

For Language as Cultural Dynamic (Special issue of Cultural Dynamics, M.A.K. Halliday, Issue Editor)

DISCOURSE, DYNAMICS, AND SOCIAL CHANGE

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The Problem of Cultural Dynamics

Which aspects of social and cultural change are in principle predictable and which are not? How can we usefully model the dynamics of such complex systems as human communities? What is the role of discourse, and of culturally and historically specific semiotic formations generally, in co-determining the processes of social change? How are discursive, semiotic practices and material, ecosystem processes inextricably linked in the dynamics of social systems?

In what follows I will attempt to sketch the broad outlines of a theoretical framework within which the answers to such questions may be sought, and I will suggest some tentative solutions to these general problems of cultural dynamics. I believe that the basic tools needed for these tasks have recently been developed in other disciplines, needing only critical re-interpretation to be applicable to cultural dynamics. In a brief exposition such as this, many details must be omitted, but they already are or soon will be available elsewhere (see citations below).

Sophisticated readers will be well aware of the hazards of theory-making in this field. It is all too easy to be seduced by single principles, or by partial perspectives, including those congenial to our own cultural biases or ideological class interests. It is notoriously difficult to bridge between microsocial and macrosocial approaches, or between the materialist and idealist traditions. Above all, it is difficult to make a truly dynamic account of social and cultural systems, since most of our traditional concepts (individuals, institutions, cultures, societies, languages, discourses) are formulated in essentially static terms.

There are more fundamental limitations on our ability to model systems of which we are ourselves a part. As observers and theorists we are limited by scale: we exist for mere decades, while the systems we seek to model exist for centuries; we can observe only small regions of space at any one time, while social systems extend over nations and continents. We change quickly: maturing, aging, dying; many cultural processes occur so slowly that they may not seem to us to be occurring at all. We are also limited by position: we are members of some cultures and societies and not others; we speak some languages, dialects, registers, and discourses but not others; we are socially positioned observers, with only a single gender, age, class, or status,

commanding a limited range of viewpoints even within the social and culture groups of which we are members.

On the other hand, as evolutionary and social products of the systems we study, we are pre-adapted to model them (in strictly limited ways) as a condition of our own survival (cf. Rosen 1985 on 'anticipatory systems'). As members of social groups we can participate in co-operative enterprises in which multiple observers cover larger areas, command a greater multiplicity of (not always easily shared) social and cultural viewpoints, and (partially) interpret the (incomplete) records left by our historical predecessors. It is as futile to imagine that a single organism will completely model its own ecosystem, or a single individual its own society, as that a single cell will model an organism, or a single molecule a cell. But a social system, a culture, might well construct and maintain a model of itself, necessarily incomplete perhaps (cf. Gödel 1931/1962), but possibly adequate for certain purposes.

Human culture has already constructed the key tool needed to make such a model of itself: a linguistic system which is, semiotically, its own meta-system. Any natural language may serve as its own meta-language, in which its own grammar, and more importantly a theory of how its speakers make meanings with that grammar (Halliday's grammatics, in press-a, and this volume), may be articulated. A community deploys the resources of its language in discourses, social formations that define a particular way of using language to make a particular kind of meaning, and those discourses (including the discourse of cultural dynamics) may be employed to model of at least some processes of the whole cultural system which includes them.

Discourses are made by the social and cultural interactions of many actual, individual speakers over a period of time: interactions which are also simultaneously processes in the living material, ecological system which is their human community.

Social Semiotics and Cultural Dynamics

The theory of cultural discourses as social semiotic formations (Halliday 1978, 1988, in press-b; Lemke 1988a, 1989, 1990a, 1990b; Threadgold 1986, 1989; Hodge & Kress 1988; Thibault 1986, 1989a, 1989b) has arisen from the study of the semantics of texts inspired by Bakhtin's social linguistics (Bakhtin 1929/1986, 1935/1981, 1953/1986) and Halliday's functional semantics (Halliday 1985). It provides a model for a general theory of social formations, which is a key element in the theoretical synthesis we need.

Social semiotics begins by disputing the primacy of the sign and the exclusive emphasis on sign systems in formalist semiotics (e.g. Eco 1976). Instead it gives priority to the signifying act as instance, and to social signifying practices as regular, repeatable, recognizable types. Social semiotics offers the view that socially meaningful doings constitute cultures (social semiotic systems): that cultures are systems of interlinking, socially meaningful practices by which we make sense to and of others, not merely in explicit communication, but through all forms of socially meaningful action (speaking, drawing, dressing, cooking, building, fighting, etc.). Sign systems are abstractions from such practices (e.g. linguistic signs from speech), changing as social practices change.

Sign systems are semiotic resource systems; they enable us to make meaningful actions (including utterances) by deploying these resources in recognizable, mostly habitual (and marginally creative) ways. The habitual ways in which we deploy them are identifiable as

semiotic formations: the regular and repeatable, recognizably meaningful, culturally and historically specific patterns of co-deployment of semiotic resources in a community. A literary genre of a period is a semiotic formation; so also is an architectural style and type of building, a religious ritual, a typical holiday meal, the making of a particular type of costume. All these formations are defined in terms of the regular patterning of actions, of social meaningful practices, that members of a community are engaged in when producing them.

Discourse formations are social semiotic formations in which the deployment of linguistic resources is essential to the social meaning of the result (though other actional semiotic resources may also be deployed as part of the formation, as with gesture in speech, graphics with writing, etc. Cf. Lemke 1987). The linguistic (semantic and grammatical) resources specific to a particular discourse formation form a register of the language (a specific distribution of the probabilities of deploying any meaning alternative the language provides; see Gregory 1967, Ure & Ellis 1974, Halliday 1978). A particular type of Weather Report, for example, would be a specific discourse formation, deploying a portion of the register of meteorology, and doing so according to a schema of organization and sequence which is often called a genre (Hasan 1985, Martin 1985, Ventola 1987, Lemke 1988b, 1990a). There are speech genres, and genres of both literary and non-literary writing; and there are also, more generally, action genres, which need not involve language at all, though their enactment may be guided by use of a discourse formation, as when we 'talk ourselves through' a complex performance or an activity requiring difficult, context-dependent choices.

Semiotic formations provide an intermediate level of conceptual analysis between the microsocial (utterances, texts, particular acts and events) and the macrosocial (dialects, institutions, classes, ideologies), but more importantly, they formulate the scale from microsocial to macrosocial in terms of actions (social practices) and patterns of relations of actions (cultural formations) and not in terms of entities and aggregations of entities (individuals: corporate groups: societies). This is an essentially cultural view: social systems are systems of doings, not of beings as such. They are systems of interrelated cultural practices, not systems of socially interacting individuals as such. The ultimate theoretical constituents of a social system are not interacting dyads, not even individual members, but individual social and cultural practices. Social 'individuals' must be theoretically re-constructed (e.g. Lemke 1988c); they are no longer 'givens' in a semiotic social theory.

The link between formations and macrosocial structural relations and dynamics is provided by another cultural notion: organized heterogeneity (cf. Wallace 1970 on 'organization of diversity'). Social and cultural systems are not homogeneous, they exhibit an essential internal diversity: their subsystems present alternatives, complementary or conflicting (e.g. male vs. female practices, class conflicts, age-grade diversity, etc.). In the case of discourse formations (and more generally the language varieties and semantic orientations associated with differentiating social variables, cf. Bernstein 1981, Hasan 1986, Hasan & Cloran 1990), Bakhtin (1935) labelled this phenomenon heteroglossia. In every community there co-exist different regional and social group dialects, different historical usages, different modes of speaking associated with interest groups, age-groups, genders, ideological points-of-view, etc. Social semiotics identifies, with Bakhtin, both the ideational and the value-orientational relations among these different social voices (Lemke 1988a, 1989, 1990b, in press; Thibault 1989). Each subcommunity constructs a different reality by the views it formulates in language on any matter,

and it constructs its views always and only from a particular social position of interests and values vis-a-vis other possible or actual views.

