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BUREAUCRACY, SYSTEMS MANAGEMENT, AND THE MYTHOLOGY OF SCIENCE

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Richard B. Norgaard*

Bureaucracy is perhaps the most universal, successful, and abhorred aspect of modernization. Many scholars have documented bureaucracy's meteoric rise[1/]. Many have tried to explain its pernicious particulars[2/]. Only a few have pursued the paradox of our repugnance for an evolutionary success[3/]. This essay explores the paradox. The argument intermingles with various branches of the existing literature on organization theory but is itself rooted in the epistemological clash between our belief in objective knowledge and our long-standing use of cultural knowledge. I argue that both bureaucracy's success and our abhorrence are rooted in the incongruities between our beliefs about science and the cultural context in which most social decisions are made.

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1. See: Henry Jacoby (The Bureaucratization of the World, trans by Eveline Kanes, Berkeley, University of California, 1973) or Richard Bendix ('Bureaucracy' International Encyclopedia of the Social Sciences, V2, David L. Sills <ed> New York, Macmillan, 1968).

2. Charles T. Goodsell presents an excellent summary of the literature on the problems and dissatisfaction with bureaucracy in the first chapter of The Case for Bureaucracy (Chatham, New Jersey, Chatham House, 1983.)

3. See: Goodsell, op. cit. and Herbert Kaufman, Fear of Bureaucracy: A Raging Pandemic (Public Administration Review, 41:1-9 <Jan-Feb, 1981).

A COEVOLUTIONARY FRAMEWORK.

Bureaucracy did not simply appear, it coevolved with other phenomena over generations: with world views, values, technology, and ecosystems (Figure 1). These phenomena have affected and been affected by each other through interactions over generations. These interactions have been specific to each country. Yet at another level there were coevolutionary phenomenon experienced by all countries during modernization, a process characterized by the adoption of and adaptation to Western science, values, and technology. This essay emphasizes these common experiences.

Coevolutionary frameworks such as that depicted in Figure 1 have been used by anthropologists to describe how social organization, belief systems,

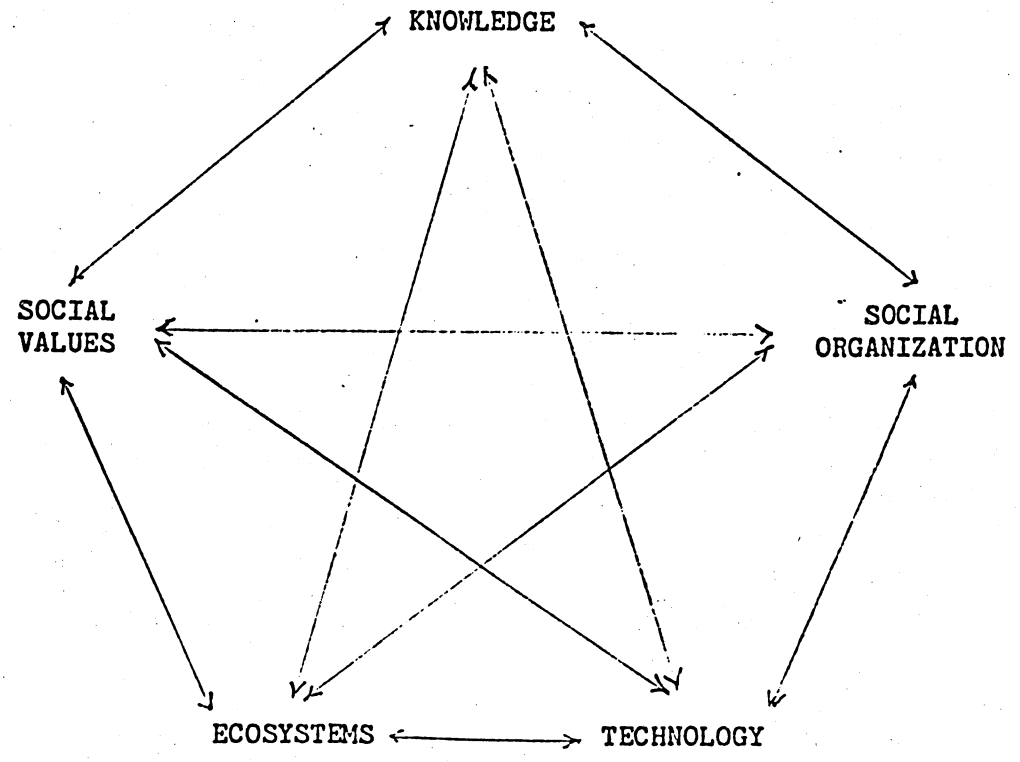

Figure 1. The coevolutionary framework.

