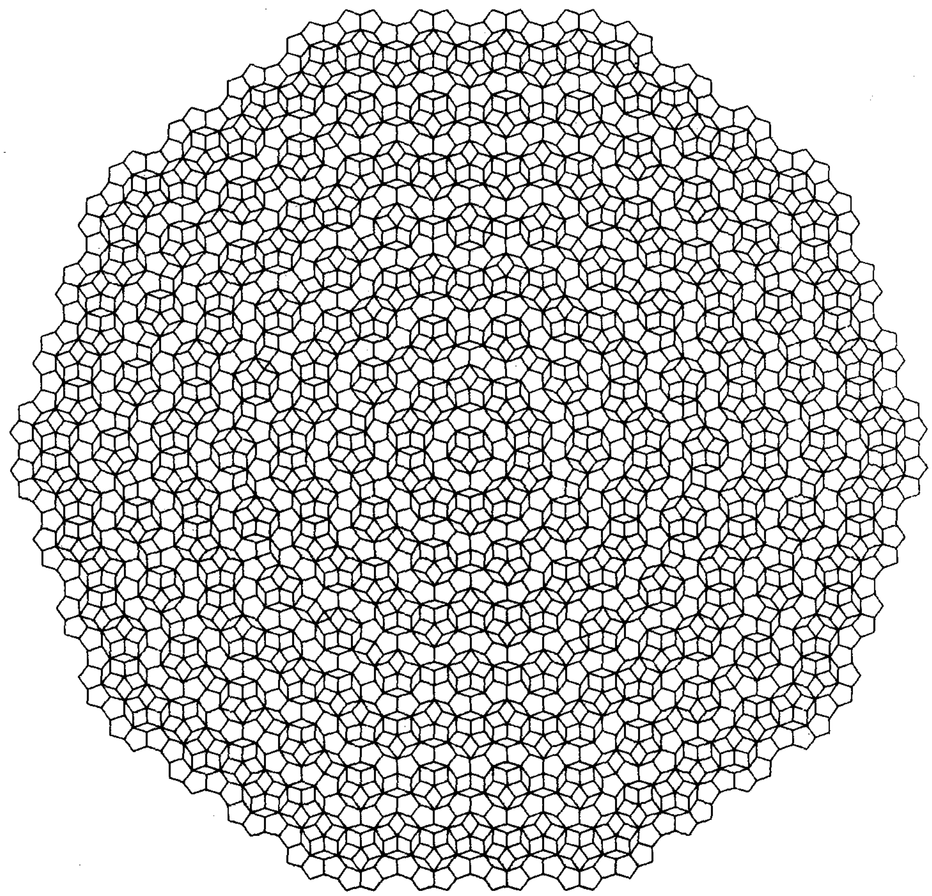
Symmetry: Culture and Science

Symmetry and Information

The Quarterly of the
International Society for the
Interdisciplinary Study of Symmetry
(ISIS-Symmetry)

Editors:
György Darvas and Dénes Nagy
Volume 7, Number 3, 1996



Symmetry: Culture and Science
Vol. 7, No. 3, 231-246, 1996

SYMMETRY: SCIENCE AND ART

CONTEMPORARY SCIENCE AND THE SEARCH FOR SYMMETRY IN NATURE AND SOCIETY

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Abstract: *Modern science described a dehumanized world of matter in motion controlled by deterministic force laws. Since there was no place in this "reality" for species-specific human attributes, nineteenth century philosophers and historians saved a "spiritual" realm where consciousness, freedom, and morality obtained by uprooting humanity from nature. Recent scientific developments, however, discern patterned processes of change which might provide a scientific paradigm able to reground humanity in a more congenial nature.*

In the nineteenth century the triumphant march of science seemed destined to monopolize all learning. This was potentially devastating, since explanations suited for science were dehumanizing. In science, the general and abstract counted: Scientists sought universal laws, which enabled them to predict outcomes and control nature. Concrete individuals, by contrast, mattered to humanists, who used sequences of historical accidents to account for the unique. Their goal was to empathize with other human beings while preserving freedom. Accepting that techniques and presuppositions used to explain nature would not apply to the human world, philosophers like Wilhelm Dilthey worked out a division of labor distinguishing methods appropriate to the spiritual realities of the "mind-effected world," in which people lived and acted consciously, and the physical realities of the material realm, in which dead bodies moved deterministically (Rickman, 1961).

Humanists saved themselves from scientific imperialism by segregating their disciplines, preserving the "spiritual" realities defining people at a dreadful cost. The humanities protected consciousness, freedom, and morality by making every person and event singular. If every concrete individual was unique, and every event without parallel, however, no covering law could apply, and the study of human behavior was deprived of explanatory tools. Thus humanists were not only left more "Baconian" than scientists, they were incapable of explaining societal realities. Humanists ferreted out more and more details about actual historical events. But by restricting themselves to sequencing the facts in chronicles admired strictly for their accuracy, less and less was understood about why people acted. Appeals to realities like consciousness, freedom, and value were made, of course, but since these humanistic realities were beyond the pale of causal explanation monopolized by science, saving humanism meant alienating humankind from nature.

There was no place for human attributes among the purely material nature described by Modern science. Modern science denuded nature of purpose and meaning. Elementary particles, Newton's massy bodies, moved thither and yon along precisely calculated trajectories determined by force laws. But regardless of the scientists' presumed ability to predict where they would be in the future, and even to demonstrate exactly where they had been in the past, dead material bodies had no goal as they moved about and occasionally collided. Moreover, if science forbid purpose to nature, there could be no meaning in the physical world. And if only the material was "real", Modern science left no room for values and morals. Goethe said of this world that "we shuddered at it as if it were a ghost" (Quoted in Cassirer 1932/55). This situation endured well into the twentieth century, where scientists like the biologist Jacques Monod concluded that life was a statistical miracle and people "gypsies" in nature (Monod, 1971).