It is our own culture's ideology that fuses the ideational dimension of language's semantic resources (and of semiotic resources generally, cf. Lemke 1989, 1990a), with the real, the natural, the universal, the immutable, the absolute, while disjoining this from a contrasting fusion of the social-orientational dimension with the relative, the conventional, the cultural. Semiotic resources in themselves, the potential for cultural meanings, independently combine both the 'social-cultural' and the 'natural' with both 'making it be' ('action') and 'telling what is' ('representation' 'knowledge'); cf. Halliday (this volume). Contrary to the ideology of our culture, what an analysis of the resources it deploys shows is that the 'natural' is just as 'conventional' as the social, the 'real' just as much a product of action as the 'cultural'. We make both the social and the natural, or better: the natural and the cultural make each other and are one, not two. The natural has all the properties of the cultural: it is mutable, conventional, and relative to the orientation of the observer. Semiotically (i.e. epistemologically, and probably historically as well) the natural is derivative from the cultural, a specialization later made to seem an opposition.

What applies to the discourses of diverse and often conflicting subcommunities applies equally to all their social practices and formations: there is in general a system of heteropraxia, of specific relations of alliance, opposition, etc. among their ways of doing, each with respect to the others, of which the system of heteroglossia is one very important part. No text can be read, no action interpreted, without taking into account the aspect of its meaning that derives from the existence or possibility of alternative and conflicting ways of saying and doing within the same total community. And no utterance or action escapes making meanings, anticipated or not, in these terms.

Semiotic formations are relatively stable elements in the flux of day-to-day social action; they insure the minimal short-term predictability necessary for social coherence. Formations may be represented in terms of their constituent actions as selections from sets of alternatives with contrasting meanings, each selected alternative implying something about the structure and sequence of action as well as the specific acts to be performed. This is a straightforward generalization of the paradigm-and-realization model of language used in Systemic Linguistics (Halliday 1976, Fawcett 1980). They may also be represented in some cases structurally (Hasan 1989, Ventola 1987) according to a syntagm-and-realization model, or according to a mixed approach appropriate to the kind of formation being described (cf. the representation of discourse formations by thematic patterns diagrams in Lemke 1983, 1988a, 1990a).

Since semiotic formations are co-deployments of resources that form systems of (paradigmatic) semiotic alternatives (often from different semiotic systems, e.g. language and gesture or picture, cf. Lemke 1987), and since they are in turn characteristic of and constitutive of divergent subcommunities (heteroglossia, heteropraxia), it is most general to represent them in terms of the conditional probabilities for the co-occurrence of various practices in various contexts, according to the subcommunity, and indeed the culture as a whole. This can be done within the general relational-contextual model of meaning employed in social semiotics.

Any action or process (or simultaneous or sequential combination of such) is socially meaningful only in relation to other alternative actions or processes (and combinations) that might have occurred in its place. The specific meaning is interpretable only in relation to the set of socially

relevant contexts which are constructed for the purposes of that interpretation. Such contexts are generally analyzable into syntagmatic contexts (events before and after), paradigmatic contexts (alternative events), and indexical contexts (situationally co-occurring events); see Lemke (1990a). All of these contextualization relations may be formally represented as meta-redundancy relations (Lemke 1984: 35-39; see also Halliday in press-a), which specify the conditional probabilities for co-occurrence of various alternatives in various contexts, but hierarchically, so that higher-level alternatives (e.g. higher vs. lower social class) co-occur with entire probability distributions linking, say, semantic types of utterances to situational uses (cf. Hasan 1990), and not with particular acts or situation-types separately. Thus to be a member of a social-class subculture is not to use only some semantic strategies available in the language, or even to use them with a certain distinctive probability, but to combine them differently with the demands of situation from what a member of another class might do.

The irreducible formal hierarchy of contextualization in social meaning reflects the dynamical hierarchy of emergent levels of organization in human social-material systems, as we will see below. This connection is already implicated in the social semiotic view of meaning. The semiotic systems of a community are abstractions of the resources in actual use in that community. The semiotic formations present their habitual patterns of co-deployment, and the metaredundancy relations summarize their mutual co-occurrence distributions with respect to each other. All these analytic forms are abstractions of types from tokens; they all depend entirely on the moment-to-moment happenings in the community. It is instances (events, acts, occurrences, performances) which are primary.

No inertia or active constraining force is attributed to semiotic systems like language, formations such as genres, or metaredundancy relations. If these abstractions from practice behave as if they were dynamical systems (e.g. by persisting, by changing coherently, by evolving over time), it is because the instances from which they are derived are themselves simultaneously elements of genuine, material dynamical systems. If formal semiotic relations exhibit an irreducible hierarchical organization, it is because the dynamical systems which enact them do so. Semiotic systems and formations, and thus culture, do not have an autonomous dynamics of their own, but rather a complex dialectical interdependence with the material dynamics of social communities.

Although social semiotics avoids the dead-end of idealist reification, it still only allows for, and does not yet provide a true dynamics, which must equally avoid the trap of a naive materialism. Every scientific discourse of material processes and relations is still a discourse, a semiotic formation which stands inside some culture and not outside culture altogether. Every instance, even a nuclear detonation, is only meaningful insofar as we can construe it as an instance of some type(s) already (or nascently) provided by our meaning system (system of semiotic practices). But meaning systems, and cultures, change; what was not meaningful before can become meaningful, and this process depends critically on a dialectic between material and semiotic dynamics within a total (material-cum-social) system. We need to understand the dynamics of the larger eco-physical systems in which cultures are embedded and from which the energy of their dynamics derives. Human social communities are material ecosystems. Even though physics, chemistry, and eco-biology are themselves simply cultural discourses just as linguistics and social semiotics are, these two different orders of discourse construe two different kinds of relations among events and processes, and it is the connection between those different kinds of relations that is the key to modeling cultural dynamics.

The Dynamics of Complex Systems

We may regard a social practice as a 'type', as a semiotic, cultural abstraction, but every particular, actual instance of that social practice is enacted by some material process in a complex physical, chemical, biological, ecological system. Every action thus enters into two systems of relations, for which our culture has two different sorts of descriptive discourses. As an instance of a social practice, it enters into relations of meaning with other social practices. These are semiotic relations. As a physical event, it enters into relations of energy, matter, and information exchange with other events. These are material relations. Every instance of a social practice is simultaneously also an instance of some material process. Every system of social practices, linked in semiotic formations according to their meaning relations (cf. the metaredundancy relations), is also a system of material processes linked by physical, chemical, and ecological relations.

When we build a building, we quarry stone or cast concrete, we construct doors and walls and windows, we build floors and stairs and shafts, we place ducts and vents, all in accordance with a system of cultural practices that defines for us an architectural style, a desirable design according to historically and culturally specific discourses of what buildings and rooms should be like, how comfort and privacy should be provided for, what spaces are monumental, which public, which private, how size and shape and light should co-occur with use and function: in short, with the architectural semiotics of our culture.

But in doing so we also assemble masses with densities, weights, compressional and tensile strengths, electrical and thermal conductivities; we arrange flows of water and air according to principles of hydrodynamics, flows of heat by principles of thermodynamics, and allow for material flows of people and goods. We may provide a system of communications capable of handling certain rates of information transfer, a supply of energy that may flow from solar panels on the roof to heating channels in the walls, or from underground generators through cables to electrical connections in every room. These things we do also according to discourses of our community, those regarding science and engineering, but in all these doings, our actions belong simultaneously to the order of the semiotic and the order of the material (itself articulated, modeled, through the semiotic). The relations we construct are simultaneously semiotic relations in a cultural meaning system and material relations in an eco-physical system.

