THE CULTURAL EVOLUTION OF CIVILIZATIONS 4047

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> . . . Human ecology has its moments of enlightenment for prehistory, especially for the study of peoples on a relatively simple and environment-bound level of organization. With the pristine, or any other, civilizations we have moved to what Steward terms a higher level of integration, and additional kinds of causality must be sought. The precipitous ascent from an Early Formative village life to the Olmec civilization is an example of a quantum evolution for which the valid explanation may well lie more in the realm of ideas and institutions rather than in modes of production.
>
> Michael D. Coe (14), p. 65

> In a refreshing way, the new data redress a balance and turn our attention from an overworked interest in the ecology of the ancient Near East back to the more central archeological themes of social organization and cultural content, a subject worthy of more intensive study than it has received in recent years.
>
> Robert H. Dyson, Jr. (16), p. 1420

INTRODUCTION

During the course of both ancient and modern times, some human societies have evolved to levels of great sociopolitical complexity.[1] The study of these "high cultures," "states," or "civilizations" presents problems of great magnitude, and few attempts to explain them (whether ethnographic or archeological) have met with success. This is no accident; in recent years, a growing body of data suggests that complex societies are simply not amenable to the simple kinds of structural, functional, or "culturological" analyses which anthropologists have traditionally carried out. The limited success of so-called "ecological approaches" to complex societies has led to understandable criticism from humanists, as the quotations which open this paper show. Indeed, there is a widespread belief among both archeologists and ethnolo-

[1] The reader should note that complexity of sociopolitical organization does not imply ecosystem complexity. Indeed, as this article will suggest, some of the most complex societies may be associated with deliberately simplified ecosystems. For example, the intensive monocrop cultivation which supports some states is ecologically less complex than the diversified and eclectic wild-plant harvests of some hunting-and-gathering bands.

gists that ecological approaches are fine for hunters and gatherers and primitive food-producers, but inadequate for the study of civilizations. This is about as convincing as the religious dogma that evolution works fine for all lower forms of life, but Man took an act of special creation.

There is a reason why past "ecological approaches" have failed, and it lies not in ecology but in the self-styled "cultural ecologists." Modern ecologists, who not only analyze but even simulate dynamic ecosystems (cf. Watt 55), take into consideration that all populations exchange *matter, energy,* and *information* with their environments. Up until now, it has mainly been the humanists who have studied the informational aspects of complex societies—art, religion, ritual, writing systems, and so on. The "ecologists" have largely contented themselves with studying exchanges of matter and energy—the "techno-environmental" factors as Harris (24) calls them. To read what the "ecologists" write, one would often think that civilized peoples only ate, excreted, and reproduced; to read what the humanists write, one would think civilizations were above all three, and devoted all their energy to the arts. In this paper I will argue that humanists must cease thinking that ecology "dehumanizes" history, and ecologists must cease to regard art, religion, and ideology as mere "epiphenomena" without causal significance. In an ecosystem approach to the analysis of human societies, everything which transmits information is within the province of ecology. Such an approach will be taken in a later part of this essay.

The first civilizations.—The world's most ancient civilizations, including the so-called "pristine states" (Fried 22), have long been a subject of scholarly interest and debate. All evolved before written history began in their respective parts of the world, and all share a striking number of characteristics despite their having arisen totally or partially independent of one another. Thus, although some scholars would argue that the earliest civilizations in the Andes (Peru, Bolivia) and in Mesoamerica (Mexico, Guatemala. Honduras) may have been in at least tenuous contact with each other, overwhelming evidence suggests they arose independently of early civilizations in the Near East, Egypt, and India, all three of which were in contact with each other to an undetermined degree. It is not yet known to what extent early civilization in China was autonomous.

Like other fields, archeology is cursed with terms so vague and ambiguous that they tend to obscure more than they clarify. Since "civilization" is one such term, I will use it only sparingly to refer to *that complex of cultural phenomena which tends to occur with the particular form of socio-political organization known as the state.* The state is somewhat easier to define, since it has been worked over by skilled sociologists and anthropologists. We may lead up to it, however, by briefly considering some of the simpler and antecedent forms of socio-political organization (Figure 1) which have recently been distinguished from states by Service (50), Sahlins (46), and Fried (22).

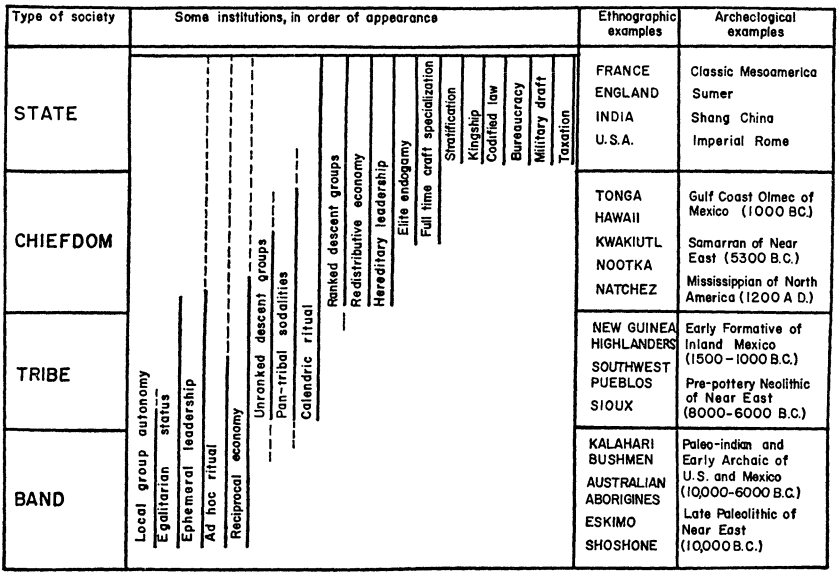

FIGURE 1. Types of societies in ascending order of sociopolitical complexity, with ethnographic and archeological examples of each. A selected number of sociopolitical institutions are shown, in the approximate order in which they are believed to have arisen (see text).

EGALITARIAN SOCIETY

Bands.—Simplest of the egalitarian societies are bands, whose only "segments" are families or groups of related families and whose means of integration are usually limited to familial bonds of kinship and marriage, plus common residence. Leadership is informal and ephemeral; division of labor is along the lines of age and sex; and concepts of territoriality, descent, or lineage are weakly developed. Most important ceremonies are ad hoc, taking place whenever sufficient people are assembled and sufficient resources are available. This organization is frequently found among hunters and gatherers like the Australian aborigines, the Bushmen and Eskimo, and the Paiute and Shoshone of the Great Basin. It is assumed on the basis of archeological evidence that prior to 10,000 B.C. most of the world's population was so organized.

"Tribes."—Although many evolutionists are now unhappy with the term "tribe," Service (50) originally found it convenient to describe larger egalitarian societies whose segments are groups of families related by common descent or by membership in a variety of kinship-based groups (clans, lineages, descent lines, kindreds, etc), the description of which has kept ethnologists occupied for decades. As Sahlins (45) has suggested, one latent func-

tion of some of these kin groups is as land- or property-holding units, and it is thus not surprising that they are more common among primitive agriculturalists than among hunters. Ancestors are often revered, and it is believed that they continue to take part in the activities of the lineage even after death; good examples can be found among the Pueblo Indians of the Southwestern US (Ortiz 36) and the New Guinea highlanders (Rappaport 38). Since "tribes," like bands, have weak and ephemeral leadership, they are further integrated (and even, it has been argued, regulate their environmental and interpersonal relations) by elaborate ceremonies and rituals. Some of these are conducted by formal "sodalities" or "fraternal orders" in which members of many lineages participate; examples include the dance societies, clown societies, or medicine societies of the Pueblo Indians. "Tribes" frequently have ceremonies which are regularly scheduled or "calendric," occurring at the same time every year. These ceremonies—as well as longer-term ritual cycles which stretch out over decades—may help to maintain undegraded environments, limit intergroup raiding, adjust man-land ratios, facilitate trade, redistribute natural resources, and "level" any differences in wealth which threaten society's egalitarian structure (cf. Rappaport 39, pp. 8–9).

