic margin. Motorized warfare, for example, increases the options of an attacking force but is still amenable to Clausewitzian analysis. Air power shifts the battle to a true third dimension, but does not invalidate the paradigm. So too, the increased destructiveness and accuracy of munitions leave war explicable within the classical framework. On the national strategic level, we have found it useful to examine the strategic "balance" between East and West, and to maintain and reform alliances that have their analogues in mechanistic alignments of centuries past.

But we can only draw uneasy comfort from this: as the world becomes more complex, traditional theories explain less. The gap between theory and reality exists on the levels of both military and national strategy. Militarily, a number of weapons and modes of warfare have been developed in the past century which fit poorly within classical strategy. New weapons are comparatively easy to develop but difficult to place within a doctrinal framework. Biological agents and nuclear weapons are two of the tough cases. Indeed, the process of battle itself is disordered. Army doctrine now openly

*Politics is a continuation of war
by linguistic means*

declares: "The high- and mid-intensity battlefields are likely to be chaotic, intense, and highly destructive. . . . [O]perations will rarely maintain a linear character."⁶

On a grand scale, the increasing complexity of foreign affairs cuts against the comfortable assumptions of classical strategy. Can we indeed describe our exquisitely variable international environment in traditional terms of balance of power, polarity, or a shift of tectonic plates? The mechanistic worldview is good but not good enough. The daily headlines bring inconvenient reminders of how oversimplified these models are.

Not only does classical strategic thought seek to explain conflict in linear, sequential terms, but it compels us to reduce highly complex situations down to a few major variables. Traditionally, we see strategic thought as the interplay of a limited number of factors, principally military, economic, and political. More sophisticated discussions expand the set to include factors such as the environment, technological development, and social pressures. Yet even this list fails to convey the full complexity of international affairs: what is the place of religion and ideology; where do non-national actors such as terrorist movements fit; what of supranational actors such as global corporations; what of the role that personalities and institutions play? Moreover, as global communication increases, economic interdependence progresses, and democracy spreads, the number of policy influences grows exponentially. The accelerating pace of decisionmaking adds to the complexity. The closer we come to an honest appreciation of the international environment, the more we must confess that it is nonlinear and frustratingly interactive. This complicates analysis tremendously: "Nonlinearity means that the act of playing the game has a way of changing the rules."⁷

Our daily experience as policymakers validates this dawning perception. We bruise against reminders of imperfection and randomness every day. The classical worldview calls this "friction" and shunts it aside as a complication of the well-laid plans of policymakers.⁸ On reflection, though, it becomes clear that "friction" is a major determinant in affairs of state, not an appendage. To keep our strategic paradigms workable, we have taught ourselves to ignore this. Yet life is too complex to be described or explained by the interaction of a few simple variables.

We need to change the way we think about strategy. This is an uncomfortable task. Strategic thought of the past few centuries does not appear to allow much room for innovation. As we have shown, however, our strategic frameworks are based on the mechanistic assumptions of classical physics. If we start with different assumptions, by incorporating different scientific paradigms, we may see more productive strategic principles emerge. A shift in framework is not a panacea—war and diplomacy will remain as demanding and dangerous as ever—but if we wish to pull ourselves out of the current analytical stagnation,⁹ we must recognize the assumptions that permeate our strategic culture and open ourselves to new frameworks.¹⁰

The Discipline of Chaos

The new science of chaos, lying on the uneasy border between mathematics and physics, is defined by certain key principles:

- Chaos theory applies to dynamical¹¹ systems—systems with very large numbers of shifting component parts;
- Within these systems, *nonperiodic* order exists; seemingly random collections of data can yield orderly yet nonrecurrent patterns;
- Such “chaotic” systems exhibit sensitive dependence upon initial conditions; a slight change in any one of the initial inputs leads to disproportionately divergent outcomes.
- The fact that order exists suggests that patterns can be predicted in at least weakly chaotic systems.

The earth in revolution around the sun is nonchaotic. A slight change in orbital speed would yield only a slight change in its path of revolution. In contrast, a column of smoke rising into the atmosphere is chaotic. It rises straight up for a time, then suddenly breaks into a turbulent medley of whorls, twists, and zigzags. These loops seem to follow no particular order, yet mathematical modeling discloses regular patterns when tracked.¹² A slight change in velocity of the smoke stream will form a completely different grouping of whorls and streams—yet this second smoke stream will also yield mathematically regular patterns.