Every meaningful social practice can be enacted only through some material processes, and the semiotic formations that link practices through their cultural meanings for us inevitably couple material processes which have other actual and potential eco-physical relations in a system of an entirely different order of discourse. In this way, whether in obvious cases such as the construction of cities or the clear-cutting of rainforest, or in less evident ones such as the publishing of books, the imprisonment of offenders, the selection of mates, or the setting of wages and prices, cultural linkages of social practices into semiotic formations produce eco-physical linkages of material processes. And reciprocally, the linkages of material processes on which the eco-physical being of the community depends, which indeed are the eco-physical being of the community, form the ground of all possible and actual change in the relations of semiotic practices.

The full implications of this intimate dialectic of practices and processes, semiotic-discursive and material-ecophysical relations cannot be fully appreciated without the realization that both aspects of a total ecosocial system are hierarchically organized at many different scales through

complex couplings of processes which feedback on one another to produce entirely surprising, emergent phenomena. In the dynamics of complex, tightly coupled systems with strong multiple feedback loops, even small regularities can produce surprising global effects. Semiotic formations, which slightly bias the linkages of material processes according to their semiotic meanings for a human culture, are essential elements in the material dynamics of human communities, and this material-semiotic coupling is reciprocal. There cannot be two systems here, changing according to separate laws, relatively independent of one another. There can be only one unitary ecosocial system, material and semiotic, with a single unified dynamics, described under two aspects, by two different sorts of culture-specific discourses.

The unity of ecosocial systems is somewhat hidden from view by our failure to appreciate the pervasiveness of the material-semiotic coupling. Our own culture brings with it the ideological biases of a dominant class whose interests favor a view of the world as indefinitely exploitable materially and infinitely flexible culturally. We are an urban culture for whom agriculture, a primary site of the material-semiotic coupling, is distant and trivial. We are a machine culture accustomed to simple proportionality of cause and effect (not massive self-amplifications) and stable dynamics (not emergent self-organization). We are a culture reluctant to examine what we do culturally to and with organic bodies (our own, our children's, our enemies, other species'; Lemke forthcoming-a). We are only beginning to realize that we are not the Lords of Creation, but the most expendable, vulnerable, dependent, recent extension of a far older, non-human planetary ecosystem (e.g. Lovelock 1989), and that our survival depends on enhancing, not exploiting, a system which takes no cognizance of our interests and values, except insofar as they long ago adapted to its realities. We are also only beginning to realize that we do not make history, and culture, exactly as we please, but only within the limits of a vaster, trans-human system, whom we cannot in principle observe or control.

What makes a system 'complex' in this sense? How are the dynamics of such complex systems as human communities and their ecosystem bases fundamentally divergent from intuitions about them based on the dynamics of simple, machine-like systems? Consider some examples of complex systems in this sense: a dust-devil (or a tornado), a cell, a developing embryo, a caterpillar-pupa-butterfly, a human organism, a living lake (or rainforest), a living city, an ecosocial system, the living Planet (Gaia).

The study of complex systems is now well advanced in physics and chemistry (e.g. Prigogine 1980, Prigogine & Stengers 1984, Jackson 1989, Harrison 1982) and is beginning to make progress in developmental and evolutionary biology, ecology, and geophysiology (see Weber, Depew, & Smith 1988; Odum 1983; Salthe 1985, 1989; Holling 1986; Lovelock 1989). What makes a system truly complex dynamically is not simply the number of variables (or 'degrees of freedom'), but how these variables depend on one another, the pattern of their 'couplings'. The more interdependent they are, both in numbers of interconnections and the strength of the interconnections, the less predictable the future of the system. When the couplings 'loop back' on themselves (e.g. changes in A produce changes in B, which produce changes in C, which in turn produce changes in A again), the system may grow in complexity, generating new global patterns and new information.

Physics first studied systems with many degrees of freedom but only weak coupling between its elements (e.g. gases with large numbers of weakly interacting molecules). For systems like this the first symptom of complexity already appears: the Newtonian symmetry of Past and Future is

broken, dynamics proceeds irreversibly and uni-directionally into what we call the Future. Each separate internal interaction or collision of molecules is a simple system and could in principle be reversed in time, brought back exactly to its previous state with a finite amount of information and a finite amount of energy. But each collision produces correlations in the subsequent motions of the participating molecules, which now have further and further collisions, the correlations multiplying rapidly toward a state which would require infinite information to be set into an exact reversal (Prigogine 1980).

This phenomenon of irreversibility was first formulated as the famous Second Law of Thermodynamics: that closed systems tend to the state of equilibrium, the state with the most probable values for any overall macroscopic property of the total system, corresponding to any one of a set of the largest possible number of thermodynamically equivalent distributions of the molecules. Any other state would be much less probable because there would be many fewer molecular combinations corresponding to it; random collisions would rapidly favor the equilibrium state. Equilibrium is also the most homogeneous, most symmetric, least diverse, coolest, lowest energy state. It is the final death, the endpoint of decay and decomposition: neutral, inert, exhausted, stable. Spontaneous thermodynamic change moves from the unusual, the specialized, the differentiated, the energetic to the generic, the uniform, the quiescent. From what is uncommon and improbable in world of random influences that destroy order and organization to the most probable state of no order, no organization; from states high in order and organization ('high negentropy') to those high in disorder and disorganization ('high entropy').

But in the real world many complex systems, and all the ones on our list of examples, do not behave in this way. A mass of air with a vortex (dust-devil or tornado) is more organized than the turbulent mass of air before the vortex formed, not less. A developing embryo goes from a state of lesser to a state of greater differentiation, away from homogeneity. Mature ecosystems are more complex and differentiated than immature ones, not less. The living Planet as a whole is today further from the state of equilibrium than it was 4 billion years ago, not closer to it. It would be very easy to predict the future of a culture, of an ecosocial system, if it behaved thermodynamically: it would disintegrate, collapse, become homogeneous and incapable of further change. Distinctions would be lost, diversity would disappear, decay would outstrip construction, useless wastes would be more common than useful resources. But in fact our history has veered far away from this path to the ecosocial death of equilibrium, placing many buffers between us and the long slide to ruin. How?

All our examples are open, not closed systems; they all exchange at least energy and information, and usually matter as well, with their exterior environments. The living Planet lives because energy flows to it from the Sun, is transformed by life, and returned to space as radiated heat at a lower temperature than it would be by a barren planet in the same orbit. The developing embryo (and child) feeds on the nutrients and organizational information of its external (mother) and internalized (DNA) environments, producing great amounts of waste heat and waste chemicals which must be safely conducted away. The city claims resources of energy and raw materials from its environment and exports back to that environment heat and solid wastes in quantity. In all these systems, the transforming processes (metabolism, chemical ontogenesis, urban production and consumption) are irreversible ones and generate entropy (disorder, matter and energy closer to equilibrium than they began), but the high entropy elements are excreted

from the system into the environment, allowing a net increase in the order and organization of the system itself at the expense of its environment.

The unavoidable, irreversible thermodynamic processes that generate entropy (in the form of heat and waste) are called dissipative processes, and a system that keeps itself going (and perhaps becoming even more organized and differentiated) by the trick of importing energy, information, and resources from and exporting disorder to its environment is called a dissipative structure (Prigogine 1980, Prigogine & Stengers 1984) or dynamic open system (Lemke 1984). Dust-devils, cells, developing embryos, organisms, ecosystems, cities, ecosocial communities, and the living Planet are all dissipative structures. So also are fires, hurricanes, convection cells in heated fluids (e.g. Rayleigh-Benard cells, atmospheric circulation and oceanic currents), certain chemical cells that maintain concentration gradients and produce elaborately beautiful patterns (see Prigogine 1980; Berge, Pomeau, & Vidal 1984).

The flows of energy, matter, and information that maintain these systems in existence are thermodynamic constraints, they keep the system away from the path to equilibrium by supplying order and safely conducting disorder away. How can such systems come into being in the first place? Once in existence, how can they become even more organized and complex, actually moving further from the path to equilibrium? The answer again is strong coupling. This is most easily seen in the case of chemical reactions involving several different chemicals which tend to form loops of chemical reactions, with some of the initial substances eventually being reproduced in the course of subsequent reactions, thus leading to even more possibilities for the chain of reactions to continue instead of eventually coming to a halt (the path to equilibrium). Such systems of coupled, looped reactions are called autocatalytic systems, and they lead to conditions in which the amounts of various substances and the rates of reactions using and producing them depend on one another in more than proportional ways (i.e. an increase of 10% in some amount or rate might lead to more than a 10% increase in something else, even, ultimately, in itself!). Mathematically, these are non-linear systems, and they do not behave according to the intuitions commonly found in a machine culture.