Modern science did, of course, explain a great deal, but, said the Danish theologian Soren Kierkegaard, its approach was fatally flawed by the dissymmetry between science and society it necessitated. Modern scientists looked outward rather than inward, Kierkegaard said, intending by their work "to fascinate and astonish the world ... and not to understand oneself." This was understandable, even worthy. But it led to a self-defeating paradox, for the more scientists learned about the world the less they knew about themselves. When, mused Kierkegaard, "... everything is explained by an X which is not explained, then nothing is explained at all. If this is not skepticism then it is superstition" (Quoted in Miller, 1962).

But symmetry in science and society could be restored, provided an historicizing science and a contextualizing humanism "converge" in describing an evolving nature that incorporates physical, biological, and social realities. Then the same explanatory paradigm would apply to both "natural" and social realities. A bridge between these "two cultures" is being built (Prigogine, 1988), although its construction owes most to the forging of a new scientific paradigm. Work in the self-organization of dissipative structures has been among the most significant, and, moreover, scientists have been the first to fully appreciate the potential for convergence (Prigogine, 1976). Nobel Laureates like Prigogine have written books explaining the new science to "lay audiences" (Prigogine, 1980; Prigogine and Stengers, 1984; Nicolis and Prigogine, 1989), actively involved representatives of various humanistic disciplines in this research, and encouraged numerous international conferences aimed both at displaying the influence of history on scientific fields and exploring possible applications of dissipative structures models to traditionally sociological problems (Prigogine and Sanglier, 1985; Zanzi, 1996).

Developments in early twentieth century science undercut the universal claims of Modern science. Einstein's theories described a macrocosm where time was relative and space four-dimensional. The Copenhagen Interpretation of Quantum Physics (CIQT) denied science could describe the microcosm totally and perfectly, and allowed that what advanced observations implied defied understanding (Rae, 1986). But this seemingly radical attack on Modern science offered humanists very little. G.B Shaw summed their position nicely in *Too True To Be Good.* "The universe of Isaac Newton," he said, "was my faith. Here I found my dogma of infallibility. And now — now — what is left of it? ... All is caprice ..." (Quoted in Frank, 1957). A world which was beyond understanding was no more congenial than a world which made sense but was unbearable. Humanists opted to continue denying the laws of nature applied to people and societies. Thus the dissymmetry between nature and society survived the early twentieth century challenge to Newtonism.

Now, of course, if science *is* objective truth, Descartes' "clear and certain knowledge", there is no ethical alternative to accepting the picture it paints. If a division into two cultures separated by an unbridgeable gulf results, there is no wishing it away. Nevertheless, it is not surprising that, in these circumstances, many turn from science — and reason — in a desperate search for meaning and purpose. But, since its inherited paradigms have been challenged, there is no reason for humanists to bind themselves to a confrontational definition of science. This is not to imply humanists can make up new paradigms to meet the needs of the moment or to make themselves comfortable. The paradigms of science may be something less than perfectly objective reports on observations of external realities that "speak for themselves," but they are collectively framed, publicly defended, and corporately held. They cannot simply be ignored because they are dissatisfying. If, on the other hand, contemporary science promises a rediscovered symmetry between nature and society, then humanists should take it seriously, for mind-effected realities would be as "natural" as any other and would be understandable as well as describable.

The twentieth century challenge to scientism suggests that a collectively embraced picture of the world, a "science", is not a perfect copy of external reality. Individual scientists typically believe in the nature they describe, and others share world pictures only when they can repeat experiments and experiences. But Modern scientists have been misled by the public, repeatable quality of their findings into assuming they were merely recording a purely objective view of an independently existing external nature. They considered themselves to have risen to a God-like position from which nature could be observed once and definitively. Nevertheless, shared experience loads the philosophical dice with which we symbolize reality in favor of world views reflecting social experience, and any set of symbols which is endorsed by a community will reflect the experiences of its members (Durkheim, 1912/47). Thus, although a great deal can be said about the world and how it works, science tells us at least as much about the society in which it originates as it does about nature (Bloor, 1991).

The scientific paradigm emerging in the late twentieth century has the potential to restore symmetry to the scientific and humanistic realms by rooting society in a nature congenial to consciousness, freedom, and value. The new paradigm substitutes history — contingent experience — for universal laws, interactions for impacts, relationships for things, randomness for determinism, patterns for forces, and discontinuities for homogeneities. The effect of this emerging paradigm is to postulate a nature in which one set of metaphysical objects and behavioral rules is not privileged over others. Yet as radical as this departure from Modernity is, the dangers of idealism, anarchy, and mysticism are avoided. The actuality and significance of phenomena and laws are preserved within the context of a rigorous explanatory model. This balancing act is accomplished by respecting the diversity of nature, a diversity which is, so far as we know, more a function of time then place. That is, the new paradigm, concentrates more on explaining how nature works than what nature is. Its goal is to comprehend the *processes* by which nature is transformed over time.