“Chaos” is an unfortunate shorthand for this discipline. The word carries associations of formlessness and pure randomness that complicate the conceptual task. “Nonlinear dynamics” is a less loaded, more descriptive term, but chaos is the widespread scientific label, so chaos it will be in this article.

The chaos paradigm does not contradict the classical paradigm. In fact, chaos theory stems from classical physics and mathematics—but it transcends it. The classical framework describes linear behavior of individual objects; chaos theory describes statistical trends of very many interacting objects.

What are the implications of this science for the strategist? There are important implications on at least two levels. On the tangible level, technologi-

cal innovations that exploit chaos theory will change the hardware of war. On the theoretical level, it offers up a new foundation of strategic thought.

In hardware terms, chaos theory will have path-breaking effects on military affairs through changes in the way we use technology now, as well as through development of new types of weapons. Information theory, artificial intelligence, and the military technologies based on these sciences will be transformed. One researcher postulates that chaotic changeability "is the very property that makes perception possible."¹³ At the very least, robotics will see major strides, and chaos theory may bring us closer to employment of armed robots in combat. The list of applications has no limit: epidemiologic spread, meteorology, aeronautic design, and cryptology come easily to mind. Nuclear targeting may become more accurate, given chaos theory's ability to model fluid turbulence. Post-nuclear ecology is a topic also well adapted to nonlinear analysis, and future discussions of nuclear winter will have to encompass chaotic principles. Cryptology is an especially tantalizing case, since chaos theory poses the possibility that what we believe to be random may not always be truly random.

Technology aside, chaos theory has certain other battle-related applications. Researchers have sought for decades to make sense out of the many factors which comprise the chaos of battle. One analyst, Trevor Dupuy, has developed an elephantine mathematical model which attempts to analyze battles through the interplay of several dozen variables. This Quantified Judgment Analysis Model aims to compare "the relative combat effectiveness of two opposing forces in historical combat, by determining the influence of environmental and operational variables upon the force strengths of the two opponents."¹⁴ Although the focus of the model is historical, Dupuy suggests that it may be predictive. If so, the implications are tantalizing: commanders would be able to quantify their chances of battlefield success and systematically identify areas of weakness. Leaving aside the problem of subjectivity, a basic flaw is that the model is linear, yet the process of battle itself is manifestly nonlinear and irregular. Chaos theory may uniquely be able to take Dupuy's concept to its ambitious end.

On a theoretical level, we see a dismaying number of Ph.D.s attempting to understand patterns of wars in history. In 1972, J. David Singer and associates claimed to find regularity in peaks of global violence over a 150-year period—"A rather strong periodicity emerges, with the dominant peaks about 20 years apart"—as well as a peak in war beginnings in April and October.¹⁵ The goal of the Singer research was to use the periodicity as a clue to factors which give rise to the violence. Other authors have linked patterns of conflict with "long cycles of world leadership" (Modelski), polarity-stability models (Waltz), and with the Kondratieff wave cycle of economic prosperity and depression (numerous authors).¹⁶ As with the Dupuy model,

chaos theory may be the tool that transforms these subjective undertakings from parlor games to predictive models. Chaos researchers have already found unexpected identical patterns in social phenomena as disparate as cotton price levels and US national income distribution. This attribute of *universality*—the principle that different nonlinear systems have inherently identical structures—is a central principle of chaos theory.¹⁷

There remains much research to be done on the applicability of chaos theory to operational and tactical analysis. On one hand, the process of battle is universally acknowledged as disordered and thus amenable to nonlinear analysis.¹⁸ On the other hand, combat involves only a small number of actors as we define them, generally one force versus a second; thus theater-level combat arguably falls outside of chaos theory, which describes the behavior of very large numbers of actors. Moreover, commanders exert great effort to make armed forces act and interact in linear, mechanistic, predictable ways. Devices such as rank hierarchies, military discipline, unit structure, warrior tradition, and structured operation orders serve to impose order and overcome random behavior. This further limits the dynamism of the system and suggests that chaos theory may have only limited applicability on the level of military strategy. Is battle truly chaotic or not? There are two useful answers to the question. One is to view the process of battle as fundamentally chaotic, but moderated to an orderly system with varying degrees of success as described above. A second possibility is to consider the process of battle as fundamentally linear and *nonchaotic*, and assert that it is our individual *perceptions* of battle which are disorderly. In any case, these questions will bear more inquiry.