Such "tribal" societies seem to have evolved during the early Post-Pleistocene period in the various parts of the world we have been considering; they are archeologically manifested in the remains of villages or residential compounds where differences in wealth and status between households are negligible. In the Near East and on the coast of Peru, such settlements appear to have arisen before agriculture and were supported by intensive collection of wild foods; in Mesoamerica, on the other hand, they appeared only after many thousands of years of gradually improving but still-primitive agriculture (Flannery 19). The rise of multigenerational descent lines can be seen in some prehistoric Near Eastern villages, where ancestors' skulls were saved and their features reconstructed or where their secondarily-reburied skeletons were stored under the floors of their descendants' houses. In Mesoamerica, multilineage sodalities like the dance societies of the Pueblo Indians are suggested by pottery masks buried with their owners, by countless figurines of dancers in fantastic disguises, and by incredible accumulations of shell rattles, deer scapula rasps, turtle shell drums, conch shell trumpets, and the bones of countless macaws who provided the necessary feathers (ibid). Approximate dates for the appearance of egalitarian tribes might be 7000 B.C. in the Near East, 3000 B.C. in Peru, and 1300 B.C. in parts of Mesoamerica.

Chiefdoms

One of the thorniest problems in cultural evolution is the origins of hereditary inequality—the leap to a stage where lineages are "ranked" with regard to each other, and men from birth are of "chiefly" or "commoner" descent, regardless of their own individual capabilities. Since lineages are also property-holding units, it is not surprising to find that in some chiefdoms the best agricultural land or the best fishing localities are "owned" by the highest-

ranking lineages. Societies on a chiefdom level include ancient Tonga and Hawaii, the Natchez Indians of the Mississippi Valley, and the Kwakiutl and Nootka Indians of the Pacific Northwest.

"Chiefs" in rank society are not merely of noble birth, but usually divine; they have special relationships with the gods which are denied commoners and which legitimize their right to demand community support and tribute. Frequently, they build up elaborate retinues of followers and assistants (often relatives)—the chiefly precursors of later state bureaucracies. Often, chiefdoms have not only elaborate ritual but even full-time religious specialists; indeed, the chief himself may be a priest as well. Further, the office of "chief" exists apart from the man who occupies it, and on his death the office must be filled by one of equally noble descent; some chiefdoms maintained elaborate genealogies to establish this, and in some cases (e.g. Hawaii) chiefs married full sisters when no one else of sufficiently high status was available. Finally, high-ranking members of chiefdoms reinforce their status with sumptuary goods, some of which archeologists later recover in the form of "art works" in jade, turquoise, alabaster, gold, lapis lazuli, and so on.

Chiefdoms are difficult to identify archeologically, but probably appeared as early as 5500 B.C. in the Near East and 1000–800 B.C. in Mesoamerica and the Andes. One clue used by archeologists is the appearance of burials of infants of high status—status which, because of their youth, must have been ascribed at birth. The child burials with alabaster statues and turquoise and copper ornaments at Tell es-Sawwan in Iraq (5500–5000 B.C.) and those with jade sumptuary goods in basalt-column tombs at La Venta in Mexico (800 B.C.) are frequently cited examples (El-Wailly and Abu es-Soof 17; Coe 13, p. 690). Also, chiefdoms have large populations, with the villages of paramount chiefs sometimes running into the thousands, and these may be archeologically detectable. They also have a higher degree of craft specialization, both in necessities and luxury goods. Archeological examples from the Near East include villages which specialized in the manufacture of high-quality pottery, obsidian blades, copper, and flint; in Mesoamerica, there were villages which produced magnetite mirrors, obsidian blades, shell ornaments, or other goods for consumption over wide regions. Yet, although there are village specializations, there is usually as yet no *class* of craft specialists, no occupational castes as in stratified societies. Search every craftsman's house in the archeological remains of a chiefdom, and you will usually find tools which indicate he was a farmer as well.

Stratified Society

States.—The next, and highest, form of socio-political organization is the state, and we now come to its definition. The state is a type of very strong, usually highly centralized government, with a professional ruling class, largely divorced from the bonds of kinship which characterize simpler societies. It is highly stratified and extremely diversified internally, with residential patterns often based on occupational specialization rather than blood or

affinal relationship. The state attempts to maintain a monopoly of force, and is characterized by true law; almost any crime may be considered a crime against the state, in which case punishment is meted out by the state according to codified procedures, rather than being the responsibility of the offended party or his kin, as in simpler societies. While individual citizens must forego violence, the state can wage war; it can also draft soldiers, levy taxes, and exact tribute.

States have a powerful economic structure; they are characterized by both reciprocal and redistributive exchange, and often by markets as well. The economy is largely controlled by an elite (usually hereditary) with preferential access to strategic goods and services; this elite constitutes the usual stratum from which high officers are recruited. As in chiefdoms, the office itself exists apart from the man who fills it; and states have many more offices.

States *usually* have populations numbering *at least* into the hundreds of thousands (and often millions), only a certain percentage of whom are engaged in actual production of food; many are full-time craft specialists residing in urban occupational wards. They attain a high level of artistic and "scientific" achievement, often because of the state's support of, and constant demands upon, artisans of all kinds. States have public buildings, works, and services of various sorts, usually implemented through professional architects, engineers and bureaucrats. Among these will usually appear public works of a religious nature, attended by full-time specialists maintaining a state religion. Such a religion typically has a pantheon of gods with an internal hierarchy and task-differentiation as complex as that of human society itself. In addition, many states use an "official" art style to portray these gods (and the secular rulers who serve them) throughout the area they control or influence, even when those areas are ethnically and linguistically diverse.

The search for "prime movers".—What are the mechanisms by which a "tribe" becomes a chiefdom, and a chiefdom a state? This problem has attracted social scientists since Lewis H. Morgan, Friedrich Engels, and V. Gordon Childe. Most recent evolutionary studies by ethnologists are *synchronic*; they take a series of unrelated, contemporary societies on different levels of development and, by comparing them, try to imagine which institutional changes could have turned the simpler into the more complex. Most archeological studies, on the other hand, have been *diachronic,* tracing the development of society through time in a single region. The ethnologists quite rightly point to the richer amounts of detail available in their contemporary societies; yet all their reconstructions amount to "just so" stories, because there is almost no society for which time depth and rigorous proof of evolutionary causes are available. Archaeological data lack the richness of detail, yet often provide 10,000 years or more of continuity in a single culture; and many archeologists are now subjecting their data to rigorous testing of a kind that cannot be applied to a synchronic "just-so" story.

Two recent papers by ethnologist Robert Carneiro (10) and archeologist Henry T. Wright (61) summarize current theories on the origins of the state. Among the "mechanisms of state formation" which have been proposed are population growth (per se, or in areas circumscribed in various ways), warfare, irrigation, trade, symbiosis between contrasting peoples or environmental zones, "cooperation and competition," and the "integrative power" of religions or great art styles.

Irrigation.—Irrigation was originally proposed as a prime mover in the rise of the "hydraulic state" by Karl Wittfogel (57). He believed that water was a resource of unusual qualities, vital to agriculture in arid lands, yet manipulable by human societies in ways that other environmental variables are not. Wittfogel felt the rise of the state lay in the establishment of a body of rulers and officials who provided the management for large-scale hydraulic agriculture. Carneiro (10) and Adams (2,3), while granting the importance of irrigation in some regions, reject it as a general mechanism because (*a*) many states, such as the ancient Maya, arose in areas where irrigation is of limited to negligible importance, and (b) even in arid Mexico and Mesopotamia, archeological evidence indicates that complex, large-scale irrigation appeared only after the state had already formed (ibid).

Warfare.—For Carneiro (10, p. 734), "warfare is surely a prime mover in the origin of the state," though "it cannot be the only factor. After all, wars have been fought in many parts of the world where the state never emerged." With the discovery of possible defensive works, paintings of war scenes, and capture scenes on stone monuments (e.g., stelae at Yaxchilán, Morales, and Bonampak) among the ancient Maya—once regarded as the classic example of a "peaceful" civilization—Carneiro (ibid) is probably right in assuming that no early state was without war. But was war really a cause, or a result, of state formation? Most of the evidence cited by Carneiro dates to periods long *after* the state is thought to have formed. In the formative periods which preceded it, the evidence is still ambiguous, and no rigorous test has shown whether warfare results *in* or results *from* the state—or stems from some third factor, responsible for both.