Repudiating the reductionism of Modern physics, contemporary scientists concede "nature is too rich to be described in a single language" (Prigogine, 1980: 55). Physics always has a place in describing nature, but it is no longer expected to fully explain chemistry, biology, ecology, and sociology. In fact, rather than attempting to make the whole of reality look like physics, the emerging paradigm relegates physics to a relatively small and carefully bounded range of applications. Matter, motion, and force laws may operate everywhere in the universe, but the biologists' claim that the universe evolves must also be respected (Lewin, 1992; Goodwin, 1994). In time, according to the new paradigm, realms of existence emerge, each of which has an integrity obliging scientists to describe its characteristics using unique symbols orchestrated by special laws. Physics, in other words, may be used to explain how dead matter moves; but it is demonstrably incapable of demonstrating how more complex phenomena come into existence different (Matsuno, 1989a). Thus, if all reality were reduced to atoms, or whatever smallest particles, and if the actions of these particles were exclusively described using only force laws, then molecules, cells, ecosystems, and societies would be as inexplicable as scientists. Fortunately, new mathematical tools, especially applicable to use on computers, expand descriptions to nonlinear regions beyond the range of elegant but narrowly simple equations that proved egregiously inept at describing complex realities (Zabusky, 1987).

To respect the reality of complex molecules, life, ecosystems, and societies, laws of chemistry, biology, ecology, and morality are essential. The Modern science of which Kierkegaard complained rejected the reality of each of these realms, and any supposed laws describing such domains in terms transcending physics was dismissed as mystical nonsense. Whole realms of experience were denied reality. Certain practitioners of contemporary science, by contrast, are consciously striving to restore symmetry between humanity and nature by formulating a paradigm which can account for complexity without reducing humanity to a robotic state in which consciousness is epiphenomenal, freedom illusory, and morality superstition.

The position of these contemporary scientists may appear paradoxical On the one hand, they recognize both the reality and irreducibility of the "mind-effected world" of human experience. That is, a symmetry-break between physical, chemical, and biological nature and human experience *is* conceded. But, on the other hand, contemporary scientists seek to account for the "emergence" of the human world by modeling how information is created and stored through self-organizing processes that are universally locatable. That is, symmetry-breaking discontinuities are typical of both nature and society. Thus, the problem of meaning may be addressed and mysticism finessed by applying the same patterned processes observed in the rest of nature to account for social evolution and the creation of moral information.

A paradigm able to track the evolution of nature — e.g., the appearance of scientific Xs who are part of the nature they observe and explain — must map the creation of new kinds of information. The existence of different kinds of realities must be accepted, and qualitatively different modes of explanation must be articulated to explain their behavior. It would be no more appropriate to explain the behavior of people in societies by an appeal to chemical flows or genetic determinism than it is to explain life in terms of masses and momenta. To be sure, a vast industry within the scientific establishment aspires to do just that. But, although this work is often remarkably productive, for instance, in treating psychological disorders (Levinthal, 1988), more philosophically sophisticated theoreticians do not insist on explaining morality in terms of genes. Contemporary science "no longer seeks symmetry in static forms like the regular solids, but in dynamic laws" (Weyl, 1952: 77). Inspired by a more refined vision, symmetry no longer makes people atoms and societies crystals.

If contemporary science no longer finds symmetry by reducing all reality to the same level, it need not proclaim that morals are genetically determined, that genes are created by impacting particles, and that everything particles do is determined by force laws. To be sure, the atoms forming molecules and the people forming societies did interact But in these bottom-up interactions each was transformed by others and wholes emerged which have top-down effects (Kauffman, 1993). This kind of process may have been discovered in thermodynamics and biology, but it is actually easiest to envisage in human societies. Here cooperation among aggregated individuals, who no doubt gathered together for biological reasons like child-rearing or for purely contingent ones like serendipitous raiding, altered environmental flows. Working together, human groups multiplied available resources, which, in turn, permitted population to soar. But once population rose above the level sustainable by grazing behaviors, individuals were no longer fit or unfit because of their particular biological attributes, which is why genes alone cannot explain behavior.

In environments supporting large populations survival depends on preserving the organized patterns of cooperative behavior that transformed the environment originally. Having altered the scale on which environments were effected, cooperative action, in turn, changed the scale on which selection operates. Once societies exist, material nature is not the only selecting agent and nature no longer merely selects between organisms on the basis of their individual abilities to avoid dangers and access resources. After cooperative action released environmental flows on a large scale, social criteria select between behaviors, while nature acts on the collective whole. Since the flow released by many people working together can be much greater than the resources released by the sum of individuals each acting separately, individual choices and actions must be made in terms of collective criteria. It is not merely what an individual is biologically, which is determined by DNA and selected for or against by the natural environment, that counts. Henceforth, actions chosen locally for the immediate benefit of an individual organism may have global consequences affecting the survival chances of many other people.

When the cooperating humans constituting different social systems become dependent on those systems, individual members of societies improve their chances of biological survival by acting to preserve their societies. Of course, in a sense this is merely saying that fundamental biological drives retain their urgency, even in societal structures. But it would be inadequate to leave the argument here, for it must inevitably stumble over the fact that actions chosen for the good of the social system may — and often do — have deleterious effects on individuals. This is the problem of "altruism," and attempts to solve it by linking self-sacrifice to shared genetic legacies attribute virtually supernatural prescience to genes — clever little constructors who invented people to preserve themselves (Dawkins, 1976). It seems more promising, however, to introduce a symmetry-break between biology and culture here, recognizing that what happens at the societal level will be partly decoupled from the biological entities and laws which created it. Biology, of course, is not denied — there could be no human societies without humans, after all. But describing social systems in an appropriate language would avoid reducing people exclusively to the internal chemical components of their separate bodies.