The Critical Threshold

The true value of chaos theory is to be found on a higher plane, in the domain of national strategy. Chaos should change the way we view the full set of human interactions, of which war is only one special part. The international environment is an exquisite example of a chaotic system. An intriguing offshoot of chaos theory—“self-organized criticality”—is perfectly matched to such an analysis. Bak and Chen here define self-organized criticality:

Large interactive systems perpetually organize themselves to a critical state in which a minor event starts a chain reaction that can lead to a catastrophe. . . . Although composite systems produce more minor events than catastrophes, chain reactions of all sizes are an integral part of the dynamics. . . . Furthermore, composite systems never reach equilibrium but instead evolve from one metastable [i.e. temporarily stable] state to the next.¹⁹

IBM researchers are examining this theory using sandpiles: grains of sand are added one by one to a pile until a critical state is reached in which the next

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grain of sand added produces an avalanche. After that catastrophic reordering, the system is relatively stable as it builds toward the next reordering.

Interestingly, a number of metaphors already exist in political science which hint at criticality. The picture of international crises as a "tinderbox" is the most well-known one. In one respect, this metaphor remains particularly accurate: the development and spread of a forest fire is a useful example of a chaotic system and has been modeled by Bak, Chen, and Tang.²⁰ The tinderbox idea, however—an explosive object waiting for a match—falls short in conveying the dynamical nature of world affairs. A newer metaphor is the concept of "ripeness," as described by Haass and others. This view of international negotiation holds that some disputes are insoluble for a variety of reasons until the time arrives when they are "ripe." The key to successful negotiation, therefore, lies in recognizing and then exploiting this critical state.²¹

What framework better describes the reordering that is now taking place in the world than self-organized criticality? The "plate tectonics" metaphor, based on the classical framework, fails. It postulates basic stability, broken by realignment of a few major forces. The full complexity of the situation is left to the imagination of the reader. The last years of the Soviet Union present a useful case study. The classical framework encouraged us to think in simple terms of a clash of forces: Yeltsinian populists, Gorbachevian reformers, and conservatives. The classical framework contains a bias toward stability and status quo, since only under relatively calm conditions are classical strategic and diplomatic principles workable. Thus we saw the repeated warnings against "Soviet chaos" by timid diplomatists and cautious politicians. The traditional view considered the breakup of the USSR as the beginning of the slide into disaster and argued for cohesion and a strong center. Self-organized criticality, in contrast, leads us to see a tremendous multiplicity of actors in a critical state that will inevitably progress to one of transient stability after a catastrophic reordering. No need for stability here in order for the model to be useful: criticality views "Soviet chaos" as part of an explicable process. Criticality welcomes the rise of the republics and the downfall of the Union government as a precondition to a new, productive, metastable arrangement.

On the international stage, the traditional model leads us to overestimate our influence on events and discount the ability of all but the major players to have a decisive impact on events. The paradigms of chaos and

criticality, in contrast, highlight the disproportionate effects seemingly minor actors can provoke. The German physicist Gerd Eilenberger remarks:

The tiniest deviations at the beginning of a motion can lead to huge differences at later times—in other words, minuscule causes can produce enormous effects after a certain time interval. Of course we know from everyday life that this is *occasionally* the case; the investigation of dynamical systems has shown us that this is *typical* of natural processes.²²

Chaos theory further notes that these deviations are self-organized; that is, they are generated by the dynamical system itself. Even absent external shocks, a sufficiently complex system contains the factors that will propel the system across the boundary of stability and into turbulence and reordering.

Now a troubling question arises: is chaos theory merely a useful *metaphor* to describe these interactions, or do these interactions actually follow the occult laws of chaos? This metaphysical puzzler is beyond the scope of this modest article; but intuition, the conscience of the intellect, suggests that the second explanation is correct.