Population growth and social circumscription.—Most recently, population growth has been singled out as a prime mover, whose popularity seems almost to have resulted in a new theoretical school. Since the time of Malthus, many social scientists have believed that the adoption of new agricultural technologies led to food surpluses, which in turn stimulated population growth as well as leisure time in which to develop the arts. These views have been challenged (*a*) by Esther Boserup (6), who suggests that population growth occurs first and provides pressure for new agricultural technology; and (*b*) by Carneiro (op. cit.), Sahlins (47), and others, who destroy the myths of "surplus" and "leisure time." The cold ethnographic fact is that the

people with the most leisure time are the hunters and gatherers, who also have the lowest productivity; even primitive farmers don't produce a surplus unless they are forced to, and thus the challenge is "getting people to work more, or more people to work" (Sahlins op. cit.). With better technology, people simply work less; what produces surplus is the coercive power of real authority, or the demands of elaborate ritual (see below). This being the case, population growth is now being seen as a *cause* of social evolution rather than a result, in the Near East (Smith & Young 52), Mesoamerica (Sanders & Price 49, p. 230), and the Andes (Carneiro 10, p. 735). A corollary theory has been presented by Carneiro, who argues that what is most important is population pressure *within a circumscribed area,* e.g., a mountain-ringed valley, or a limited but fertile flood plain. Within such an area, the intolerable struggle for scarce land or resources triggers warfare, which leads to cooperation, competition, mutual defense, and eventually state government to keep peace and allocate resources. And Carneiro stresses that circumscription need not be wholly environmental: peoples living densely packed near the center of an otherwise open area may be "socially circumscribed" by neighbors who surround and impinge on them on all sides, albeit at lower densities.

Complicating the population growth hypothesis is a growing body of data which suggest that human groups (especially hunter-gatherers and primitive farmers) engage in many kinds of behavior which homeostatically maintain their population below the theoretical carrying capacity of their environment (cf. Birdsell 5). In order for population to grow, people must not simply have more food, they must also cease to engage in such self-limiting practices —infanticide, senilicide, long lactation, ritual sexual abstinence, and so on— to the extent they did formerly. No paper using population growth as a prime mover has yet explained *why* population should grow in the first place, and yet this explanation seems especially incumbent on those who see population growth as cause, rather than a result, of intensified food production. Moreover, the theory does not go far toward explaining peoples like the Chimbu tribesmen of highland New Guinea (Brookfield & Brown 7), whose population density reaches 400 persons per square mile, yet who have no kings, no chiefs, no social stratification, no ranking, and indeed, none of the trappings of civilization whatsoever. Among these people, whose exchange is still virtually all reciprocal, environmental and interpersonal relations are regulated not by political power and institutions, but by an incredibly elaborate ritual system which seemingly has evolved as an alternative to power. One can only fall back weakly on the position that population density is relative, and we don't know what density is "enough" to trigger state formation in any given part of the world.

Trade and symbiosis.—Several of the areas where early civilizations arose are lacking in raw materials thought to be "essential" to daily life. A lack of building stone, wood, and metal in southern Mesopotamia was long held to

be responsible for stimulating trade in that area; and more recently Rathje (41) has argued that a lack of salt, obsidian, and suitable stone for maize-grinding tools in the Petén region of Guatemala stimulated trade and the rise of lowland Maya civilization. This mechanism, however, does not explain the rise of civilization in central Mexico, which seemingly lacked none of these "essential" raw materials, yet at times had more documented interregional trade than any other part of Mesoamerica. Moreover, since major settlements are apparently spaced more closely together in the Petén than on its periphery (see discussion of "hypercoherence," below), one could as easily argue that Carneiro's "social circumscription" was operating, rather than resource scarcity. In the Old World, Wright (60) has demonstrated that in at least one case, on the fringes of southern Mesopotamia, a great leap in volume of trade *followed* the formation of the state, rather than preceding and causing it. Once again, we are faced with a "mechanism" that may have been important in some areas and not in others, thus lacking universality.

Much the same could be said of interregional symbiosis, which is related to trade. Perhaps not surprisingly, symbiosis has been proposed as a mechanism in areas with clear-cut environmental diversity on a "biome" order of magnitude, such as Mexico (Sanders 48) and greater Mesopotamia (Flannery 18), but never in areas where most of the "civilization" lay within one biome, such as the Nile Valley or the Maya lowlands. Either "symbiosis" needs to be redefined, or it also fails as a universal prime mover.

Other "prime movers".—We are left with "cooperation and competition" (cf. Sanders & Price 49) and the "integrative power" of great religions or art styles (cf. Willey 56), which I will treat only briefly. Though undeniably important, cooperation and competition are generalized processes which go on at all levels of human society, from simplest to most complex; and if they were mechanisms of state formation, there would be no bands or tribes left in the world. In fact, cooperation and competition can as easily function to maintain homeostasis as to promote evolution.

Although the late Stephan de Borhegyi (personal communication) used to say with some justification that "the invention of Heaven and Hell contributed a more powerful prime mover to human society than the wheel," the roles of religion and great art have been handled with imprecision by many anthropologists. It is the hierarchical arrangment of the members and classes of society which provides the actual integration in states. The critical contribution of state religions and state art styles is to legitimize that hierarchy, to confirm the divine affiliation of those at the top by inducing religious experience—the kind of awesome experience that Rappaport, in a previous issue of this Review (40 p. 31), refers to as "numinous."

Multivariant causality.—As Wright (61) points out, most state origin theories deal either with managerial requirements or with conflicts between social classes or polities. Robert Adams (3) has produced a theory which is

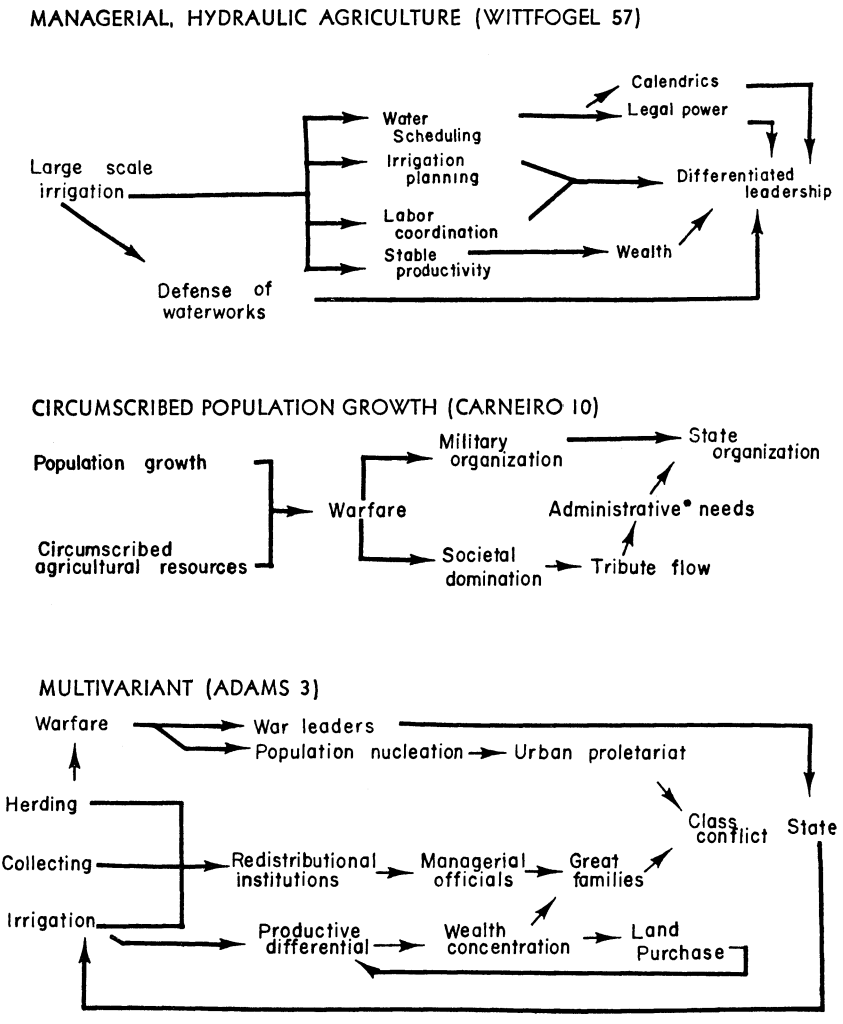

FIGURE 2. Models for the origin of the state proposed by Wittfogel, Carneiro, and Adams. After Wright (61), with modifications.

described as "synthetic" by Wright, since it combines both approaches (Figure 2). For Adams there are no "prime movers," but rather a whole series of important variables with complex interrelationships and feedback between them. This model does not satisfy those who, like Carneiro, feel that simple explanations are more elegant than complex ones, but it appeals to those of us who like circular rather than linear causality. In the remainder of this article I will consider some of the implications of multivariant causality.