In or out of societies, of course, people compute solutions to problems using "emotions" (Wimmer, 1995). It should be possible, however, to harness inherited biological capacities to social purposes, which would exemplify Francois Jacob's notion of the way in which nature evolves. Jacob sees evolution as a kind of tinkering, whereby existing organs acquire new attributes by entangling them in altered contexts (Jacob, 1982). In the societal case, biologically driven instincts and urges — e.g., learning to survive by avoiding pain and enhancing pleasure — are triggered by association with symbols representing global feedback. Once cooperative action has created a network of mutual interdependencies, the feeling of fear characteristic of encounters threatening to individuals in nature is transformed into sensations of, say, guilt, characteristic of individual actions threatening the societal contexts on which others depend.

Since collective survival may necessitate individual sacrifice, social systems really are wholes greater than the sums of their parts. Thus, a new level of reality has emerged, where moral rules constrain actions. Moral rules store information about what happens to many people. When they operate functionally, moral rules excite people to act by associating pain and pleasure with symbols representing collective experiences. But now the other side of the evolutionary process enters in, for no two groups of people are likely to organize for collective survival in exactly the same way. A "population" of social systems exists, and natural selection can act on different bodies of social information, as well as individual biological organisms. Those societies which organize internally more effectively will be advantaged — it is the variations in internal relations that makes the fit survivors! Thus, to understand how and why people act morally, the reality of social constructs such as laws and roles must be recognized, which is equivalent to saying that to understand molecules affinities and catalysts — not just trajectories — have to be respected.

To many scientists and some humanists this might still seem to introduce mysticism into science, for it makes criteria variable, models fluid, and explanations indeterminate. It also introduces a succession of symmetry-breaking discontinuities that would distinguish humanity-in-societies from nature, which itself is punctuated by gaps and gulfs. This reaction indicates the contemporary scientific revolution is not complete. But it should also be noted that many criticisms of the claims being made for and by a new scientific revolution are articulated in terms of the old paradigm, with which new methods and presuppositions are incommensurable. The inability to precisely predict the outcome of random events, for example, no longer exclusively tests the validity of scientific theories and does not represent a "betrayal" of science (Thom, 1980), yet ambiguity about predictions remains a frequent complaint. If precise predictions were possible, satisfying LaPlace's claim that a scientifically informed demon would know the whole past and future perfectly, then nature would never evolve for time would merely unpack the implications of whatever initial conditions had existed. Actually, in these circumstances, time would be an illusion and nature would have no history. Similarly, there would be no moral value if human behavior were predictable, for what people did would be mechanically determined.

The new paradigm, however, introduces diversity and ambiguity, resolving the anomalous inability of modern science to account for scientists by making time fundamental. Expressed in more pedestrian terms, the flagrant anomaly in Newtonian science is that it can explain motion, not change; it can trace the trajectory by which the momentum and position of a particle alters but not explain how the particle's attributes might become qualitatively. Most simply, the old paradigm stumbled over the problem of "newness" (Salthe, 1993), of how nature evolved. The reason for this failure may be that Modern science was born amidst the turmoil of radical social change and violent cultural conflicts. In the transition from "medieval" social systems, which were essentially the same as those created in antiquity, all certainty was lost. As Galileo put it, the "great organ of our philosophy" was "discordant". Heir to even older metaphysical conflicts between Medieval realists and nominalists and framed in the military confrontations of the Reformation religious wars, an emerging modern society sought stability above all. Modern science warred against ambiguity and supplied certainty through symbols of such transcendent abstraction that all differences dissolved in

Leibniz's calculations (Toulmin, 1990). But to regain social stability people embraced a static picture of nature from which they had been "quite cut out" (Schrödinger, 1954).

Of course, even if science is socially constructed, there would be no way to predict what specific symbols scientists would create — scientific theories and laws are, Einstein said, "free creations of the human mind." Yet it is reasonable to suppose both that Modern societies embraced Newtonian symbols, once he had invented them, because they seemed able to solve the crisis of transition from one kind of social system to another. Society converted to the new world view because people and classes in critical positions supposed that operating on the basis of symbols which could be applied universally in space would give them distinct advantages. These advantages followed from the stimulation of individual creativity and the release of vast new resources of energy, matter, and information. Over the three hundred years since Newton's *Principia*, however, vastly increased resource flows have driven social systems so far from equilibrium that another phase transition seems immanent (Laszlo, 1987). The very certitude which was so valuable to Modern societies may now become a liability. If so, endorsing a new scientific paradigm demonstrating the advantages of diversity, openness, and change will be essential.

There are signs that a new scientific paradigm will be adopted as postmodern society learns that uncertainty has benefits. The loss of predictability in science restores creativity to nature as it maps the experience of living in societies regularly altering internal relationships in response to new environmental challenges. The future opens up because ambiguity enters in — which hints at a new symmetry emphasizing evolution through error-making in both nature and society (Allen and Lesser, 1993). Scientists no longer have God-like omniscience or certainty, of course. To learn about nature, scientists must interact with the object of their studies, which, as the CIQT regularly pointed out, changes what is observed (Heisenberg, 1958a). From the Modern perspective, whose goal was to describe what *is* externally, to change the observed is to lose information. In CIQT, therefore, the limits of Modern science were reached when it was shown that the observational method became an obstacle to describing nature (Sullivan, 1933/49).