and ecosystems coevolved in pre-industrial cultures[4]. Relatively few scholars, however, have looked at modernization in so broad an evolutionary framework[5]. Some of the interactions, nevertheless, have become common knowledge. The literature on the history of Western science and technology documents how science leads to technology and how technology produces instruments to further science. The environmental literature documents how technologies which have been designed to affect specific characteristics of ecosystems often have side effects which require the development of additional technologies.

Important links have already been made between world view and social order. Modern political philosophy, with its conception of society as a sum of individuals rather than a hierarchical order, coevolved with the atomistic view of Western science. Hobbes and Locke sought political theories of society as pure and rational as the reasoning of Galileo and Newton. They envisioned political interaction as a balancing of and

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4. Julian H. Steward initiated this approach under the name of 'cultural ecology' in the early 1950s; see his: (Theory of Culture Change, Chapter 2, Urbana, Univ. of Illinois Press, 1955, and The Concept and Method of Cultural Ecology, International Encyclopedia of the Social Sciences, David L. Sills <ed> vol 4 pp 337-44, New York, Macmillan, 1968). For recent reviews of this literature and its various reinterpretations as ecological anthropology, see: Emilio F. Moran (Human Adaptability: An Introduction to Ecological Anthropology, North Scituate, Mass. Duxbury Press, 1979), as human ecology, see: A. Terry Rambo (Conceptual Approaches to Human Ecology, Research Report No. 14, Honolulu, East-West Environment and Policy Institute) and as coevolution, see: William H. Durham (Toward a Coevolutionary Theory of Human Biology and Culture, The Sociobiology Debate: Readings on Ethical and Scientific Issues, Arthur L. Caplan (ed), New York, Harper and Row, 1978).

5. Karl Marx and marxists since deserve considerable credit for having explored the historical interactions of all of these phenomena except ecosystems. But Marx and many marxists have postulated a deterministic progression in economic systems, taking science and modernization as 'given'. Historical determinism clashes with the evolutionary approach of this essay.

response to forces. Likewise, the concept of the interplay of numerous independent producers and consumers balancing supply and demand in the market developed from atomistic and mechanistic thinking. Economists admired Newton's mechanics and sought equivalent mathematical formulations of market systems. The linear programming models by which socialist countries try to "scientifically" coordinate and optimize production are similarly mechanical. The arrow between our scientific world view and the political and economic philosophies which validate democracy and market exchange, as well as socialism, are well recognized[6/].

Scholars have begun to trace other interactions depicted in Figure 1. The interactive loop between social order and technology is now recognized. Our agricultural institutions are organized to devise and facilitate the adoption of new technologies while at the same time their organization is constantly evolving in response to the unfortunate social and ecological consequences of the new technologies[7/]. Political scientists are describing how technology both facilitates some types of social organization and demands particular organizational features for its management and control[8/].

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6. See: Mark Blaug (The Methodology of Economics: or How Economists Explain, Cambridge, Cambridge University Press, 1980).

7. See: V. W. Ruttan (Induced Institutional Change, in Hans P. Binswanger and V. W. Ruttan with Uri Ben-Zion et. al. Induced Innovation: Technology, Institutions, and Development, Baltimore, Johns Hopkins, Univ. Press, 1977) and Richard B. Norgaard (Coevolutionary Agricultural Development, Economic Development and Cultural Change, vol 32, no 3 (April, 1984) pp 525-46).