One way of organizing the variables in such an evolutionary theory is to regard human society as one class of living system, and apply to it a general model for such systems (Miller 34; Rappaport 39, 40). In such a scheme, the state appears as a very complex system, one whose complexity can be measured in terms of its *segregation* (the amount of internal differentiation and specialization of subsystems) and *centralization* (the degree of linkage between the various subsystems and the highest-order controls in society; see below). An explanation of the rise of the state then centers on the ways in which the processes of increasing segregation and centralization take place. This explanation also requires that we distinguish carefully between 1. such *processes,* 2. *the mechanisms* by which they take place, and 3. the *socio-environmental stresses* which select for those mechanisms. I suggest that the mechanisms and processes are universal, not merely in human society but in the evolution of complex systems in general. The socio-environmental stresses are not necessarily universal, but may be specific to particular regions and societies. It is in this latter category that I place the "prime movers" already discussed, and this categorization helps explain why, although important, they cannot be shown to operate everywhere in the world.

In order to understand how socio-environmental stresses select for certain evolutionary mechanisms, let us diagram a simple human ecosystem (Figure 3*a*). It consists of a series of subsystems arranged hierarchically, from lowest and most specific to highest and most general. Each subsystem is regulated by a control apparatus whose job is to keep all the variables in the subsystem within appropriate goal ranges—ranges which maintain homeostasis and do not threaten the survival of the system. Management of crop plants, for example, might be regulated by a lower-order control issuing specific commands; the distribution of harvests and surpluses (the "output" of the latter subsystem) might in turn be regulated by calendric rituals or group leaders somewhere in the middle levels of the hierarchy. On all levels, the social control apparatus compares output values not merely with subsistence goals but with ideological values, the demands of deities and ancestral spirits, ethical and religious propositions—the human population's "cognized model" of the way the world is put together. The highest, most abstract, and most unchanging of these propositions lie in the highest-order (or "governmental" controls), which deal in policy more often than commands; it is against this abstract set of standards that the human ecosystem's most dramatic events are judged and the need for regulation evaluated. This is almost diametrically opposed to the model used by the "cultural ecologists," for whom such operations as crop production make up the "core" of culture, while rituals and ancestral spirits are mere epiphenomena (Steward 54). It also implies that such "epiphenomena"—whose study has fallen largely to the humanist—lie at the heart of society's environmental and interpersonal regulation, and as such cannot be omitted from any comprehensive ecological analysis, as has so often been done in the past.

Normally, higher-order controls regulate only the output of lower-order

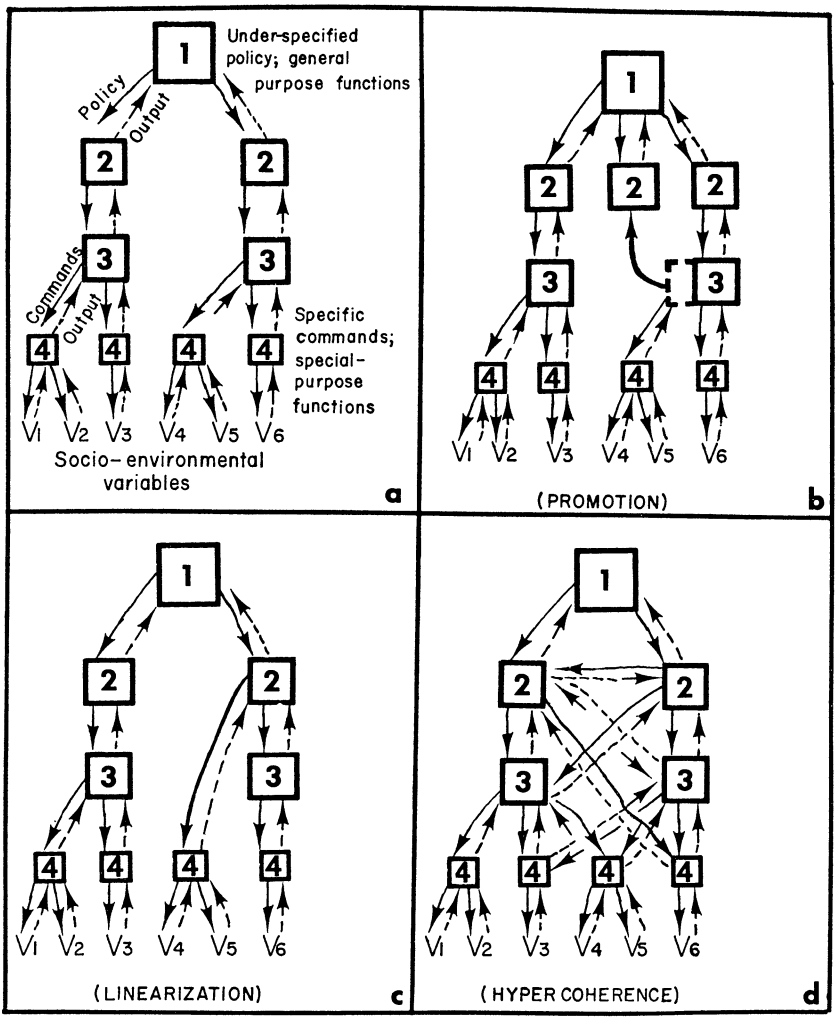

FIGURE 3. Models for the operation of control hierarchies: (*a*) the model for a control hierarchy as described in the text, with socioenvironmental variables (V_{1-6}) at the bottom regulated by low-level institutions (4), and each successively higher level (3–2–1) regulating the output of the level below it; (b) an example of "promotion," with one function of a third-level institution rising to assume a position of importance in the second level; (*c*) an example of "linearization," with a second-level control bypassing level 3 and directly regulating the output of a fourth-level institution; (*d*) an extreme case of "hypercoherence," with too great a degree of direct coupling among institutions on various levels.

subsystems, and not the variables kept in range by the latter. But should a lower-order control fail to keep its relevant variables within their ranges, (as in the case of socio-environmental stress), the control apparatus on the next higher level of the hierarchy may be called into operation as a "back up." Should all controls on the levels fail, the system is in trouble; it needs a new regulatory institution, and unless one evolves the system may collapse, or "devolve" to a lower level of integration. If a system is buffered in such a way that deviant variables in one subsystem take a long time to affect other subsystems, it is likely to be stable. But "increasing coherence in more inclusive systems is a concomitant of evolution" (Rappaport 39, p. 21); this means that more complex, more "highly evolved" systems may be less stable or more demanding, with more direct influence of one subsystem on another, and thus with a need for stronger and more centralized management at the top of the hierarchy. Such centralized, powerful, often unstable systems—of which the state is the ultimate form—are also more successful competitors, in that they quickly push aside or absorb simpler and more stable systems which stand in their way. They seemingly expand continuously until they reach certain scale limits, or until threatened or repulsed by a still more powerful state, such as happened when the Aztec and Inca came in contact with the Spanish.