Although it is common to categorize the loss of certainty reached at "the end of the road" (Popper, 1982) for Modern science as a Kuhnian "revolution," the CIQT is really only a negative statement about the inability of science to describe nature. It actually represents the last formal acceptance of the metaphysical goals of Modernity and is a crie-de-coeur over the inability to achieve those goals. To have a "revolution" in science the old metaphysics must be replaced and a new perspective introduced. Aspiring to understand how nature evolved, the new perspective replaces "Being" with "Becoming" in a science of processes. For a science of qualitative change, the kinds of interaction discovered in quantum physics laboratories represent not obstacles to knowing what nature is but opportunities for understanding how natural information is created. CIQT left the dissymmetry between nature and society unaffected, for it only made *science* quantum theoretical. A positive statement about how interaction creates information is making *nature* quantum theoretical, which constitutes a true "revolution" in science and opens the door to dynamic symmetries between nature and social systems.

Yet the epistemological rigor of CIQT cannot simply be ignored. It is, after all, true that scientists know nothing until they look and that looking changes what they see (Bohr 1934/61; Heisenberg, 1952). But if the same dynamic is applied to nature, then thermodynamic flows play roles comparable to instrumental observations — they perturb some existing entity. Just as laboratory instruments change the subatomic particles they were designed to observe, the flow of energy through an entity can be expected to change it. In fact, the same sort of changes Heisenberg described in laboratory experiments will occur naturally when similarly scaled flows and entities interact--and with the same uncertain results (Heisenberg, 1958b). Similarly, just as what is observed in quantum laboratories must be regarded as the result of an observation, which Bohr carefully called a "phenomenon" and which he insisted on discussing only as a product embedded in an apparatus (Bohr, 1963), so the information created when a thermodynamic flow transforms an entity in its path will be embedded in the flow — if its component parts organize themselves to process the flow. There is nothing mystical or miraculous about this, for working to reduce an energy gradient a self-organized system generates entropy and conforms to the Second Law of Thermodynamics. A self-organized system records information created by the interaction of components perturbed by an energy flow. That is to say, nature evolves, effectively, by the observation of itself, occasionally creating unpredictable kinds of information by interactions of the type first discovered in quantum physics (Hanson, 1970).

If nature evolves by creating information through interactions, then the experiences of people in self-organized societies working together to distribute the products of energy flows become symmetrical with natural processes. Thus, just as interactions between particles created the molecules which chemistry describes, and interactions of molecules created the realm biology describes, so interactions between human beings created the societies which morality describes. But societies cannot be described simply by treating them as aggregates of biological organisms. If that were the case there would be nothing new created when societies self-organize, and people in societies could be understood biologically and their behavior described genetically. But if societies do represent an evolved level of reality they must be treated as systems, as wholes greater than the sums of their parts, in which the attributes of their parts change. In this case, when members of societies tried to describe the systems to which they belong, they would be in positions comparable to scientists embedded in the nature they seek to describe.

Koichiro Matsuno once addressed this very serious issue in the joking title of a paper on the origin of life, which he called "What Molecules Think When They Observe One Another" (Matsuno, 1989b). Analogously, regrounding scientists in the nature they describe makes science what nature thinks about itself, once nature gets complex enough to speak. If there is a symmetry between society and nature that contemporary science can capture, then there should be a comparable expression of the information created when people observe one another. But this expression will be ambiguous not only because it will be made by people who belong to the societies their interactions have created but also because they will have to use the language which made interaction and cooperation possible to describe the information it created. Nor would descriptions of social knowledge be predetermined. But the existence of information describing a society to itself suggests that, beyond some critical threshold of complexity, societies become aware of themselves. This information would have to represent not the concrete individual people composing a society but the relationships binding them together into a whole greater than the sum of its parts. Myth, with its value-laden symbology, is how self-organized societies speak about themselves when they become complex. As social symbols, myths record what happens when an "us" emerges from an aggregate of "yous" and "mes" (Artigiani, 1991).

Myth is a kind of algorithm, the use of which allows cooperating individuals to solve environmental problems. The solution of the problems is a social system, which is what a myth means in terms of lived experience. A society does not perfectly match its myths, any more than a biological organism is entirely determined by its DNA. DNA guides development, but the organism records how genetic information interacted with an environment. Similarly, although myth describes social roles and institutions rather than organs and metabolic processes, the actual fabric of a society depends upon an immense number of variables, some of which are freely choosing, creative, and unpredictable individuals. A society is "incompressible information," the shortest description of an environment possible, using the people, roles, institutions, and myths available.

The "stuff" of societies is not cells and tissues but the institutions orchestrating the behaviors which make the cooperative actions of biological humans possible. Ritual was probably the first medium for recording social information, and it no doubt originated in a biologically programed propensity to play (Huizinga, 1950; Whitehead, 1926/54). Linguistic communication, starting with legends and passing through myths to, it seems, sciences, greatly enriches the adaptive potential of social systems, for it can store information much more efficiently than the time-consuming repetition of practiced behaviors. But whether ritual or linguistic symbols, information must be communicated about the society rather than the individuals in it. Nature can record information about people as individuals materially, in biological tissue. Social roles and scripted behaviors are described using values, ethics and morals (VEMs), just as DNA describes organisms by directing the construction of their parts. When people interact under the influences of environmental flows to organize societies, information about the resulting relationships, not the individual people, must be preserved. This information, about the structure between people rather than the separate organisms, is preserved in a language suited to its qualitatively new kind of message, the language of moral symbols. In other words, mythically recorded VEMs are information created by people interacting (Lincoln, 1986).