8. Todd La Porte has guided and affected my thinking on technology and social organization (La Porte <ed> Organized Social Complexity, Princeton University Press, 1975, and La Porte, Technology as Social Organization, Studies in Public Policy Working Paper 84-1, Institute of Governmental Studies, University of California, Berkeley, 1984). Jacques Ellul's The Technological Society (New York, Knopf, 1964) is the classic on the social implications of accepting technology. Langdon Winner presents a more recent synthesis (Autonomous Technology: Technics Out of Control as a (cont.)

At least two scholars have begun to explore the full interplay before and after the Newtonian revolution[9]. These initial analyses of pre and post Newtonian world views pursue questions heretofore unasked about the coevolution of values, social relations, technology, and the use of land.

It is within this controversial, broadly based, coevolutionary framework and the respective literatures it identifies that I make and ask you to consider my argument on the relations between our beliefs in science, the actual nature of science, and the paradox of bureaucracy.

BACKGROUND.

Bureaucracy is characterized by a constituency that delegates restricted authority for the purpose of achieving specific objectives; a hierarchy of officials, organized by specialty, who devise regulations and undertake activities to achieve objectives; and people and organizations that are affected by the regulations and activities of the bureaucracy[10].

(8,cont). Theme in Political Thought, Cambridge, MIT Press, 1977). Richard Sclove is making the case for democratically choosing technology, see: Decision-making in a Democracy, The Bulletin of the Atomic Scientists, May 1982 p44-50. Eugene B. Skolnikoff addresses this interaction internationally (The International Imperatives of Technology: Technological Development and the International Political System, Research Series No 16, Institute of International Studies, University of California, Berkeley, 1972).

9. Morris Berman (The Reenchantment of the World, Ithaca New York, Cornell University Press, 1981; republished by Bantam Books, New York, 1984) and Carolyn Merchant (The Death of Nature: Women, Ecology, and the Scientific Revolution, New York, Harper and Row, 1983).

10. M. Albrow (Bureaucracy, London, Pall Mall, 1974) distinguished seven general uses of the term 'bureaucracy' sufficiently different to lead him to argue that the term should be retired from rigorous analyses. My characterization and development of the term is consistent with Max Weber ('Bureaucracy', Essays in Sociology, H. H. Gerth and C. Wright Mills <eds> Oxford, Oxford University Press, 1946; reprinted in On Charisma in (continued)

Liberally interpreted, this definition spans all forms of social organization short of several pure extremes: social orders based solely on independent families or small groups, solely on a dictator, solely on democratic decision-making, solely on market forces, or solely on a combination of these.

Bureaucracy exists because our understanding of reality and of the choices we can make do not validate these extreme social orders. Societies made up of independent families or small groups might be workable if we did not perceive gains from specialization and large scale production. Pure democracy might be workable if we did not perceive that it required a fully informed electorate. A pure market economy might prove workable if we really did perceive property as perfectly divisible. Bureaucracy is a workable compromise given our perceptions of reality: given our understanding of the advantages of specialization and large scale production, the need for perfect information for rational decision making, and the nature of property. This reality we know and must act on, however, is conditioned by how we think we know. And for this reason, this essay is epistemological.

Bureaucracy began as a projection of the authority of priests and nobles and, later, of independent capitalist-entrepreneurs. Bureaucracy in its classical form was simply a hierarchy of disinterested professional clerks and accountants acting under a consistent set of rules on behalf of

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(10, cont). Institution Building, S. N. Eisenstadt <ed> Chicago, University of Chicago Press, 1968, and The Theory of Social and Economic Organization, Talcott Parsons <ed> New York, Oxford University Press, 1947 pp 329-45), Reinhard Bendix (op. cit.), Bengt Abrahamsson (Bureaucracy or Participation, Beverly Hills, Sage 1977), and with the key features of bureaucracy empirically documented by R. H. Hall (The Concept of Bureaucracy: An Empirical Assessment, American Journal of Sociology, LXIX <1963-4>:32-40).

authority. Objectives -- typically as simple as the collection of taxes, the census of population, and enumeration of commercial activity -- were limited and well defined. Judgment might have been necessary to classify a case, but once classified, appropriate action followed from the rules.