Non-linear, autocatalytic systems are complex in the second degree. They not only show irreversibility, they exhibit the phenomena known as bifurcation (e.g. Prigogine 1980, Prigogine & Stengers 1984; cf. 'catastrophe' in Thom 1975) and chaos (Gleick 1987, Jackson 1989). Essentially these are systems that can shift unpredictably from one metastable non-equilibrium state to another. When they are embedded in buffering, regulating environments (supersystems) they can shift to new states further from equilibrium by dynamical symmetry-breaking.

Irreversibility was already a breaking of the symmetry of time in fundamental interactions (which are time-reversible, not distinguishing a 'past' from a 'future'). Bifurcating systems create for themselves possible states with less symmetry (in time, e.g. periodicity, or irregular rhythms, or in space, e.g. gradients or spatial patterns) than they began with. There are always several such states, and if the system spent equal amounts of time in each, the net result would be to restore the original degree of symmetry. But this is not what happens. As the possibility of the new states is reached (because of a build-up of some internal or external factor), random fluctuations determine that the system will become stable in one of these less-symmetric, less homogeneous, more specialized, differentiated, orderly, organized, further-from-equilibrium states. If the experiment is repeated, it might be another of these asymmetric states that is entered and which then persists, but in each case the system moves further from equilibrium.

Such systems are often called self-organizing systems, although it is important to remember that the organizing of the system is the result of interactions with the environment, not an internal and autonomous process. In each new state of the system the internal dynamics are different: there are different rates of reactions, different amounts of chemicals built up, new effects on the environments and new environmental responses, and new possibilities for still newer reaction pathways to come into being. In this way a new state of the system prepares the way for yet another bifurcation, yet another jump to a still newer state, even more organized and differentiated, breaking more symmetries of the previous state. Again, accidental factors may play an important role. New couplings of reactions may occur in this individual system and not in that, random fluctuations (internal or external) may influence the possibilities of subsequent jumps to new states. We now arrive on the threshold of a further order of complexity in dynamics, one particularly characteristic of organic and ecosocial systems: the order of epigenesis, evolution, and emergence.

Epigenesis, Evolution, and Emergence

Electrons and atoms do not age. They have no history, no individuality, no youth, maturity, or old age. An atom is already a compound, though not in our sense a complex, system. It has different states, but they are always the same set of possibilities. It does not know irreversibility, it is not a dissipative structure. It is stable. If you shift it to an alternative unstable state, it quickly returns to its original configuration and all memory of the excursus is lost. You cannot tell one atom of oxygen in its stable state from any other; the definition of the state itself specifies all variables, there are no supernumerary degrees of freedom left to record a past history and allow us to distinguish different individuals in the same state.

Complex systems are very different, they have so many more degrees of freedom than an atom, that there are always degrees 'left over' as it were to record history, even if it is only the correlations that reflect the history of past random collisions. Complex systems are individuals and they have a history; it is possible to construct a continuity of individuality from before to after an interaction that changes the system in some way. But if such systems have undergone a series of bifurcation jumps to new lesser-symmetry states farther from equilibrium, then it is not possible to predict (or model in any way) these future states from a knowledge of prior states, except by recapitulating the intermediate states, i.e. the entire developmental sequence of bifurcation jumps, leading to that future state. Self-organizing systems thus have a second, invisible history: not just marks of wear and tear, the accumulated memory of past encounters, but the developmental trajectory of changes in their dynamics by which they came to the more organized, less symmetric state they are in.

In a profound sense, complex systems which develop in this way, including both human organisms and ecosocial systems, are temporally-extended entities. The system, as an individual entity, cannot be defined at one moment in time, because the dynamics which maintains it in being must occur over time. In each instant, it is dead; only over time is it alive. So much is true for any dissipative structure, but a truly developing system cannot be defined even over an interval of time limited to one stage in its developmental career, because its constitutive dynamics will be quite different in later stages. Only the system extended in time along its complete developmental trajectory, from formation to disintegration, from conception to decomposition, is a properly defined theoretical entity. We will refer hereafter to the

developmental trajectory entity, meaning the system-over-its-lifetime, when necessary, to emphasize this new perspective. The caterpillar-pupa-butterfly is one individual developing system, as is the embryo-child-adult-dotard. The notion of trajectory-entities in this sense allows us to formulate new, genuinely dynamical definitions of ecosocial systems, cultural formations, language dialects, corporate institutions, and even social individuals.

With the notion of developing systems we reach a new threshold. But before we go beyond self-organizing dissipative structures, it is worth noting that all such systems exhibit a common thermodynamic outline to their trajectories of development (see Salthe 1989). Whether we are speaking of hurricanes, embryos, organisms, or ecosystems, there is a common sequence of developmental stages. In the ascendant stage (or phase) the system is dissipating energy, producing heat and wastes (entropy), at a maximal rate in proportion to its total mass, and its internal organization and order are increasing at the maximum rate. This rate of generation of disorder (exported to the environment) and order (accumulated in the system itself) gradually slows as the system passes through its various developmental bifurcations, moving further from equilibrium, until some limit is reached, and a metastable state develops (mature phase) with minimum entropy production consistent with maintaining the mature organization of the system. Finally, there may be a senescent phase in which an overly self-regulated dynamics becomes vulnerable to external disturbances, eventually degrading and finally decaying back toward the path to equilibrium and death. The most complex developing systems may be able to avoid terminal senescence, as we will see.

The existence of such a generic developmental trajectory points the way to a new strategy for modeling complex systems. For any given system, it is not possible to anticipate bifurcations and predict dynamical futures beyond the current stage (or even whether there will be a new stage), but if the system is of a recognizable type, then there is a good chance that it will follow, at least up to a point, the typical developmental trajectory of its kind. Type-specific developmental change is predictable from a knowledge of the type. This is the basis of embryology, and of the prediction that most caterpillars, if they survive under more or less normal conditions, will eventually be butterflies. But how does it happen that developmental trajectories as specific to a set of ecological conditions as those leading to butterflies can become fixed and repeatable? This is the next order of complexity in dynamics, that of epigenesis.

An epigenetic system is a developing system that recapitulates the major stages of a type-specific developmental trajectory. It is a system that develops according to its kind, recapitulating a sequence of bifurcations in the dynamics of its type that may have evolved over many generations of its predecessors. I hope it is clear that while we have for some time now been using the language of living systems, that at no point in the specification hierarchy (Salthe 1989) we have been defining (each type of system a special case of the previous: complex systems with irreversibility, dissipative structures, developing systems, epigenetic systems) is there a clear transition to Life, as such. Hurricanes are alive in many significant ways; so is the Planet as a whole. Organismic life as we know it is based on a very specific strategy (DNA-mediated epigenesis), but ecosystems are also alive and use a different strategy. What is special about the class of epigenetic systems is that the developmental trajectories of individuals recapitulate a prior evolution of the trajectory of their type.

The terms 'development' and 'evolution' are used loosely and often interchangeably outside (and even inside) biology. Because they are paradigms of different modes of change in the study of

complex systems, however, it is important to separate them. Individuals develop; types evolve. Individuals also individuate; that is, the developmental trajectory of an individual system recapitulates that of its type only in general: in many specific ways it is unique, reflecting its own individual history. In particular, an individual system may deviate from the type-trajectory in a way which can be passed on and recapitulated by future developing systems: it may contribute to the evolution of the type. What evolves is the developmental trajectory of the type (and not, actually, the type as such). Evolution occurs when individuation leads to a new dynamical stage (through a new bifurcation) which can be recapitulated, and when the new trajectory actually is recapitulated in the developmental trajectories of a significant number of successor systems.