The information about how people interact to create social wholes must be stored in the societies, which information, like the information stored in DNA, catalyzes actions (Wicken, 1987). A society knows how to preserve itself in time, replicating defining roles and relations by shaping the behavioral choices of future generations of its human components Storing information about what people share in common, rather than what they are individually, social information must be stored in symbols that are community properties rather than individually owned chemical molecules or material tissues. VEMs catalyze actions by individuals which compute solutions to social problems by correlating behaviors. Values are templates, ethics top-down rules guiding decision-making, and morals are descriptions of states whose known consequences are proven desirable. VEMs store information concerning feedbacks from the global to the local level, inclining individuals to act in ways which collective survival rewards and avoid punishable actions threatening the system. When VEMs catalyze behaviors by triggering associations between individual choices and social consequences — or stop behaviors for social reasons — societies are behaving analogously to B-Z Reactions or biotic cells: They are influencing the local choices of their human members by informing them about global circumstances (Bruner, 1990).

VEMs symbolize the "context-dependent information" which reveals the existence of complex systems (Gatlin, 1972), but it is sometimes hard for individuals to recognize its significance. VEMs do not determine behavior, the way force laws control matter. Thus, they can be violated. Moreover, it is always possible for nature to intrude into society, as Louis Dumont often noted, the way a hiccup can burst into a dinner party. Yet so long as a social system runs smoothly, individuals tend to identify theirs with the collective fate and to confound shared VEMs with cosmic principles. When societies recalibrate to process altered environmental flows, however, the rules of the social game become visible because they are changing. VEMs no longer describe behaviors that can be trusted, people are inclined to both condemn others whose choices surprised them and also to wonder about the validity of inherited beliefs and customs. Individuals disoriented by unexpected results become conscious of themselves as they explore roles with unknown consequences and search for rules stabilizing relationships. It is at these crisis stages, equivalent to the mathematical bifurcation points mapping natural transformations, that societies, like other natural systems, are able to evolve rather than merely develop. They evolve when individuals released from conventional constraints establish new relationships, which contextualize roles and behaviors in VEMs that redefine what people are.

Often enough the causes of radical shifts in societal structure can be minor events, for societies are laced with nonlinearities that disproportionately amplify effects. The pamphlets of an outraged monk or the pistol shots of a tubercular nationalist can, literally, shake the mind-effected world to its foundations. Often, however, the results differ profoundly from what their initiators intended. But that is because when a recalibrated social system stabilizes, its form captures the intentions and agendas of *all* interacting components. The ironies of history surprise even the makers of history, more often than not.

Regrettably, the great evolutionary discontinuities, although relatively rare, have usually been associated with considerable violence. Inspired by inherited VEMs, people fight to preserve existing orders against enthusiasts committed to their immediate transformation. Perhaps the greatest gift a convergence between science and the humanities can offer would be developed skills in navigating transitions and a sense of how unpredictable the human future is. The speed of social evolution makes mastering the discontinuities typical of natural processes all the more pressing. But there is no need to segregate society from nature by introducing Lamarckism to accommodate the speed of social evolution. Societies shaped by myths can change more quickly than biological storage systems because words are cheaper than genes. A behavioral hypothesis can be formulated and examined symbolically relatively quickly, whereas a biological organism probing an environmental possibility must survive long enough to test its ability to reproduce. But the interesting moments in social evolution would be as dramatic as the sudden transformation punctuating biological evolution, for periodically social evolution would have to invent new *kinds* of symbols.

Thus the shifts from rituals to linguistic symbols, from legends to myths, and from myths to science write time into social evolution, for increasing symbolic abstraction tracks increasing social complexity. The more complex a social system is, the greater the number of environments its roles and relationships must model. Not even linguistic symbols could map the dynamic environments of complex societies if a specific name were needed for every experience. Symbols must have one to many relations in complex systems, and they become more abstract to make orienting human behavior easier as social complexity requires the ability to adapt to an increasing variety of environments necessary.

Adapting to environmental conditions is how societies "think" (Douglas, 1986), which is a type of computation. The form of a society — its prescribed roles, defining relations, and institutionalized behaviors — are solutions to the problem of processing flows released by collective actions. The form of a society, moralized as a desirable state whose recreation is catalyzed by values and ethics, is the solution to the problem of how people working together are to survive given certain environmental flows: A society is a phenomenon embedded in a thermodynamic flow released from an environment, which amounts to a perturbing observation made by nature! Moreover, societies record solutions to problems in social roles — as they evolve "societies make up new people" (Hacking, 1985). Thus, the number of specialists in a social system measures the number of problems it can solve, which is to say, specialization measures complexity.

Once a solution has been computed it will be moralized because the society is solving problems individuals cannot solve for themselves and by solving those problems has created a circumstance in which what happens to one happens to all. In a society the lives of each depend on the actions of all — and vice versa. Consequently, the VEMs describing a society will invariably constrain perceptions and catalyze actions designed to preserve the system on which all depend. Members of societies are encouraged to select behaviors that preserve systemic coherence because their choices are influenced by their perceptions. Shared symbols and internalized rules for choosing and acting encourage individuals to perceive similar realities and react to them in mutually comprehensive ways.

The mythic web of shared VEMs embedding members of societies are, by analogy, the software operating societal computers by triggering and directing institutionalized behaviors to solve environmental problems. Myths describe collective environments and, through VEMs, prescribe the behaviors calculated to stabilize societies in those environments. Societies, like other natural systems, are goal-directed because they maintain a distinguishable structure within a determinable boundary. But now "purposefulness," which Modern humanists preserved by alienating themselves from the rest of the world, has been reintroduced. Purpose provides "meaning" to individuals and their actions, as Aristotle said, but now meaning has emerged as a perfectly natural aspect of the self-organization of social systems. Purpose is not cosmic — except in the sense that all natural activities maximize entropy — but is strictly local. Purpose is the programed behavior by which a structure responds to perturbations or fluctuations and "snaps-back" to restore its form. Purpose does not represent anything added to nature from outside. It merely reflects the fact that systems preserve their identities as they respond to altered flows of energy, information, and matter.