Much of the control apparatus in human society consists of institutions, which vary greatly in form and function. Especially among lower-order controls, one finds what might be called system-serving or "special-purpose" institutions; these are set up to perform special tasks or regulate certain variables for the good of the system at large. Fewer in number, and found mainly among higher-order controls, are self-serving or "general-purpose" institutions. When their survival is synonymous with the survival of the system at large, they are adaptive and beneficial. When their survival is at the expense of the system, they provide stress. Two of the phenomena of evolutionary advance are the generation of new institutions and their gradual metamorphosis from system-serving to self-serving (see below).

Some of the most important institutions are those which process information for human societies. These are the ultimate detectors of deviant variables; and their numbers increase with more complex societies, for evolving systems—as Maruyama (32, p. 174) points out—generate new information autonomously through the interaction between their parts. Thus, one of the main trends in the evolution of bands into tribes, chiefdoms, and states must be a gradual increase in capacity for information processing, storage, and analysis.

Among bands, much of the data handling is done by informal headmen, who collect and distribute knowledge about which groves of edible nuts have been thoroughly harvested, which canyons currently have high concentrations of game, and so on (Steward 54, Chapter 6; Richard B. Lee, personal communication). These headmen support themselves, taking no "overhead" from society; but the number of bits of information they can process is limited, and serves probably no more than 100 persons at any time. With agri-

culture comes a need to control not only data on wild foods, but the allocation of land, timing of planting and harvest, and collaboration on land clearance; perhaps most importantly, disparities in harvests and surpluses resulting from differential fertility must be regulated for the overall good of the group. Among egalitarian tribes and even in some chiefdoms, elaborate ritual programs detect such disparities and ceremonially circulate harvests, resources, obligations, and rights to land among members of society (Rappaport 38). These rituals are costly (overhead is still overhead, even when it is ritually committed to gods or deceased ancestors), yet they process more data and perform more regulation than informal headmen.

In chiefdoms—where the number of institutions is far higher, population often very large, warfare frequent, agriculture often complex, crafts more highly developed, and exchange intense—even elaborate ritual may not alone be able to handle regulation adequately; much of it is done by sanctified hereditary chiefs and their retainers, to whom some of the responsibility is delegated. This chiefly retinue is expensive for society to maintain, for it requires sumptuary goods, subsistence, and logistic support for a large group of persons who engage in little or no food production; yet it processes a great deal of data, or processes it faster, and regulates thousands of persons through the establishment of a highly diversified and specialized set of offices on a level above the local headman (Sahlins 44). In states, the managerial superstructure becomes still more elaborate, multilevel, and centralized; and the royal bureaucracies who process data for hundreds of thousands of souls must be supported by costly tribute, corvee labor, and often the pillaging of less powerful neighbors (Kottak 26). In the case of some ancient civilizations, such as the Classic Maya, such a superstructure was supported in spite of agricultural practices believed to be no more sophisticated (except in rare cases) than those of most egalitarian tribes (Dumond 15). Looked at in this way, the most striking differences between states and simpler societies lie in the realm of decision-making and its hierarchical organization, rather than in matter and energy exchanges. Herein lies another problem faced by those "cultural ecologists" who place such primary emphasis on the ways that civilized peoples get their food.

Socio-environmental stresses and evolutionary mechanisms.—Slobodkin (51) has suggested that when variables exceed their goal ranges, they subject systems to stress which can lead either to breakdown or to evolutionary change. Perhaps as a result of the system's attempt to return a runaway variable to its range, new institutions or new levels appear in the control hierarchy (segregation), or higher-order controls become strengthened (centralization). Warfare, population pressure, the demands of large-scale trade, or any combination of the socio-environmental conditions discussed in the earlier part of this paper may provide the adaptive milieu in which various *evolutionary mechanisms* are triggered. I will discuss only two of these, which I will call *promotion* and *linearization*. They are diagrammed in Figure 3.

In *promotion* (Figure 3*b*), an institution may rise from its place in the control hierarchy to assume a position in a higher level; it may in the process go from "special-purpose" to more "general-purpose." Alternatively, a new institution may arise out of what was simply one role of a previously existing institution, as the office of chieftainship presumably rose out of the leadership role of the informal headman in a simpler society. Promotion is particularly prevalent among institutions with discrete personnel (Rappaport 39); it may occur if those personnel are heavily supported or "funded" during a stress emergency, allowing them to become more self-serving when the emergency has passed. Promotion contributes heavily to the process of segregation, since it generates new institutions.

Other examples of promotion may include 1. the evolution of the Sumerian "palace" out of the secular residences included in southern Mesopotamian temple complexes at 3000 B.C. (Adams 1), with its implications for the evolution of kingship out of some kind of "priest-manager" role in the preceding chiefdom stage; and 2. the transition from the so-called "theocratic" first-generation civilizations to their more "militaristic" successors. All the data at our disposal suggest that in the "pristine" first-generation states, rulers were recruited from sanctified royal lineages, while the military was a special-purpose arm of the state. Eventually, however, men of less-than-royal descent, who had risen in the military, seized or acceded to kingship instead of the "proper" royal heirs (ibid). It is possible that unsettled political conditions—times of war and great stress—provided the adaptive milieu in which such special-purpose leaders could promote themselves to general-purpose offices. If so, the failure of normally effective lower-order controls may be indicated. Finally, as a third example, we might hypothesize that the military arose in the first place through promotion of some institution like the "warrior societies" which many chiefdoms have (cf. Gearing 23).

In *linearization* (Figure 3*c*), lower-order controls are repeatedly or permanently bypassed by higher-order controls, usually after the former have failed to maintain relevant variables in range for some critical length of time. Examples include 1. the takeover of local irrigation regulation by federal agencies, given below; 2. the bypassing of local headmen by the state when it makes every crime against an individual a crime against the state, outlawing feuds and blood vengeance; and 3. the payment of taxes by each citizen directly to the federal government, instead of the payment of tribute by local chiefs on the basis of the pooled resources of their followers. It must be clear that linearization heavily contributes to centralization. I suspect it is particularly strongly selected for by the need for conflict resolution on all levels of human society, and that it is the mechanism most often triggered by warfare.

Responding to socio-environmental stress, promotion and linearization lead to evolutionary change, but advance is not without problems. Promoted-institutions too often serve their own interests rather than society's, and linearization too often destroys the intervening controls which buffer one subsystem from perturbations in another. Either can lead to what Rappaport

(39) has called a systemic "pathology," which subjects the system to still further stress. In coping with this stress, the system may engage in still more progressive centralization and segregation, and still further evolutionary change; the process is thus one with many positive feedback loops.

Two of Rappaport's pathologies are *usurpation* ["the elevation of the purpose of one's own subsystem to a position of preeminence in a more inclusive system" (Rappaport 39, p. 26)] and *meddling* ["to subject directly to a higher order control the variables ordinarily regulated by lower order controls" (op. cit. p. 24)]. As their definitions suggest, these pathologies resemble promotion and linearization, though they need not involve any change in evolutionary level; the instability and further stress they produce, however, can select for one of the evolutionary mechanisms. In a multivariant model, we might see the state evolving through a long process of centralization and segregation, brought about by countless promotions and linearizations, in response not only to stressful socio-environmental conditions but also to stress brought on by internal pathologies.

I will now present three concrete examples of how some of these mechanisms operate. Two, dealing with promotion and linearization, are drawn from the research of myself and my colleagues on the rise of the state in southern Mexico (Flannery et al 20). The third deals with another of Rappaport's pathologies—*hypercoherence*—which will be defined in another section.

Ritual, promotion, and social stratification.—Early speculative historians attributed the origins of social stratification to the "conquest" of one tribe by another, with the victors making slaves of the defeated. Modern ethnologists, however, point out that tribesmen defeated by other egalitarian tribesmen are just as likely to be married or adopted into the victorious tribe. Fried (22), who stresses the truly central position of this problem, makes it clear that the evolutionary pressures for stratification must be sought *within* society. Elsewhere (21), he has further suggested that the potential for stratification is already present in egalitarian society, simply waiting for the right socio-environmental context in which to make itself felt. In "tribal" societies, this potential is held in check by what are sometimes called "leveling mechanisms" —social or religious institutions which pick up information on inequalities in landholding, wealth, or power and regulate these variables before they exceed the goal ranges of egalitarian society (see discussion of *mayordomía,* below). In many societies, the accumulation of inordinate amounts of private property by an individual or his kinsmen triggers a ceremony in which he is compelled to give it all away, at the risk of losing face or being accused of witchcraft. In doing so he may gain great prestige, but he does not gain "unequal access to strategic resources or the means of production," which is generally thought to be a criterion of stratification. Nor does he achieve hereditary prestige; his son must gain it in his own way, in his own generation, or not at all.