The originators of the concept indeed foresee application in security affairs: “Throughout history, wars and peaceful interactions might have left the world in a critical state in which conflicts and social unrest spread like avalanches.”²³ Consider the example encountered earlier: the end of the Cold War as compared to a shift of tectonic plates. Which framework gives a more accurate basis for strategy? The mechanistic framework seems to say that the plates have now shifted and we are in an indefinite period of stability upon which we can now rebuild a uniquely new world order. Criticality describes a dynamical process, precariously stable, which is even now building toward the next set of catastrophic reorderings.

The mechanistic view is too arbitrary and simple for international affairs. We must start from the point that disorder, proceeding to reordering, is an inherent, inescapable feature of complex, interactive systems. We are deluding ourselves if we choose metaphors which suggest that externally-imposed, long-term stability can be a defining feature of the world. The world is destined to be chaotic because the multiplicity of human policy actors in the dynamical system have such widely variant goals and values.

The mechanistic paradigm encourages us to seek the causes of major change in external factors. It postulates basic inertia in a system, unless acted upon by some outside force. Criticality, in contrast, is self-organizing. The system proceeds to major change as a result of a small, almost negligible event. World War I presents an outstanding example of self-organized criticality. The killing of an archduke in an obscure Balkan town triggered a worldwide catastrophe that led to the deaths of 15 million human beings and whose effects are felt even today.

Lebanon may offer an example of perpetual criticality. Its location at the center of conflict between nations over the centuries, its tortured geography, its bitter ethnic, religious, and clan antagonisms, give little hope for stability and predictability. Working within the classical strategic framework, however, the United States entered the fray in 1982, emplacing Marines to bring balance to the situation and separate opposing forces. As the Marine commander remarked: "We walked a razor's edge."²⁴ The basic assumption was that the United States could be a neutral, stabilizing force. A system in criticality, however, offers no neutral ground, no hope of permanent stability. Once in it, you are of it, as we learned after the catastrophe in which 241 Marines lost their lives to a terrorist bomb.

Reordering Strategic Thought

Amid the disorder, we are not bereft of strategy. Criticality theory is not a limitation for the strategist but a promising framework which helps explicate the fascinating disorder of the world. Once we arrive at an accurate description of our environment, we are in a position to create strategies which advance our interests. To create these strategies, we must begin with an examination of the factors which shape criticality. Some possibilities:

- Initial shape of the system
- Underlying structure of the system
- Cohesion among the actors
- Conflict energy of the individual actors

Taking these factors one by one:

The *initial shape*, that is, the contours of a system at the beginning, influence the system's later development: the post-catastrophic outcome forms the basis of subsequent actions. In our sandpile, the post-avalanche slopes and hills influence the shape of the new cone to be formed; in foreign affairs, the changed boundaries after World War II could not help shaping the subsequent course of events.

Again, in sandpile terms, the grains fall onto a flat, circular surface: this is the *underlying structure*. This basic structure, or matrix, helps determine the shape of the developing sandpile. In the international sense, underlying structure can be factors such as environment and geography. Kuwait's proximity to Iraq is a fundamental fact that shapes all subsequent policy in that area. Water supply is an example of an environmental underlying factor.

Cohesion determines the rate at which reordering takes place. Wet sand has different dynamics than dry sand. So too do ideologically and ethnically homogeneous systems have different dynamics than multiethnic or ideologically various societies. On a military level, deterrence and arms control serve to increase cohesion among states. Increased cohesion does not prevent criticality; it means only that the progression to criticality is slowed. Ineffective arrange-

ments create *false* cohesion—the illusion that reordering is being effectively managed. The League of Nations covenant to establish global collective security (1920), the Kellog-Briand pact to renounce war (1928), the Yalta conference to shape the post-World War II international order (1945), and all such delusional diplomacy stand as instances of false cohesion.

Finally, each actor in politically critical systems possesses *conflict energy*, an active force that instigates change in the status quo, thus contributing to the formation of the critical state. In our international system, this energy derives from the motivations, values, and capabilities of the specific actors, whether governments, political or religious movements, or individuals. These actors can seek change in the status quo through peaceful or violent means, but either course inches the state of affairs toward its date with criticality and the inevitable cataclysmic reordering.