How is recapitulation possible? Epigenesis adds one element to development itself: a guiding environment shared by different individual systems and relatively slowly changing compared to the lifetime of these systems. The sequence of bifurcations, of development, cannot be left entirely to chance, to random fluctuations, if there is to be recapitulation. Random fluctuations must be harnessed and guided by an external source of information, regulation, control, and that can only reside in the environment of the developing system. An adequate analysis of a developing system must not only be extended in time, but it must examine system-environment interactions: it must extend to the immediate supersystem that contains both the system under focus and its immediate environment (cf. Lemke 1984). Dissipative structures and their environments are necessarily mutually interacting. The sequence of bifurcations will depend strongly on environmental conditions. If many individual systems develop under the same environmental conditions, the odds are that they will undergo similar sequences of bifurcations. Developing systems can and do also modify their environments (often for the worse, by exporting disorder into them), but they are dependent on these environments for energy, material resources, and information-regulation-constraint.

The next step is simple: a new bifurcation in an individual leads to an effect on the environment that favors similar bifurcations in other individuals: epigenesis is born. A series of 'accidental' dust-devils in a narrow defile might erode landscape surfaces in a way that produces contours which favor the formation of locale-specific dust-devils. Globules of organic polymers engaged in autocatalytic chemical reactions might modify the surrounding silicate clays in ways which tend to favor their latest chemical innovations in successor globules. In each case, along with epigenesis comes a supersystem and a hierarchical relation of system and supersystem. That hierarchical relation is one of scale (cf. Salthe 1985, 1989 on scalar hierarchies), in which the supersystem is more stable, changes more slowly, and exerts a regulatory influence on the dynamics of the now 'sub' -system. In the case of organismic lifeforms, the relatively stable 'environmental' molecules (RNA, DNA) were eventually internalized, incorporated into the supersystem which became the modern cell.

But epigenesis depends only on the existence of the subsystem-supersystem regulatory scale-hierarchy relation and the possibility of innovations in subsystems being recapitulated through their long-term 'memory' by the supersystem environment (and not specifically on the DNA strategy). Epigenesis is simply development under an environmental guidance that enables the recapitulation of type-trajectories in individual development. Moreover, the hierarchy principle is automatic: because dissipative structures are already a product of system-environment interactions, a supersystem is always already implied. This account of things (like many of the accounts of the origin of organismic life) is a bit backwards: there have always been supersystems, there have always been ecosystems, there has always been a planetary dynamical

system. Particular self-organizing units always came into being in the context of such supersystem environments. Life did not begin with micro-organisms that eventually got together to form ecosystems that eventually united into Gaia. There was always Gaia, even pre-biotically, and there were always the precursors of ecosystems. What has happened in the history of the planet is that new intermediate levels of organization have emerged between the Gaia-system and her autocatalytic and cross-catalytic molecular subsystems. Ecosocial systems and the human cultures they sustain form one of those intermediate levels.

All epigenetic systems belong to regulatory subsystem-supersystem hierarchies from the molecular to the planetary. But organismic lifeforms are not the only epigenetic systems, there are also ecosystems, and they take us on to the final principles of complex dynamics needed for understanding cultural and social change.

Ecosystem Dynamics

Living forests, lakes, and cities are also epigenetic systems, but they have evolved somewhat different strategies from those of organisms. Organisms and ecosystems are both larger-scale supersystems constituted by and acting to integrate and regulate the smaller-scale subsystems they contain. Organisms integrate the processes of organ systems, organs, tissues, cells, and intra- and extra-cellular body chemistry down to the molecular level. Ecosystems integrate the processes of interaction of organisms with each other (within and between species) and with the flows of matter, energy, and information through the total system, including solar radiation and heat flows, water and nutrient flows, and hydrologic, atmospheric, and geologic, processes on local and larger scales.

Organisms show 'planned obsolescence', they enter a developmental phase of terminal senescence and die. Most higher organisms seem to have a fairly definite maximum lifespan, after which they quickly return to the path to equilibrium. This is associated with their strategy of individual reproduction: organisms are like autocatalytic reactions, they multiply themselves to the limit of available resources or until they are regulated by the supersystem (e.g. by predator population increases). If such 'breeder' lifeforms did not die, they would soon preempt all available resources for their progeny and the further evolution of their type would be inhibited. At the ecosystem level of organization, however, things are rather different (Odum 1983, Holling 1986, Schneider 1988).

Ecosystems do not seem to die of old age; neither do they directly reproduce new individual ecosystems. The relation between individuation, evolution, and recapitulative development is different at this level, but it exists nonetheless. Ecosystems do show a form of type-specific recapitulative development, known as ecological succession. A newly opened area (a new volcanic island, a burned-out forest, abandoned farm-land) is first colonized by one group of species that form an ascendant phase ecosystem with its own stage-specific dynamics. This ecosystem tends to spread rapidly, with fast-reproducing, short-lived species; it also alters the soil and local environment generally in a way that is favorable to its replacement (succession) by another group of species that forms a later phase of the ecosystem's over-time developmental trajectory, and which can flourish in the conditions created by the first phase. This continues with a slowing in the rate of growth and the rate of dissipation and accumulation of structure;

there are more complex couplings of species and nonbiotic elements, longer chains for the cycling of nutrients, more stored resources, etc., forming a mature ecosystem.

But instead of heading on into terminal senescence, two things will have happened instead. The system may enter a stage of post-maturity in which it is not as resilient as previously and is more vulnerable to external disturbances, but at the same time it will have grown 'patchy' with a mosaic structure on many scales of small regions in which the dynamics are distinctively different. When a great oak or redwood finally dies, when a small fire burns out a part of the forest, when a storm damages part of a coral reef, when pollution degrades the environment in part of a lake, a mini-succession will begin again in that patch, progressing faster or slower depending on proximity to other mature patches, which species' propagules get there first, and what the local soil, light and water conditions are. The natural topographical variations in soils, and for marine ecosystems the natural patchiness of nutrient flows and plankton populations, also insures that ecosystems are everywhere 'patchy', mosaic aggregates. Stresses on patches may even cause a retrogression in the successional developmental sequence.

The result is that ecosystems are mixed-age aggregates. They consist of parts at different ages or stages of successional development. And they consist more generally of little mini-ecosystems with slightly different mixes of species, or even different species in the same functional niches. Ecosystems do not, like organisms, reproduce new individuals with a distribution of variation in characteristics; they contain this diversity within themselves in simultaneous mosaic patches. Not only age, or successional stage, but every other characteristic of an ecosystem is present within it with a distribution of various values at various scales. Ecosystems are mixed-age, mixed-character mosaic aggregates.

Every ecosystem is an individual, and in a looser sense than for organisms, a member of a type. Its successional trajectory is not as rigid as that of an organism, but it has a recognizable outline. The succession of ecosystems is not under as tight a regulatory control as is the development of an organism, because the ecosystem is not itself part of as highly organized a supersystem as is a developing embryo. Ecosystem types are not as well-defined as organism species are; they are 'fuzzier' types. Ecosystem types certainly evolve (in our strict definition of evolution, it is their actually their successional trajectories which evolve), and may do so very rapidly. The same species may form a different ecosystem if the dynamics of interaction in that system are different, and innovation (new couplings, interactions, effective bifurcations in the population or energy and matter dynamics of the patch-subsystem) in a relatively young patch as it undergoes its partially unique succession can then spread in time through the territory of the total ecosystem, or at least be recapitulated in other patches, with evolution taking the statistical course of the most frequent pattern in future patches.

Ecosystems do not reproduce, but they do spread (and survive, and 'dig in', becoming more resilient and stable occupants of their territory). The criteria of success, of 'fitness' for ecosystems cannot be posed in the same terms as for breeder lifeforms (whose reproductive fitness is of course itself very critically a function of their ecosystem contexts). For ecosystems the criteria of success include: persistence (metastability, resilience), adaptability, creation of a successful relation with an environmental supersystem (for resource inflow, waste outflow, buffering against disturbances), colonization potential, and optimization of mosaic age- and diversity distributions.