While classical bureaucracies still exist, a new form has evolved[11]. Today, authority is dispersed and the state is intertwined in the management of complex systems. Legislative bodies and boards of directors replace kings and capitalist-entrepreneurs. Bureaucracies now promote industrialization and eliminate poverty in economic systems; reduce pollution in environmental systems; manage timber, minerals, recreation, and water supply on public lands; and, in the private sector, run multinational corporations engaged in research, extraction, production, and marketing of diverse goods, The objectives of bureaucracies are now far more complex. Simple, consistent sets of rules can no longer be formulated. Indeed, the constituents no longer understand what the bureaucracy is to do or how it does it and looks to it for guidance. Bureaucrats must have technical expertise to manage systems. And along with all of these changes -- indeed probably facilitated thereby -- the formal models of scientific thinking and our associated system of beliefs have become the linkage between dispersed authority, complex mandates, technical expertise, specific bureaucratic actions, and justification to the public.

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11. The social service bureaucracies still reflect their heritage. Entitlements to payments for disability compensation, health care, pensions, and welfare are determined through a taxonomic process after which after which transfers are made by established rules. Jerry L. Mashaw describes procedural rationality in the Social Security Administration (Bureaucratic Justice, New Haven, Yale University Press, 1983).

Agencies, however, did not simply go from classical to systems management bureaucracy. For many institutions there was a period during which the professional judgments of manager-experts were accepted. In the United States, District Rangers with forestry expertise, District Engineers with flood control and water reclamation expertise, Atomic Energy Commissioners with nuclear engineering training, and corporate managers with technical expertise had considerable autonomous authority. But as the problems confronting bureaucracies became more complex -- as demonstrated by unforeseen accidents and side effects -- the objectives of political and corporate bureaucracies were broadened.

Managing increased complexity required more expertise. And this, in turn, required an understanding of how specialized knowledge could be linked to produce answers, how experts could be coordinated, and how criteria for performance could be established. Western science does not provide this understanding, but our beliefs about Western science include this ability. Thus there has been a coevolution of the complexity of problems, a transition from a reliance on clerical rule following to professional judgment to coordinated scientific expertise, and a decreasing satisfaction with the whole combination because of the contradictions between our beliefs about and the actual nature of objective knowledge.

THE ARGUMENT

Our belief in the objectivity, universality, separability, and tractability of scientific knowledge justifies the targeting of specific objectives, the delegation of authority, the design of institutional structure, and the enforcement of responsibility in bureaucracies that manage complex systems. The validation has increased as our beliefs have strengthened with

the apparent success of science. Furthermore, we are caught in a vicious circle. The stronger the structural bond between bureaucracy and our beliefs in scientific knowledge, the more prone we are to attribute bureaucratic failure to insufficient attention to science.

Bureaucracies, of course, succeed or fail for many reasons. But the appropriateness of expectations, mandates, structures, and behavior either encompasses or directly affects all reasons. Appropriateness depends on the congruence between our understanding of reality and reality itself. And our understanding, at least that which forms the consensus when decisions are made openly and collectively, is rooted in positivist Western epistemology.

The most successful sciences advanced through atomism and mechanism, through the assumption that system components can be studied separately and that they relate mechanically[12/]. When questions are framed appropriately, atomistic-mechanistic models of systems yield answers which serve as predictions or prescriptions. Often they are made tractable by assuming their complexity away. But models that reflect the true complexity of systems are rarely tractable. When they are tractable, they are likely to yield multiple solutions. Yet the management of complex systems, at least within today's bureaucracies, presumes the applicability of knowledge based on tractable models for predictions and prescriptions.

Systems are characterized by more than components with complex connections. The components and their connections evolve over time. Individuals constantly experience the consequences of evolving, complex connectedness,

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12. Ilya Prigogine documents the atomistic-mechanistic nature of western science (Order Out of Chaos: Man's New Dialogue with Nature, New York, Bantam, 1984). See also: Carolyn Merchant, op. cit.

acquiring experiential knowledge in the process. Bureaucracies also confront complex connectedness and evolution. And, like individuals, bureaucracies learn through doing. Unlike individuals, however, the bureaucracies are bound to mandates which changes more slowly than the environment in which they must operate and the objectives they seek. Furthermore, complex connectedness, evolution, and experience cannot be formally acknowledged within bureaucracies for our epistemological beliefs about how we think we know, on which bureaucracies' mandates are based, are limited to objective knowledge of tractable systems.