Chaos theory dictates that it is very difficult to make long-range predictions. The difficulty increases with the number of actors in the system and the duration of forecast desired. As a starting point, therefore, we should be suspicious of long-term strategic outlooks. This is a hard addiction to abandon. We cling to the belief that there are maps that will take us through the dark woods of international affairs. But perhaps a different metaphor will help: we should look instead for lanterns with a short beam to illuminate somewhat a path that shifts with the pace and direction of our stride.

Is this argument not contradicted by the success of our containment policy, the crown jewel of long-term strategic thinking? This policy, with its prescription for “unalterable counterforce at every point where [the communist enemies] show signs of encroaching,” represented the full flowering of the mechanistic worldview in national security affairs.²⁵ Conventional wisdom, in view of the collapse of the Soviet empire, says the policy of containment worked. But looking at the aggregate record, can we not say this same policy gave us Vietnam—with its fatally limited aims and insurmountable constraints on conduct of the war—and also led us into self-defeating support of authoritarian regimes from Iran to Nicaragua to the Philippines? Might we not have achieved a better end result with less cost if we had moved more flexibly between islands of order within the global sea of political chaos?

Now, having moved beyond containment, we are debating the correct concept of polarity—whether the world is multipolar, unipolar, or tripolar, now that it is no longer bipolar. This debate is another example of how we work to unsee the obvious. Politically, the world has far too many and varied actors to be thought of in terms of any polarity. Yet we seek to impose a metaphor from the mechanistic lexicon to give us a comforting sense that we truly do understand the new world.

We are desperate in our desire for structure, thus the overblown appeal of the “new world order,” “strategic consensus,” “peace dividends.” Will par-

tisans of the new world order mimic the mistakes of containment, forcing us to take unwise policy stands in pursuit of an illusory long-term stability? We may have already sacrificed more than we know in pursuit of this new stability: by conditioning Desert Storm on UN approval, we have constrained our future military options. Much of Congress, the American public, and the international community will expect a UN imprimatur as a legitimating prerequisite to future US use of force. Sadly, the attempt to create the new world order through international legality has left Saddam Hussein defiant, duplicitous, and firmly entrenched as the decimation of the Kurds proceeds.

Our desire for structure also helps explain the Western thirst for arms control. Even when the arms control regime is declaratory and has no military utility, as with the 1972 Biologic and Toxin Weapons Convention, we keep the faith that the simple, declaratory existence of the treaty will help prevent the horrors it describes. Americans sanctify the arms control "process" as a good in itself, regardless of the strategic situation or the virtue of the treaties under negotiation.

Effective treaties and compacts can slow the progress of a system toward criticality, but we indulge in illusion if we believe absolute stability is attainable. In international affairs, all stability is transient. The international environment is a dynamical system composed of actors—nations, religions, political movements, ecologies—which are in themselves dynamic systems. We should therefore be wary of incurring immediate policy costs to achieve a future stability: odds are that we will not get what we bargained for. Indeed, "stability," like "presence," "nation-building," and even "peace," is a context-less goal. When such a goal is advanced as a policy objective, it betrays either the inadequacy or the duplicity—recall the Soviet family of "peace-loving" nations—of the underlying strategy. Stability is no more than a consequence, and should never be a goal.

How then to use criticality to our advantage? The true aim of national strategy is shaping the broad context of security affairs, achieving the desired end state with the mildest upheaval. There are times when we will wish to delay formation of a critical state; there are times when we will wish to encourage it and will seek to shape the reordering. As all foreign policy operators know, shaping events is easier dreamed than done. There is not much we can do about initial shape or underlying structure. These are the givens of history, geography, and environment. Our policy efforts must center on achieving cohesion and mitigating conflict energy. Internationally, such devices as military alliances, economic agreements, trade protocols (e.g. GATT), and agreed rules of the road in general build cohesion into the system. But the more promising, but more neglected way to effect desirable international change lies with the individual.

Conflict energy is at base a human property, since the individual is the basic building block of global structures. Conflict energy reflects the

goals, perceptions, and values of the individual actor—in sum, the ideological software with which each of us is programmed. To change the conflict energy of peoples—to lessen it or direct it in ways favorable to our national security goals—we need to change the software. As hackers have shown, the most aggressive way to alter software is with a “virus,” and what is ideology but another name for a human software virus?