Ecosystems follow an epigenetic strategy that fosters the recapitulation of type- (and microtype-, i.e. 'patch') -specific successional trajectories by both internal memory (the total ecosystem being a slowly-changing, regulatory, environmental supersystem with respect to its patch subsystems) and external memory, such as modification of soils, water tables, local landforms, microclimate, etc. In this, in their lability to rapid local evolution, in their mosaic diversity, non-reproduction, and criteria for success, they seem to present a much more appropriate model for the dynamics of cities or human social systems than do organismic systems. This is because human social communities are, or more accurately, are part of ecosystems.

Ecosocial Dynamics and Semogenesis

We can now begin to fully interconnect our three basic arguments: that human sociocultural systems are essentially systems of social practices linked into the historically and culturally specific semiotic formations in which they take their meanings; that these practices are simultaneously material processes in a complex, hierarchically organized, developing and evolving ecosocial system; and that the dialectical relations between the semiotically- and materially- based couplings of these practices/processes are the basis for a general ecosocial dynamics.

Cultural dynamics is one aspect of the total dynamical complexity of what we are calling ecosocial systems. An ecosocial system is a human social community taken together with the material ecosystem that enables, supports, and constrains it. An ecosocial system is an ecosystem, with all the characteristics and properties of ecosystems, but it is a more specified type of ecosystem: one that includes a community of organisms of our species and in which therefore the material interactions of its elements (people, other species, resources, material and energetic processes and flows) are biased, constrained, and organized, in part, in accordance with social semiotic formations. These formations are constellations of actions-as-material-processes organized in terms of their meaning relations as social practices in a human community.

The total ecosocial system includes not only human organisms and their interactions with one another, but all the material elements which act on, in, and through humans and which humans act on, in, and through. It includes all the other species with which we are co-dependent and with which we have co-evolved, including our food species, our diseases and parasites, our symbionts and co-dependent micro-organisms, and their webs of interdependent organisms and material and energy flows. An ecosocial system includes buildings and tools, cultivated fields and soil bacteria, generating stations and bread molds. It includes landforms and marine nutrient flows, atmospheric circulation and solar radiation levels. It includes manufacturing and waste production, education and intercourse, politics and warfare. And it is a single, unitary system in which the dynamics of processes of human social interaction are not in principle or in practice separable from the dynamics of the rest of the ecosystem, except that cultural practices represent a second level of organization of material processes according to relations of social meaning. An ecosocial system is simultaneously a material and a social-semiotic system.

Ecosocial systems show ecosystem organization in both their cultural-semiotic and their material-ecophysical dynamics. They are foremost, in both respects, not systems of things (organisms, nutrients; subjects, signs) but systems of processes (gene exchange, predation; communication, production). They are systems precisely insofar as these processes are coupled:

linked, interconnected, interdependent. They are complex, open, dynamical, dissipative, self-organizing, developing, individuating, epigenetic systems, organized in a hierarchy of levels in which subsystem development and individuation is regulated by supersystem dynamical maintenance, and in which supersystem resilience and adaptability is insured by subsystem variety and lability to new patterns of cross-coupling. Their hierarchical structure arises from the interpolation of new intermediate levels of dynamical organization as new patterns of process-coupling (directly or through the coupling of social practices in cultural formations) lead to symmetry-breaking and new dynamical states (emergent structuration). Ecosocial systems are mosaic aggregates of subsystems ('patches') of differing developmental age, composition, and coupling patterns.

Within this general model of ecosocial dynamical systems, let us consider in more detail the dynamics of social practices and formations, of cultural systems of meaning. Of all these, Language has traditionally been regarded as the least materially coupled and has been most often recruited as the paradigm for an autonomous semiotic dynamics. But Language-as-system is an abstraction from language-in-use, from the social practices that employ and deploy the resources of that system. If speech seems materially a matter of a breath and negligible energy, and writing of only the infinitesimal energy and entropy of inkstains on paper or magnetic domains in an electronic memory, the same could be said of the DNA genome that guides and channels the much larger energies of the chemistry of embryogenesis. The genome, like Language, has evolved to be what it is (and continues to evolve) exactly by serving this function, and thus precisely in and through its couplings to those larger processes. It is just the same with Language, through which we construe the meaning relations that tie together the social practices of every semiotic formation, so that we may learn to make sense of and with them. In what we do with Language (and with every other semiotic resource system), strong couplings are made between the material processes through which we enact all other social practices, many of which engage and entrain substantial flows of matter and energy. Discourse formations construed in Language guide the social practices of our architecture and our engineering, our agriculture and our industry, our choices of foods and mates, allies and enemies.

The cultural dynamics of Language cannot be independent of the uses to which language is put, but rather arises directly out of those uses. The cultural dynamics of Language-as-system, the processes of Language change, represent the effects on the overall semantic resources of a language of the new uses to which it is put, register by register, function by function, situation by situation. This putting-to-use is always a putting to use in the material doings of an ecosocial system. If a language has an inertia, it is the inertia of its use by many organisms, a dynamical inertia grounded in neurological processes and the material social practices of producing and interpreting stable, visible material images. If Language has a momentum, it is the dynamic momentum of changes in the social practices of language use.

The notion of a 'language' is not only an abstraction from use, it is an abstraction from the empirical diversity of language in use. A language is a mosaic aggregate of its dialects and sociolects, on all scales of a hierarchy of loosely integrated subsystem 'patches' (cf. 'speech communities') from those of widely used dialects down to individual idiolects. This principle of mosaic diversity applies equally to registers and to discourse formations, and with respect to the latter, ecosocial heteroglossia encompasses the diversity of language use across different age-groups (cf. mixed-age mosaic ecosystems), genders, social classes, political persuasions, etc.

And in every 'patch' of language use, in every functional 'niche' (situation-type) of language use, the pattern of use is changing: developing, individuating.

We need look no further than the phenomena of creolization to observe recapitulative and individuating development of a language 'patch'. Just as extreme stress on an ecosystem, measured by decoupling of processes and flows, by loss of differentiation and return toward greater symmetry and homogeneity, leads to a reversal of the stage sequence of succession (Schneider 1988), so the restriction of the use of a language to only a few situations and to speakers who can only learn the language in those situations ('pidginization') leads to a loss of functional and semantic differentiation (and so to phonological homogenization as well), a simplification of language not unlike the earlier stages of language-learning by children or non-native speakers. A 'language patch' is cleared, or at least pushed back to a more primitive state of development. But it is a patch in an ecosocial system; the diverse activities of the community are still being enacted, there is still a rich field of differentiated functions and contexts into which the 'pidgin' can spread. As it does so, its symmetries are broken, unitary forms become differentiated and multiply in meanings and uses, a 'full-service' language rapidly (in one generation) re-emerges. It is not identical to the original language, for it does not recapitulate a precise epigenetic trajectory like an organism (cf. a child learning the mother-tongue), it is an individuated patch, perhaps a new dialect of a larger language family (depending on the degree of integration of the local community within the larger ecosocial system of that family).

The stages of development of a creole dialect, while they may not recapitulate the history of the original language in detail (except in the presence of DNA-like environmental 'templates' to bias the development) will still proceed by a series of symmetry-breaking bifurcations, each the necessary predecessor of the next. Each later state of semantic and functional differentiation in language use patterns must be prepared for by prior developments that enable the meaning contexts to be created (and recognized) within which the dynamics can give rise to the subsequent ones. In this process, greatly accelerated in speed (cf. rates of succession or ontogenesis vs. those of evolution and phylogenesis), we see the same interdependence of social action patterns and semantic resource development that occurs in the normal course of language change.