But close examination of the leveling mechanisms of egalitarian societies reveals an interesting systemic relationship: they often carry within themselves the seeds of their own destruction. Each can, if the adaptive context is right, be manipulated in such a way as to yield hereditary preferential access to strategic resources, in direct opposition to the purposes for which it arose. I will give only one example, from Mendieta y Núñez' study (33) of San Juan Guelavía, a Zapotec Indian village of traditional maize farmers in the Valley of Oaxaca, 300 miles south of Mexico City.

At the end of the last century San Juan Guelavía was a village of small property holders, governed by a council of elders and regulated by two widespread Mesoamerican regulatory mechanisms called the *mayordomía* and the *cargo* system. The *cargo* is a system of rotation of village governmental offices among the responsible citizens of the town, while the *mayordomía* is a system of rotating financial sponsorship of the fiestas of the town's patron saint and other calendric religious festivals. In principle, the role of *mayordomo* or sponsor will fall over and over again on wealthier citizens who can afford it—thus "leveling" their wealth and distributing its benefits to the rest of the village, while at the same time implicitly legitimizing a tolerable degree of disparity in wealth since sponsors rise in prestige through successful sponsorship of successively more important fiestas (Wolf 58, Cancian 9).

In the late 1800s the latent functions of the *mayordomía* were successfully subverted by an enterprising villager named Marcial López (Mendieta y Núñez 33, pp. 216–19), who converted the institution into a means of taking over the lands of his neighbors. With the aid of some friends in the clergy (the special-purpose system in charge of fiestas) he forced the council of elders to designate *mayordomos* without taking into account whether or not the person was sufficiently solvent to undertake sponsorship. Since designation by the council carried a heavy obligation and held out the promise of prestige, the sponsors could hardly refuse even though acceptance forced them to seek loans; López provided the money, but on condition that they put up their land for collateral. By the end of three decades, López had accumulated considerable property by foreclosure, and by the eve of the Mexican revolution he owned most of the community's best land. Among the Zapotec, debts pass from one generation to another unchanged; a son inherits the debts of his father, and he can end up working his father's former lands as a sharecropper to the son of his father's creditor. By 1915, a few families (mostly Lópezes) owned 92.2% of the arable land in San Juan Guelavía, while the remaining 8.8% was spread among 354 villagers. This preferential access to strategic resources is amplified by the fact that major landowners owned all but 6% of the *irrigated* land. The López family avoided censure by strongly supporting the church (a special-purpose system eager to become a general-purpose system); they had, in one generation, become a "great family" in the sense that Adams (3) uses the term (see Figure 2). In the end, with low-order controls like the *mayordomía* and cargo "no longer capable of reducing the discrepancy between the deviation signals and reference

values" (Rappaport 39, p. 20), the great families were overthrown and their land redistributed only through "higher-order controls acting as back-ups"—in this case, the Mexican revolution with its policy of land reform.

The implications of this example are several. First, it is evolutionary. It shows the emergence (albeit abortively) of a new institution—the "great family," for want of a better term—and of an economy with preferential access to strategic resources. It is also an example of "promotion," in which a special-purpose institution (the church) took over the selection of *mayordomos,* which formerly had been done by a general-purpose system (the town government, by general consensus). Perhaps most importantly, it shows that evolutionary change can result from the *perversion of a ritual regulatory mechanism*—surely at the farthest remove from the "techno-environmental factors" on which the "cultural ecologists" have generally focused. This is not to say that socio-environmental factors were not operative—they must have been, though in this case we do not know which ones. But their role was to provide the selection pressures, while the actual instrument of change was ritual. And although the results were evolutionary, the mechanism was not unlike Rappaport's pathology—usurpation—in which "regulatory agencies . . . become the instruments of the very subsystems they were meant to regulate" (Rappaport 39, p. 27).

Linearization, buffering, and the "hydraulic state".—A second example from the Valley of Oaxaca illustrates the mechanism of linearization, as well as shedding some light on the Adams-Wittfogel irrigation controversy and the Boserup-Carneiro "population pressure" hypotheses. One phase of our Oaxaca research was an ethnographic study of more than 20 canal-irrigating villages by Susan H. Lees (29, 30), from whose monograph the following data are abstracted.

Traditional canal irrigation in the Valley of Oaxaca is a small-scale affair, managed autonomously by each community in its own way. Allocation of water is handled by a variety of methods, almost as great as the variety of towns: sometimes by the municipal president, sometimes by an appointed council, often by the *topiles* (who are little more than village messenger boys). It is simply one of a number of tasks performed by village officeholders, whose positions are rotated among the responsible citizenry by means of the *cargo* system already described. No advantage is achieved through position along the canal system; and even where two villages share the same tributary, Lees found no "depotism" by the upstream village over the downstream village. The construction and maintenance of the small, gravity-flow canal systems is carried out in the ways each community traditionally carries out all other "public" tasks, such as school or church construction, road building, and so on. Moreover, from hundreds of years (or as archeological data indicate, sometimes thousands of years) on the same spot, each village has learned what to expect in the way of fluctuations in rainfall, water table, or stream flow, and can buffer such environmental perturbations.

In recent years, however, the rural villages have become aware of the activities of the Secretaria de Recursos Hidráulicos, a "special-purpose" institution established by the federal government of Mexico to develop the nation's water resources. The SRH has specialists—engineers, designers, hydrologists, construction teams—and heavy earth-moving machinery possessed by no rural village. Several villages near suitable canyons have therefore offered to provide communal unskilled labor if the SRH will build a dam to impound water from their seasonally dry tributary, and a number of dams had already been built when Lees did her study. On completion of such a project—expanding by a considerable order of magnitude the area that can be irrigated—the SRH is understandably reluctant to leave maintenance of the dam in unskilled local hands. Instead, it leaves the water control of that village in the care of its own appointed representative or *agente*—accountable to the SRH and the federal government rather than the village. Thus the village finds that the price of development is loss of autonomy.

Centralization, therefore, represents a "linearization" of the linkage between the special-purpose arm (SRH) of a higher-order system (the federal government) and an important variable (water) in a lower-order system (the local village ecosystem); response is now direct, rather than buffered by the village government. Moreover, the stage is set for Rappaport's pathology, "meddling." Imagine, for example, a hypothetical case in which flash floods in one or two canyons (a common occurrence in Oaxaca) seriously damage the government-built dams downstream. The news travels directly to the federal government. After several such incidents, a policy decision is made: to prevent future damage due to overtopping, a set quantity of water is to be released each night during the rainy season from all federally built dams. This directive, issued to the entire rural dam system, means that such a quantity of water will be released even by dams in canyons where it has not rained in months. The higher-order system, which cannot possibly know and understand the local environments as well as the individual rural villages do, can thus introduce further instability into the system along with more centralized control. Fortunately, many out-of-the-way villages will simply ignore the directives, thus reducing linearization.

This particular example shows us the trend toward hypercoherence (see below) which centralization can produce. Through linearization and meddling from above, the various canal-irrigating villages in the system are so tightly integrated that disasters in one or two isolated canyons can make their impact felt rapidly on all other villages, through higher-order policies; formerely, a local disaster rarely went further than the local community. Second, the example touches on Boserup's and Carneiro's hypotheses, since in a few cases (but not all!) rural villages *have* called on the federal government for dams because of population growth and land pressure within tightly circumscribed *municipios*. What the Oaxaca example shows is that, while population growth in circumscribed areas *can* exert "causal" pressure for more sophisticated agricultural technology, it is not a direct mechanism of cultural evolu-

tion; rather, *it provides a socio-environmental situation in which selection pressures for increasing linearization and meddling are high, and the end result is further centralization.*

Third, we turn to Wittfogel's theory of the hydraulic state. As Lees' study shows, in the case of Oaxaca the state existed (and indeed its corps of engineers and hydrologists *had* to exist) before any "great" irrigation works. But water does possess one unique and critical quality which Wittfogel assigned it: if the federal government wants to meddle in the administration of the rural village, water control is one point at which it can do so. Water is one chink in the armor of the autonomous village—one convenient point at which the government can enter the closed corporate community, perform a service beyond that community's organizational power, and leave the village more tightly coupled to the higher-order system than ever before. Yet it is precisely this linearization—rather than the irrigation itself—which leads to evolution, and linearization can be selected for by a whole range of socio-environmental factors.