With this ideological virus as our weapon, the United States should move to the ultimate biological warfare and decide, as its basic national security strategy, to infect target populations with the ideologies of democratic pluralism and respect for individual human rights. With a strong American commitment, enhanced by advances in communications and increasing ease of global travel, the virus will be self-replicating and will spread in nicely chaotic ways. Our national security, therefore, will be best assured if we devote our efforts to winning the minds of countries and cultures that are at variance with ours. This is the sole way to build a world order that is of long duration (though, as we have seen, it can never achieve absolute permanence) and globally beneficial. If we do not achieve this ideological change throughout the world, we will be left with only sporadic periods of calm between catastrophic reorderings.

A tangible implication of this analysis is a sharp increase in support for the United States Information Agency, the National Endowment for Democracy, and the numerous private-sector exchange and educational programs. These programs lie at the heart of an aggressive national security strategy. Conversely, we need to react defensively as well. The true national security battleground is, metaphorically, viral in nature. On the level of individual choice, we are under attack by certain destructive strains, notably drug addiction. What is drug addiction but a destructive behavioral virus that spreads in epidemic fashion?

The Intuitive Core

The world is open to experience on many levels, and we would be acting unrealistically if we claimed primacy for any one scientific paradigm over all of the others as a foundation of strategic thought. Each framework offers unique insights, and the art of strategy is choosing the most enlightening one for a given situation. Strategy has traditionally been described as the iron linkage of ends and means. The complexity of national security today suggests that such an Iron Age has passed, and we must develop a more encompassing definition of strategy: not simply a match of means to ends but a match of paradigm to the particular strategic challenge. It makes little sense to define ends and select our means until we have achieved an accurate representation of the reality we encounter.

If we are open to a variety of scientific frameworks, we can generate more workable principles of strategy than we now possess. On an operational level, we can anticipate the principles of weapons still to be developed if we understand the theoretical principles which will give rise to those weapons. On a higher plane, we can understand the factors which dictate that a complex, dynamical system such as the USSR will change, and work more precisely to shape the transformation. We can learn to see chaos and reordering as opportunities, and not push for stability as an illusory end in itself. All of this awaits if we can transcend the bonds of the mechanistic framework, which still dominates strategic thought.

Finally, we must recognize the limits of any framework, even the counterframework of chaos, and pay proper respect to the irrational, the intuitive. Strategic thought rests on scientific paradigms, which in turn rest on mathematics, the language of science. The truths of mathematical systems, therefore, extend by metaphor into our strategic concepts. However, one mathematical principle above all is important to us—Godel's Incompleteness Theorem: "All consistent axiomatic formulations of number theory include undecidable propositions."²⁶ In our world is an infinite set of problems which have no logically consistent answer; there are some problems which any framework alone cannot solve. This theorem marks the limits of robotics in warfare, the limits of operations research, of scientific inquiry as applied to warfare or, indeed, to any discipline. We must accept the fact that warfare and strategy, like all undertakings which seek to describe and predict creative behavior, will contain unsolvable paradoxes. Nuclear deterrence may be an example of this: threaten to destroy only to preserve. The poignant quotation from the time of Tet, "We had to destroy the village in order to save it,"²⁷ may illustrate another.

Paradoxically, then, once we have achieved a strategic framework that is logically consistent and provides a comprehensive, predictive description of war, we can no longer fully trust that framework. In plain talk from Colin Powell, we cannot "let adverse facts stand in the way of a good decision."

Any framework contains limitations that can be transcended only by the peculiar characteristics of human intellect, what the physicist Roger Penrose refers to as "the instantaneous judgments of inspiration"²⁸ inseparable from human consciousness. What is that after all, but Clausewitz's *coup d'oeil*: those "glimmerings of the inner light which leads to truth."²⁹

Great strokes of strategy draw on this intuitive core. Yet strategists must not live by inspiration alone. Inspiration unsupported by rigorous analysis becomes adventurism. Thus intuitive gifts must be paired with an effective theoretical framework. Chaos theory is uniquely suited to provide one such framework. It can provoke us toward realistic policies in an incessantly changeable age, and inaugurate the overdue liberation of strategic thought.

NOTES

The author is indebted to Dr. Nicholas Colella, Lawrence Livermore Laboratories, for scientific review and comment.

1. "Strategic community" denotes that irregular web of academics, consultants, and servants of the taxpayer who propose governmental responses to operational, strategic, and national security issues, thus defining our strategic culture.