However, reintroducing purpose to nature establishes symmetry with the mind-effected world of the humanities. If local systems of order, which self-organize naturally, are affected by the actions of their individual components, then component behavior is meaningful, for what an individual does or fails to do can affect the stability of a system globally. Systemic stability is, therefore, the criterion for evaluating component behaviors, which "mean" the effects they have on the systems to which they belong. Recalibrating systemic relationships translates concrete, local, and individual actions into the language of structure, global, and systemic consequences. Recalibrating is how wholes decide what the actions of their parts mean. Now, of course, the language in which systemic consequences are expressed varies depending on the systems. Order and entropy suffice for describing thermodynamic meanings, sickness and health suffice for biological organisms, and judgments of moral right and wrong apply on the level of human societies. Morality emerges to symbolize information about the systems-level consequences of actions, which symbols, of course, are emotionally charged because they reflect the hopes and fears of other people.

Reestablishing symmetry between nature and society represents a major step to resolving the cultural crisis of the twentieth century. Yet extending the paradigms appropriate to the sciences and humanities has dangers, as well. Certainly the absolute and universal quality of VEMs is threatened if they are made functions of rules for collective computation of energy, matter, and information flows in accordance with a maximum entropy principle. Moreover, as systems societies strive to exercise top-down authority on their components, constraining them to choose and act in ways likely to preserve or restore organizational stability. Some of the individual autonomy cherished by both defenders and critics of Modern civilization appears in jeopardy.

Societal coherence can be preserved without violating humanistic concerns about individuality and freedom, however, and the benefit of reestablishing symmetry between science and society is not to preserve any particular morality but to reroot humankind in nature. This is easier than it might seem, for if the evolution of social complexity is symmetrical with natural evolution individuality should be a function of evolved social — not biological — complexity. At least in the rest of nature evolved complexity depends, partly, on ever more radically discriminating components from one another (Buss, 1987), and it should be obvious that basic sociological phenomena, like the division of labor, represent evolved complexity.

As societies grow more complex they have to model more aspects of the environment in specialized social roles. But, if the biographies of great pioneers are acceptable examples, the roles they learn to play which distinguish them individually from others are not created by themselves. As in other natural systems (Kauffman, 1991), social roles are created elsewhere in the system. Socrates (Vlastos, 1991), for example, formalized the newly perceived category of "philosopher", which he personified with complete individuality. But Socrates did not invent the role he played. Rather, he learned from the Delphic oracle that he was "the wisest of all Greeks" and spent the rest of his life trying to find out what being "the wisest of all Greeks" meant. In the process, he helped articulate a morality for a society that had outgrown its VEMs. It was, therefore, for the benefit of society that Socrates struggled to define the good, true, and beautiful. Sadly, the irony he used to observe social information from within proved unbearably annoying. But, even if all succeeding philosophers model themselves on his template, it is not necessary for them to be pug-nosed and fatally annoying. Philosophizing is a social role, not a biological trait.

Similarly, "freedom" only becomes a meaningful category in social systems, where the consequences of actions can be distinguished by their effects on other members of societies. In societies individuals are not just spontaneous — they have options to choose between morally. This moral knowledge, as the Hebrew story of Adam and Eve makes clear, is information created when social systems emerged from human interactions that exiled humankind from the "Garden". In a pre-social state, people were near equilibrium behaviorally. They could do pretty much whatever they felt like doing, whenever they felt like doing it. Such spontaneity was not without consequences, but the original people were ignorant of the "knowledge of good and evil" because their actions affected only their own survival. No doubt they experienced pleasure and pain, but the only discernible consequences of chosen actions would have been almost exclusively personal, and there is no need of morals to describe them — emotions, as noted earlier, do fine at this level of experience. But once interactions have created networks of mutual dependency, then it will be states of society — consequences affecting the survival of other people — which distinguish actions. States of society are described in moral, not biological, terms.

Since other people who are threatened or benefited can punish or reward through the very network whose stability is now collectively required, feedbacks will inform individuals of what their chosen actions "mean." The communication of a collective judgment is tantamount to the embedding of an individual in the apparatus of an observation. Again, as in nature and science, observation creates information, in this case individual self-consciousness (Artigiani, 1995). The "Self" as a category thus emerges in the same patterned process that operates in science and throughout nature (Mauss, 1934/85). But this self is a measure of individual complexity, for it is how human beings model themselves. Complex systems, by one definition (Nicolis, 1986), are systems with models of themselves. Complex systems have models of themselves because they access several states and must "anticipate" future needs (Rosen, 1985). Choices are moral when the anticipated future state is that of an individual's position in a society, for it is how others will react to an individual's initiatives that becomes the criteria for selecting between actions. Moral selection makes choices meaningful, which is why people can be free in societies: Freedom does not mean acting spontaneously or in ways that pleasure only individuals but choosing between moral alternatives about how others will be effected.

The death of Socrates indicates that the relationship between individual freedom and social systems is not straight-forward. Humanists have tended to see individual autonomy as a natural right, as an attribute of human being. But self-consciously individuals whose choices affect many others experience immense psychological burdens. In fact, in the past most people, like Sts. Augustine and Anselm, buckled under the stress of separateness. They exchanged autonomy for community, preferring security to the anxiety of choice. Techniques for bearing the burdens of individual autonomy emerged with Modern societies, however. Developments in religion, economics, and politics provided enough security for individualism and autonomy, in effect new human attributes, to endure. Calvinism helped implant the Puritan conscience, while private property guaranteed independence to the frugal and mature, and participatory politics empowered even the middling ranks.