The processes of symmetry-breaking common to all developing systems with complex non-linear, autocatalytic dynamics occur in developing ecosocial systems (as wholes and more obviously in each patch) and are reflected in the successive symmetry-breakings of normal linguistic change. Some of these have been documented for modern English by Halliday (in press-a), who has identified the pattern he calls semogenesis, in which a progressive semantic differentiation in the language system is built up by the context-dependent splitting of previously unitary semantic features and their subsequent independent recombination. He also indicates how this same process, writ large, leads to the emergence of a true grammar as an intermediate level of semiotic organization between functional situations and utterances in the ontogenesis of speech in children. It is very likely that this is also the historical sequence of the origins of Language as we know it.

The total semodynamic cycle is far richer and more complex than the core semogenesis process itself. It is a cycle in which differences create (or enable the creation of) further differences, in which the frequency of occurrence of a feature proceeds from being equal across contexts to being unequal (symmetry-breaking), and in which the availability of new semantic features

makes possible the differentiation of new contexts in which in turn further semogenesis can occur. An essential part of this cycle is the existence of pre-semiotic features of events or situations: material differentiations which do not yet have cultural significance, but which can enter the semiotic system as new features (cf. Lemke 1984, forthcoming-b).

Bifurcations in the material ecodynamics of an ecosocial system generally lead to a breaking of the symmetries that existed in prior states of the system, so that new differences are potentially distinguishable: what was formerly one single context may now be separable into two somewhat different contexts. This difference of contexts may now be used to 'pry apart' a formerly unitary social practice, if distinguishable (but previously type-equivalent) varieties of the enactment of the practice begin to co-pattern regularly with the difference in contexts.

Every material instance of a form or type (be it a context-type, a practice-type, etc.) exhibits both the critical features of the type and additional incidental features, which do not matter as regards the type. If some of these incidental features begin to co-pattern with different context-types, not just in isolated instances, but regularly (owing either to material connections between them or to semiotically constructed ones) and recapitulably, then the former type, previously symmetrical as between these contexts, is now split into subtypes by the formerly incidental but now critical (for the subtypes) features. Material symmetry breakings and couplings can lead to semiotic ones, and vice versa. Differentiations of contexts can lead to differentiations of practice types, and vice versa. When features (of practices and/or contexts) uniformly co-occur (perfect redundancy) across all wider contexts, they are not semiotically separable as distinct features, but when they begin no longer to do so in some contexts, a semogenic process may begin in which they become separable in all contexts in which they occur. As their degree of redundancy (probability of co-occurrence) falls from maximal toward zero, they become independent resources of the meaning system (cf. Halliday in press-a, in press-c; Nesbitt & Plum 1988), increasing its information carrying capacity.

But at the same time there is an opposing tendency, since in at least some contexts there must be greater redundancy for there to be cultural formations: when all combinations are equally probable in all contexts, there is no culture. Redundancies and finite probabilities of co-occurrence define formations and increase the total organizational information of the ecosocial system. There are furthermore 'semolytic' processes by which previously distinguished features fuse, fall into disuse, or do not continue their distinctive associations with contexts (Lemke, forthcoming-b). There is thus a 'semodynamic cycle' in which new distinctions of meaning, new resources, and new formations are continuously created and destroyed, all as part of the total material-semiotic dynamics of the ecosocial system.

The net result is that the meaning potential of the system of semantic (more generally, semiotic) resources increases (as new features are added, and become combinatorially independent, so that all possible combinations of features may occur), while at the same time the total organization of the semiotic behavior of the community increases as the probabilities of combinations become increasingly context-dependent (cf. the 'meta-redundancy relations' described above).

It is perhaps easier to see the developmental dynamics at the level of semiotic formations rather than at that of the necessarily more abstract semiotic resource systems. Consider some system of technological practices, that is, some interlocking cultural formations of technology-using social practices in agriculture, manufacturing, warfare, etc. Now suppose that a nuclear holocaust had destroyed the material base of the technologies, or caused a retrogression to a more primitive

level of technology, but that the 'template' (say a discourse formation, the 'knowledge' of the technology) still existed. This is like the classic problem of the modern man in a stone-age society, or the traveler-back-in-time seeking to make use of advanced technological knowledge in the absence of the material base. Some short-cuts may be possible, but by-and-large the 'succession' in this 'patch' will have to recapitulate the historical (or at least the obligatory developmental) sequence of technological developments. Each development makes possible the next. In historical dynamics, each development makes possible new social practices, which combine into new cultural activities and institutions, with new needs and interests, which spur new technologies to meet those needs, built on existing technologies designed to meet earlier needs, and so on.

Ecosocial systems are hierarchically structured across many scales of organization. This does not mean that they are in any sense 'authority hierarchies' or that authoritarian social organizations are more natural than democratic ones. It means that each level of organization going 'up' the hierarchy is in fact a larger-scale, more slowly-changing supersystem coupling and integrating smaller-scale, more rapidly-changing subsystems at the next level 'down'. A nation is a supersystem of its cities and provinces; the global economy is a supersystem of national economies. In authoritarian social organizations, elites become smaller as one goes 'up' the hierarchy; in ecosocial systems, the higher levels are orders of magnitude larger.

Ecosocial systems, and each patch and subsystem within an ecosocial system, is an irreducibly temporally-extended entity: it is a system of coupled, interdependent processes, including exchanges of matter, energy, and information (entropy) with its environment, which are constitutive of its existence and whose nature changes across the system's developmental trajectory partly as a result of the effects on the system and the environment of the processes at a prior stage. Ecosocial systems generate their own futures (at each level in interaction with an environment that may be partly a regulatory super-system): they create conditions which lead them to change, and they create at each developmental stage possibilities for the next stage which are not in principle predictable. Accidental, unique, historical configurations will often determine which of several possible 'branches' the developmental trajectory of the system will take. Larger-scale, longer-term conditions will determine which of the recapitulable innovations of an individuating system will in fact contribute to the evolution of the type.

At any given time the characteristic cultural patterns of action of a community must be enacted by material processes, by actual human organisms in interaction with other ecosystem elements. Each enactment of a ritual, each performance of a song, each making of a tool, each writing of a sonnet will be unique and different, but it will also re-enact criterial features common to the type, to the cultural formation, the social practice. Other, initially incidental features, may in the course of cultural change become newly criterial ones for an evolved type. There is an essential dialectic between types and their 'tokens', between abstract practices and formations and their individual instances. This is a dynamic dialectic: it leads to change, it mediates the process of change. Types (semiotic elements) change because they must be instantiated as tokens (material elements), and tokens of complex systems are always unique.

Consider this dialectic not in relation to an 'object' but to a process, or more typically for a cultural system, an 'event', an 'activity'. The abstract type here is the actional semiotic formation, the 'action genre', 'activity type', or 'participation structure'. It calls for actors in various roles to perform various actions which couple the material processes of organisms and

other ecosystem elements together in particular ways. It defines the roles and action-types which constitute it; it construes them, in terms of criterial features of the material processes, neglecting incidental features, as socially meaningful, and it is in terms of meaning-relations that it prescribes the couplings of actions/processes. But each enactment of the event will be different. The organisms performing its key roles are themselves developing systems, with unique histories of participation in other actional formations of the culture; each is a unique constellation, with a slightly different view of the current role and how to perform it. Participants are changed by their participation in cultural events, and the cultural events as types may change as a result of their enactment by different unique participants. The developmental process, the semodynamic process, is at work here. Each event, each participation, creates conditions which may lead to further change, in individual history (of organisms, of communities) and in type evolution. Ecosocial system are not stable; they create the conditions for their own change.

Prediction, Control, and Responsibility

Type-specific, recapitulative development is both lawful and predictable. Evolutionary change is lawful, but not predictable in detail beyond the short-term in which environmental constraints set conditions for the spread or extinction of new coupling patterns. Individuation is neither lawful nor predictable; it is the source of new variety in the history of the system, unique and accidental.