2. Fritjof Capra, *The Turning Point* (Toronto: Bantam Books, 1983), p. 47.

3. Albert Einstein and Leopold Infeld, *The Evolution of Physics* (New York: Simon and Schuster, 1942), pp. 57-58.

4. US Department of Defense, *1991 National Security Planning Guidance* (Washington: DOD, 1991), p. 1. This time-honored metaphor can be traced back at least to Joseph Nye's use in the 1970s.

5. See among others Morris Janowitz, *The Professional Soldier* (New York: The Free Press, 1971), pp. 22-37.

6. Field Manual 100-5, *Operations* (Washington, D.C.: Department of the Army, 5 May 1986), p. 2.

7. James Gleick, *Chaos* (New York: Penguin Books, 1987), p. 24.

8. See "Oils for the Friction of War," in Charles M. Westenhoff, ed., *Military Air Power* (Maxwell AFB, Ala.: Air Univ. Press, 1990), pp. 77-79. This section of the book is filled with quotations which track precisely with chaos theory. Indeed, one statement (Eilenberger, cited on p. 16) is attributed to a physicist researching nonlinear dynamics. The compilers perfectly identify the omnipresence of chaos and non-linearity in war; all they lack is the vocabulary.

9. Stansfield Turner notes this and poses the question of "why there have been so few prominent strategic thinkers and writers in the past 50 years." Turner, "The Formulation of Military Strategy," in George E. Thibault, ed., *The Art and Practice of Military Strategy* (Washington, D.C.: National Defense Univ. Press), 1984, p.15.

10. This article confines itself to chaos theory as a new basis for strategic thought, yet other sciences may offer equally innovative paradigms for the strategist.

11. "Dynamical," not "dynamic," is the preferred term among researchers. I follow the convention.

12. The patterns exhibit period-doubling and have analogues in fractal geometry. See Gleick, pp. 121-37, 202-07.

13. Walter J. Freeman, "The Physiology of Perception," *Scientific American*, February 1991, pp. 78-85.

14. Trevor Dupuy, *Numbers, Predictions, and War* (Indianapolis: Bobbs-Merrill, 1979), p. 50.

15. J. David Singer and Melvin Small, *The Wages of War, 1816-1965: A Statistical Handbook* (New York: John Wiley and Sons, 1972), pp. 215, 375.

16. See William R. Thompson, *On Global War* (Columbia: Univ. of South Carolina Press, 1988).

17. Gleick, pp. 83-87.

18. A possibly apocryphal quotation, ascribed to "a German general officer," makes this point: "The reason that the American Army does so well in wartime is that war is chaos, and the American Army practices chaos on a daily basis." Source unknown.

19. Per Bak and Kan Chen, "Self-Organized Criticality," *Scientific American*, January 1991, p. 46. Metastable denotes having only a slight margin of stability or only a delicate equilibrium.

20. *Ibid.*, p. 53.

21. See Richard N. Haass, *Conflicts Unending* (New Haven: Yale Univ. Press, 1990).

22. Westenhoff, p. 78.

23. Bak and Chen, p. 53.

24. Colonel T. J. Geraghty, quoted in Daniel P. Bolger, *Americans at War 1975-1986: An Era of Violent Peace* (Novato, Calif.: Presidio Press, 1988), p. 210.

25. The plan of containment was implemented far more rigidly than its architect intended. Kennan, in retrospect, terms his 1947 article a call for ideological-political engagement, and suggests today that we need a containment theory "more closely linked to the totality of the problems of Western civilization." Chaos theory to the rescue? See George F. Kennan, "Containment Then and Now," *Foreign Affairs*, 66 (Spring 1987), 885-90.

26. Paraphrased by Douglas R. Hofstadter, *Godel, Escher, Bach: An Eternal Golden Braid* (New York: Vintage Books, 1980), p. 17.

27. See Stanley Karnow, *Vietnam: A History* (New York: Viking Penguin, 1984), p. 534.

28. Roger Penrose, *The Emperor's New Mind* (New York: Penguin Books, 1989), p. 422.

29. Carl von Clausewitz, *On War*, trans. and ed. Michael Howard and Peter Paret (Princeton, N.J.: Princeton Univ. Press, 1984), p. 102.