Newtonian science was collectively endorsed because it mapped nature in the image of a society made up of individuals, whose newly formed "selves" were like radically separated atoms. Individuals behaved predictably enough to be metaphorical atoms. They seemed to follow trajectories, because in capitalist marketplaces the push and pull of supply and demand, the economic equivalents of force laws, governed all. People embraced the harmonies of Newton's solar system because they were learning to govern themselves in constitutional monarchies.

Modern science created a model for interpreting everything, which was collectively endorsed because it symbolized a complex society able to adapt by accessing resources in greater quantities than competing systems. Through Modern science societies could assume a certain stability in roles and relationships, which also reduced stress. Entrepreneurs and politicians, for instance, might be ruthless, but they honored contracts and obeyed laws. In other words, Modern societies mapped by science discovered themselves in a situation which combined elements of both chaos and order. They had evolved to such a level of complexity that they lost the crystalline rigidity of earlier civilizations, where, as Spencer said, cooperation was coerced, and unintentionally developed the capacity to compete cooperatively.

Thus the development of Modern science enabled social systems to continue evolving. Just as with individuality, the emergence of societies able to continue evolving seems to track natural processes — it is not adaptation which is selected by nature but complexity (Peacocke, 1984). And similarly, just as individuality emerges in nature without any evidence to suggest material bodies, cells, and biological organisms actually intended it, so, too, we can relate the emergence of individualism and autonomy, the quintessential human values, to the evolution of *social* complexity. If people had wanted to make themselves individual and responsible they could have done so during earlier systemic collapses, when they fell out of social networks and had to survive on their own. But individualism and autonomy emerged only when social systems needed to attribute these characteristics to their components to enhance their, the societies, chances of survival. Autonomous individuals contribute to the stability of complex societies because they are laced with nonlinearities are vulnerable to even slight perturbations, and individuals read collective environments in much finer detail than do whole systems. Moreover, autonomous individuals will respond to problems and opportunities more rapidly than people locked into unchanging social roles, providing societies with faster solutions provided individuals have the power to globalize information. Thus, societies which have created dynamic environments depend upon dynamic human beings to survive.

Social complexity continues to evolve by massively distributing computing responsibilities. Change is simply too fast and too unpredictable for systems to survive through top-down command and control methods. Yet, by the same token, anarchy must be avoided if the system is to survive. Thus, complex systems balance precariously "at the edge of chaos" (Langton, 1990), in the realm "between crystal and smoke" (Atlan, 1979), where there is enough organization for the system to remain distinguishable from its environment but so much flexibility that it can recalibrate in response to almost any challenge. This is done by mapping societies with process symbols which amount to rules for making rules rather than moralized visions of ideal states. Social evolution is driving people beyond virtue, to an accompanying chorus of philosophical laments (MacIntyre, 1984), for too many states must be accessed for any to be moralized and all to be named. Rather, individuals equipped with the ethical knowledge of how to decide which state to aim at can compute solutions in parallel, making it possible for societies, literally, to govern themselves. Of course, the agents to whom processing authority is distributed so massively must be entirely self-conscious and free.

The emerging convergence between nature and society makes profound demands on academic disciplines as well as individuals. Science must learn to define entities by tracing their real life experiences through time, rather than deducing them from abstract general principles, and the humanities must extend the scope of their concern beyond individuals to include systems, recognizing the influence of embedding contexts. Such steps are possible if science concedes there are realities transcending the explanatory techniques of Modernity and the humanities accept naturalistic explanations of people's seemingly peculiar attributes. That is, science must recognize that consciousness, freedom, and value are real, and the humanities must recognize that consciousness, freedom, and value are natural.

A new paradigm is threatening to many scientists, and most humanists are ignorant of its potentials. Nevertheless, there are grounds for hope. To begin with, the new vision of nature does account for more of experience than have earlier paradigms. That implies, at least, that science has gotten closer to describing how nature works. Humanists may object that making science socially constructed denudes it of the authority necessary to control behavior. But complex societies flounder when behavior is controlled — they lose the evolved ability to evolve — and, in any case, human values typically emphasize individuality and autonomy above control. The ambiguity of a science self-consciously embraced as if it were a myth may leave conventionally-minded scientists and humanists uncomfortable, but it also seems to display a moral irony compatible with the edge of chaos. Besides, deducing a picture of society that is liberal, ethical, and humane from a science of nature may provide so delightful a prospect a majority will be tempted to both embrace its promise and accept its obligations.

In any case, the argument for convergence introduces the wonderful irony that science, not the humanities, is restoring humanism. Between the wars, Nicholas Berdyaev concluded "History needs man as its material, but has not recognized him as her purpose" (Berdyaev, 1935/61: 23). But if the evolution of complexity in social systems leads to free, creative, and autonomous persons, then democracy and liberty, cherished human institutions, have selective advantage. It is thus the scientific picture that offers humankind, as James Jeans somewhere put it, a "home fit for man to live in". There is realistic hope that a scientific endorsement of progressive institutions may strengthen popular commitments against doubt and demagoguery. If social applications of the new science reenforce cherished values and vulnerable institutions, the lay public might be more willing to defend individual autonomy against Burckhardt's "terrible simplifiers". If, nevertheless, people flee from the stress of self-determination amidst ambiguity and decline the invitation to take up residence in this dynamic world, then the fault lies not in our stars but in ourselves. Nature will explore alternative routes to maximize entropy.

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