Recapitulative development is only as faithful to the type trajectory as accidental conditions and the epigenetic regulation of the material 'template' allow. Actual system trajectories represent the combination of recapitulative development with individuation. The 'template' in ecosocial systems is not a stabilized internal DNA, but rather the persistence in the system's environment of the patterns of coupled processes that biased the developmental changes of others of its type, perhaps reinforced (or modified) by these predecessors' cumulative impact on the environment. When an individual, or a community, 'learns' a new pattern of behavior typical of their 'kind' (e.g. how to program a computer), there will be a certain recapitulation of the historical stages of skill differentiation that led to this activity-type, guided and in part provoked by cultural discourses and other formations. But each individual and community will nonetheless develop its own unique approach, and some of these approaches will spread and contribute to the evolution of this social practice, while others will die out. At any given time there will be a mosaic of system 'patches', each with a variant approach, and the variants will most often arise in 'juvenile' patches, where the most significant differences will arise from deviations from the previous type-trajectory early along its path (cf. neoteny in evolution, e.g. Gould 1977, Montagu 1981).

Evolutionary change is lawful in that at any given time it is possible to specify the conditions that favor or disfavor the persistence or spread of a particular innovation. The evolution of the type is determined, strictly speaking, by the changes in the frequency distribution of recapitulations of the various variants of the type. But this short-term predictability of evolutionary change depends on the fact that the relevant environmental conditions are relatively slowly- changing, which is usually insured by the hierarchical structure of the supersystem within which subsystem evolution occurs. Long-term evolutionary change is not in principle predictable because of the development of the supersystem (i.e. its individuation). The dynamics of the supersystem are self-altering: it creates the possibility for its own change, for new couplings of its subsystems, for new couplings to exterior systems, for externally driven

bifurcations to new states. Moreover, the changes at lower levels add new coupling-scheme possibilities, and where these are autocatalytic, major and rapid change in the supersystem can take place which is not predictable because the precise nature of the accidental changes in subsystems which the new dynamical scheme exploits cannot be known in advance.

There is, however, one clear trend in what we may call the (non-recapitulative) development of an entire system hierarchy: progressive hierarchical structuration, through the emergence of new intermediate levels of organization. This accomplishes a tighter integration of the higher levels of the total system (through couplings among these intermediate-level subsystems). The emergence of a tightly interdependent global economy, and of regional, multi-national economic federations are instances of this trend. At the same time, the ecological interdependence of all the subsystems of the living Planet is growing greater as well, and these two trends will eventually combine to produce a bifurcation-shift in ecosocial development: either a catastrophic retrogression in both, or a significant re-organization of both. In fact, it is often observed in ecosystem dynamics that a retrogression must precede a re-organization in order for the system to 'back up' to a branch-point from which the new organizational dynamics is accessible. On the global scale, the less catastrophic alternative strategy of a new developmental trajectory being pioneered in an isolated patch is not available (unless we imagine it happening, as ultimately it must, in an extra-terrestrial colony).

Apart from the question of predictability, there is the issue of control. We can and do make history, but certainly not just as we please. The issue is more complex however from the perspective of ecosocial dynamics. If social and cultural systems were relatively autonomous, then we might imagine that the cultural future at least was mainly up to us, but what must be controlled, if controlled it can be, is the whole of an ecosocial system, not culture or social organization alone.

There can be no question of long-term control from the present; the emergent properties of a developing-evolving system preclude this absolutely. Only a continuing, adaptable, long-term effort on the same time-scale as the control sought could succeed, and clearly any such subsystem would quickly be entrained in the total ecosocial system, becoming a part of what it seeks to control. The same is true for short-term control by any individual or group, which is necessarily already a subsystem of the ecosocial supersystem. Can a subsystem successfully regulate the supersystem of which it is a part? We do not speak here of accidental influence; the individuation of the supersystem is of course vulnerable to internal events. But regulation is more than impact; it is a governing, a systematic capacity to shift the far larger processes and energies of the supersystem by critical manipulations on a much smaller scale.

Such control-from-below is not in general possible in self-regulating, hierarchically organized systems because of the great differences in scale between levels (cf. Salthe 1985), and because such systems do not evolve with sensitive vulnerabilities to subsystem processes (ecosocial selection favors robustness, resilience, and even meta-stability with respect to internal fluctuations). There are however certain special conditions under which a developing, self-organizing system becomes vulnerable to otherwise negligible influences. When the system is at a critical bifurcation point, when conditions are such that either of two (or occasionally more) dynamical configurations are newly possible for the system, its self-regulation is as it were suspended, and it becomes extremely sensitive to small fluctuations (Prigogine 1980, Prigogine & Stengers 1984). Under these conditions, small perturbations from much smaller scales in the

hierarchy may become greatly amplified, and coherent global effects can result, including the determination of which branch the system's further development takes.

In an extremely complex case such as an ecosocial system, it is possible that there are always numerous bifurcation possibilities 'available' at various intermediate levels of scale (fewer at higher levels). Coherent action by many subsystems, linked through communication, can affect supersystem behavior, especially near these critical branch-points, but also to a lesser degree away from them. Finally, the kind of action most likely to open up new dynamical pathways for the system is a reorganization of the coupling scheme: the linking of processes/practices not previously linked, or the de-coupling of those that formerly were. This is also true of the coupling of whole subsystems. Such actions, semiotically, correspond to re-definitions of equivalence classes and relations of alliance or opposition: to making semantic distinctions not previously made, to combining thematic elements not previously combined, and thus to making conceivable actions that link processes or subsystems not previously linked. In some cases, again, it may be necessary to de-couple before re-coupling in a new pattern, and it may be only in newer, younger, developing subsystems that the new dynamical patterns can first be effected.

The meaning systems of a culture, in the sense of the metaredundancy relations among social practices (describing which ones are linked in semiotic-cultural formations, in particular activity-types, and which are not), both enable meanings to be made, meaningful social activities to be enacted, and enjoin the making of certain meanings, certain connections. Where every combination is equally likely, where there is no differentiation according to situation or context, there is no meaning. And where there are meanings enabled, there are necessarily also meanings disabled (cf. Lemke 1984 on disjunctions). The panoply of meaning relations that define a culture is a figure against the ground of meaning non-relations, gaps that are not even seen as gaps. New coupling schemes of social practices (and so of material processes as well) that fill these gaps, that make meaning in the interstices of culture, in the dark places whose emptiness of meaning defines the boundaries (and so the potential growing edges) of what is meaningful, are especially likely to contribute to shifts in ecosocial organization at some level.

Mature ecosocial systems ward off terminal senility by the incorporation of a mixed-age mosaic of alternative-succession patches which serve as a reservoir of diversity. Some of these patches may even serve counter-regulatory functions, preventing the system's self-regulation from becoming overly rigid (and so unable to adapt to environmental changes). If not large-scale patches, then subsystems at some scale can be expected to fill this function. In ecosystem dynamics it has been noted (Holling 1986) that some ecosystems never reach a quasi-stable 'stationary' state, because there are no stable values of the various population and other parameters which the system's dynamics will continue to regenerate. It remains in a state of continual dynamic disequilibrium, with all its parameters fluctuating (sometimes in erratic cycles, sometimes chaotically), continually seeking a steady-state it can never achieve. In such a system (and ecosocial systems are surely like this, at least in parts) no one species or dynamic coupling scheme ever 'wins': all co-exist uneasily, in endless competition, with the result that the total diversity of the system remains higher than in any possible stable configuration.

In these terms, we also serve, who obstruct stability, who contravene tradition, who say and do the forbidden. We do not know enough yet to identify the critical moments when our small influence might be amplified and guide the course of systems far larger and more complex than ourselves, but we can offer alternatives, even if only in small patches, and we can study the

conditions of their survival potential relative to others. We can also de-couple systems of practices and processes that reduce the survival potential of all alternatives. The great intellectual task of the next century, already begun, is to unmake cultures that deny the unity of ecosocial systems and remake cultures that celebrate it. For this task we will need guiding theories far better developed than what I have sketched here, but I believe that the theories we need will make use of many of these fundamental principles.

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