Integration, hyperintegration, and devolution.—The high level of integration characteristic of states results in part from centuries of linearization, centralization, and promotion. The highly structured nature of even the earliest states often manifests itself archeologically in the absence of written records; in the Near East, for example, Wright (60) has suggested that the appearance of a three-tiered administrative hierarchy with trimodal site sizes (city, town, and village) may be one indicator of state organization, taken in conjunction with other phenomena. Still another indicator of integration over broad regions is the appearance of the characteristic hexagonal lattices of settlements associated with "central places" on unbounded level plains, developed by Christaller (11, 12) and Lösch (27, 28).

It had long been known that a hexagon was the most economical geometric form for the equal division of an area between a number of points. From this followed a body of theory, too lengthy to discuss fully here, about the spacing of those towns or cities which act as the centers for distribution of goods and services to smaller towns and the rural hinterland. Assuming 1. uniform distribution of population and purchasing power, 2. uniform terrain and resource distribution, 3. equal transport facility in all directions, and 4. all central places performing the same functions and serving areas of the same size, the most economical spacing of such service centers would be equidistant, resulting in hexagonal patterns or "lattices." One of the first archeologists to apply this model to an ancient civilization was Gregory Johnson (25), from whom much of this discussion is taken.

The equidistant, hexagonal spacing of service centers is an important clue which tells the archeologist when the "service functions" of a set of sites—whether economic, administrative, or ceremonial—have begun to strongly override such factors influencing settlement choice as good soil, water, sheltered locale, defense, and so on. Even on the geographer's ideally "unbounded level plain"—a nearly unattainable archeological phenomenon—

natural resources are not likely to be evenly distributed. Hence, the settlements of simpler societies are likely to be highly correlated with such resources, and not necessarily regularly spaced. With the evolution of complex societies, "service functions" become increasingly important, and villages which are appropriately located to become "nodes" in the integrated lattice may grow into towns, while their neighbors languish at the village level. Because many important archeological regions are in hilly or rugged country, or linear river valleys, such techniques are hard to apply; and most archeologists applying central place models have deliberately picked the levelest areas they could find.

An example of a hexagonal or rhomboidal site lattice in the Mesopotamian region is provided by Johnson's reworking of Adams' Diyala River survey (Adams 2, Johnson 25). Figure 4 shows the lattice east of the Early Dynastic city of Eshnunna, with sites of three size classes mapped. The sites forming the Eshnuuna "cell" show high correlation (+.98) with an ideal lattice (Johnson, op. cit.) in spite of deviations due to the alignments of major water courses in the area. Johnson's network can perhaps be contrasted with the region of Uruk in southern Mesopotamia where Adams (4) feels that central place models are "hardly germane to the hyper-developed urbanism of the late Early Dynastic period" when that city was surrounded only by "a very large number of small towns and villages, unimodally distributed in size rather than forming a differentiated, tiered hierarchy . . . centered on Uruk."

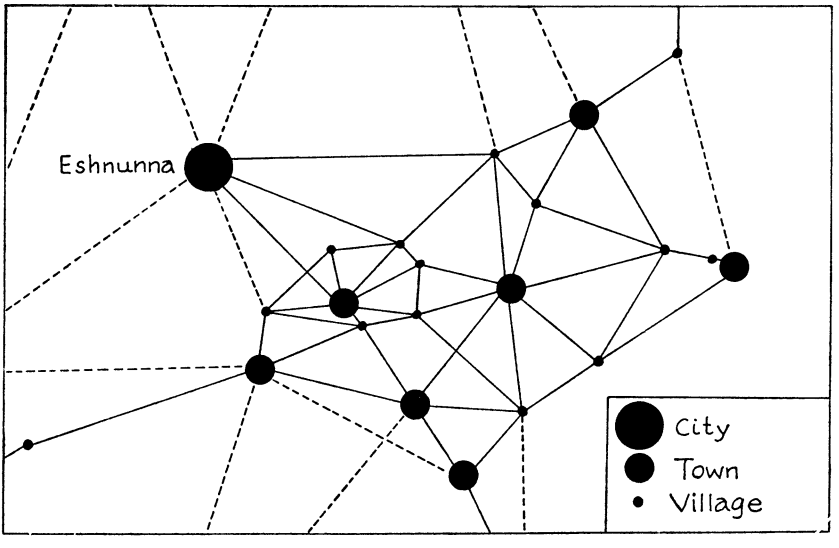

FIGURE 4. A portion of the settlement lattice east of the Early Dynastic Sumerian city of Eshnunna in the Diyala River Basin of Iraq. After Johnson (25), with modifications.

In Mesoamerica as well, some areas seem appropriate to central place models while others do not. Teotihuacán, Mexico's first great city (300–600 A.D.), was so much larger than all contemporary nearby settlements that it fits the anomalous Uruk pattern better than the Diyala lattice (Millon 35, Parsons 37). Not only was Teotihuacán on the northeastern margin of the Valley of Mexico, but any "secondary centers" which may have been its contemporaries do not form hexagonal lattices on any significant level. Such urban "megalopoli" were evidently characteristic of some early states.

Though archeologists have typically applauded settlement patterns which show "a high degree of integration," ironically they may in some cases be praising another of Rappaport's pathologies—hyperintegration or "hypercoherence." This highly centralized but sometimes unstable condition results from the breakdown or whatever autonomy the various small subsystems (or institutions) in a larger system may have; one by one, they are coupled more closely to each other and/or to the central hierarchical control until, like an old-fashioned string of Christmas tree lights set in linear sequence, change in one does in fact affect all the others too directly and rapidly (Figure 3*d*). In Rappaport's words, "it may . . . be suggested that too great a degree of coherence can be as lethal as too little" (Rappaport 39, p. 20).

One of the most common ways in which hypercoherence can occur is through "meddling" (see above), but there are other ways. Marriage alliances between the ruling families of formerly hostile states, for example, may so strengthen communication and influence between them as to destroy the natural buffering which may have insulated one from the upheavals in another. Such marriage alliances took place with frequency between Sumerian city states (Adams 3), between Mixtec and Zapotec *caciques* in southern Mexico (Spores 53), and between Classic Maya centers (Marcus 31). In another Mesopotamian case, Sargon of Akkad sent his daughter to be high priestess of the goddess Nanna at Ur. Such nepotism certainly increased linearization of the coupling between the main political (Akkad) and religious (Ur) capitals of southern Mesopotamia (Woolley 59). The critical archeological question is, how much integration is "hyper"?

In this regard, it is perhaps significant that the nearest approach to hexagonal spacing in the settlement patterns of Mesoamerica's lowland Maya civilization occurred in the Late Classic period (600–900 A.D.), shortly before their now-famous "collapse." To demonstrate this, I have used the surveys of Bullard (8) in the nuclear Petén region, and of Ruppert & Denison (42) on the northern periphery of the Petén (see Figure 5). Only "major ceremonial center ruins" (Bullard) or "sites with stelae" (Ruppert and Denison) were considered. It will be observed from Figures 5*a* and 5*b* that the hexagons around sites like Naranjo or Calakmul are even more striking than those in the Diyala region, and the lattices are amazingly uniform in view of all the hills, ridges, and wooded swamps (*bajos*) which intervene and distort them. Indeed, if one calculates the distances between "nearest neighbors" among Bullard's major ceremonial centers, one finds the following:

TABLE 1. Distances to first, second, and third nearest neighbor among major ceremonial centers in the Northern Petén of Guatemala[a,b]

	First nearest neighbor	Second nearest neighbor	Third nearest neighbor
Mean distance	10.33 km	13.33 km	16.08 km
Variance	3.867 km	4.567 km	3.942 km
Standard deviation	1.966 km	2.137 km	1.985 km

[a] Mapped by Bullard (8, Figure 1).

[b] Variance and standard deviation calculated on Constat Program, Computer Service, Univ. Michigan.

Further statistical testing shows that although the difference in means between first, second, and third nearest neighbors is significant (at the 0.0004 level), the difference in variance is not, and the standard deviation from each mean is very low—showing a highly structured situation. This hexagonal lattice, presumably created by the "service center" role of the major sites, is not in itself pathological, but in the Late Classic the centers of each hexagon were linked by marriage alliances and the peripheral centers by military alliances (Marcus 31), creating a still higher degree of integration, which may have been "hypercoherent" in our terms. Whatever the cause, the suggested integration is so great that perturbations in one center might have affected other centers strongly, a likely "precondition" for the much-debated Maya collapse (Sabloff 43). Parenthetically, one might also conclude from the fact that major sites are almost twice as densely packed (15.8 km. apart) in Bullard's central area when compared with Ruppert and Denison's northern periphery (27.8 km. apart) that Carneiro's "social circumscription" may have been operating. Social circumscription may thus be a powerful stress situation, but in this case it was followed by "devolution" rather than evolution.

Toward a generative model for the state.—The ultimate goal of a systems analysis might well be the establishment of a series of rules by which the origins of some complex system could be simulated. Obviously, we are a long way from being able to do this in the case of the state. We do have two evolutionary mechanisms ("promotion" and "linearization"), three pathologies ("meddling," "usurpation," and "hypercoherence"), and two processes ("segregation" and "centralization") which are probably universal. We have half a dozen socio-environmental conditions (population growth, social circumscription, warfare, irrigation, trade, symbiosis), probably none of which is universal, but all of which can select for either evolutionary mechanisms or pathologies and thereby speed the two processes. Let us, therefore, conclude by tentatively putting forth fifteen rules out of the scores with which we might one day be able to simulate the rise of the state.

The process begins in a simple human population with a small set of

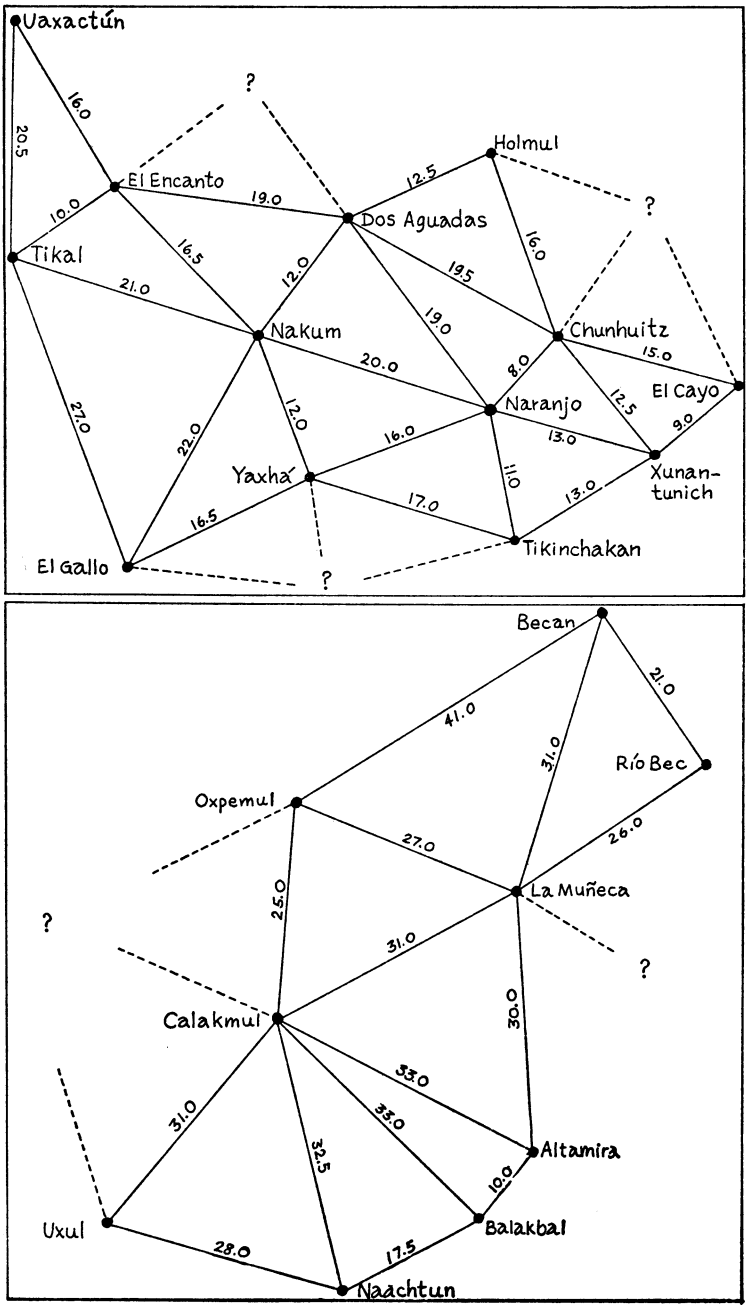

FIGURE 5. Settlement lattices formed by late Classic lowland Maya ceremonial centers. *Top*, sites given in Figure 1 of Bullard (8). *Bottom*, sites given in Figure 1 of Ruppert & Denison (42). Distances in kilometers (rounded off to nearest half kilometer) are calculated from the original maps.

rules, few institutions, and a small number of subsystems (e.g., a band or egalitarian tribe) forming part of a regional ecosystem. Controls for the lower-order subsystems (e.g. agriculture) are specific and relatively inflexible. Higher-order controls (e.g. "government") are more general and flexible, but set reference values for the output of lower-order systems.

1. Should lower-order controls fail to maintain certain variables within specified goal ranges, higher-order controls are activated. Repeated activation may lead to "linearization," or "evolution" through centralization.
2. Linearization weakens the buffers between subsystems, and consequently leads to simplification or lack of subsystem autonomy.
3. Maintaining such simplification requires more management.
4. More management requires more formal institutions.
5. Formal institutions (*a*) may engage in more linearization, thus making rules 2-3-4-5 a "positive feedback" loop, or (*b*) if heavily supported, may be "promoted" to a position in a higher-order system. This may result in the appearance of a new institution, or further "evolution" through segregation.
6. Evolving living systems generate new information autonomously through the interaction of their parts (Maruyama 32).
7. New institutions arise to process this information faster, in larger quantities, or both.
8. Any institution must grow out of some component of a previously existing institution (often by promotion).
9. A new institution will appear only after some critical threshold in need for information-processing is reached; thus, evolution appears steplike (cf. Adams 3, p. 170).
10. New institutions are initially more efficient, but are also more expensive to support; their "overhead" may provide additional stress.
11. The evolutionary trend of institutions is from system-serving (special-purpose) to self-serving (general-purpose).
12. The stress put on systems to support self-serving institutions may require the establishment of yet another special-purpose institution to cope with the stress.
13. When segregation and centralization reach a certain threshold, the state can be said to exist.
14. Enough centralization, promotion, and linearization may move the state toward hypercoherence and instability.
15. Finally, hypercoherence can lead to collapse and devolution.

Obviously, these few simple rules are only a tiny first step toward understanding the cultural evolution of civilizations. Such multivariant models, though many find their complexity repellent, can have certain beneficial effects. First of all, they force the investigator to be specific about the linkages between variables, thus distinguishing between socio-environmental selection pressures (which are local) and mechanisms and processes (which

are universal). Second, they emphasize the importance of information and ritual in the regulation of environmental and economic variables in human society. They may thus provide the meeting ground for both humanist and ecologist. For Coe and Dyson, in the quotations which open this paper, are partly right and partly wrong. They are right when they say that ideas, institutions, social organization, and cultural content have been grossly ignored by ecologists interested in the rise of civilization. What is wrong is their implication that those topics fall somewhere outside the province of the ecologist. Particularly for ecologists interested in the state, they are even more important than the ways such complex societies produced their food.

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