The contradictions between our beliefs about knowledge, the actual nature of our knowledge, and reality, lead to ill-planned system interventions that are interpreted as bureaucratic failures. The same beliefs lead us to establish more complex bureaucratic mandates and insist on more scientific rationality within bureaucracies. Tighter mandates and increased insistence on scientific rationality make it even more difficult for bureaucracies to acknowledge the complexity of systems, the existence of evolutionary change, and the value of experiential knowledge. Hence the more tightly structured bureaucracy is even more prone to fail. We are spiraling inward to a confrontation with our beliefs about science.

ELABORATION

Systems management bureaucracy is the only secular form of social decision-making based on a collective acceptance of what constitutes knowledge and rationality. Authoritarian rule stems from the enforcement power of the authority. Democracy depends on the acceptance of the will of the majority. Market allocation is accepted on the premise that exchange is mutually beneficial. Each of these forms of social decision-making may

entail individual rationality and may be collectively rational. The acceptance and use of these decision-making structures, however, are not dependent on collective beliefs about knowledge and rationality.

First, our belief in objectivity is especially important in casting Western science in this supporting role. Western science justifies its "rightness" in part through the concept of objectivity. Early Western scientists set out to know nature as God had created it. Our philosophers envisioned the process as an individual mind questioning the nature of nature. In this sense, we juxtaposed people and the natural world right from the beginning. The mind has been seen as an independent entity that perceives and interprets. It simply exists. Descartes' "Cogito ergo sum", symbolizes the emphasis that the dominant world view has placed on the mind per se. Knowledge is independent of the observer if numerous other people reach the same conclusions based on the same observations. The rightness of Western knowledge then is presumed to stand apart from people themselves. The nature of this apartness and its implications has plagued Western philosophy with various unresolved questions known as the "mind-body" problem[13/]..

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13. The Encyclopedia of Philosophy (Paul Edwards (ed) New York, Macmillan and Free Press, 1967 v5 p336) starts out with: "The mind-body problem, in the first instance, concerns the question whether a valid distinction can be made between the mind and the body. If such a distinction can be made, then we can ask whether in fact any things exist to which we can apply either term, or both terms. Finally, if there are things to which both terms can be applied, we can, for those cases, ask what the relation is between the mind and the body." This is followed by a ten page description. There are also 80 citations in the index to this problem in the description of the works of various philosophers and of other philosophical issues. For this reason, I have decided to refrain from saying anything myself about the mind-body problem.

Like the mind, the natural world just exists. Mind and nature are independent of each other. Asking questions, thinking, and acting change neither the underlying principles which govern the external world nor the mind itself. The world just is and the mind just perceives and interprets it. The dominant world view's emphasis on the objectivity of knowledge stems from this static juxtaposition of mind and nature.

The idea that knowledge can be objective is especially critical to the social sciences where the personal values and economic, political, and social beliefs of social scientists are so prone to intrude. If knowledge of society can be objective, then how things are and could be can be agreed upon and debate centers solely on how we want the world to be. Given the possibility for objective knowledge, determining how things are and could be can be left to experts in the bureaucracies while congressional bodies and the democratic process need only contend with values.

In theory, objectivity is rooted in repeated testing and verification, or not falsification, regardless of who does the testing. In fact, some experiments are not repeated for years even in the physical sciences. In the sciences dealing with complex evolving systems, controlled, repeatable experiments are never even possible. But belief in objectivity allows the methodology of Western science to be trusted by all.

These beliefs facilitate the communication necessary for systems management bureaucracies. The constituents must communicate between and agree among themselves on the nature of problems to be solved, the ways in which these problems can be sorted into separate mandates for individual agencies, and the type of power that must be transferred with each mandate for each agency to succeed. Communication and agreement on the current and

possible states of the world and the paths between them derive from common perceptions. The formal models of science and associated belief systems fill these needs.

Second, each agency must elaborate on its mandate, form a specific structure, hire appropriate experts, and decide on specific actions and regulations. Again, the formal models of science provide the criteria and facilitate communication and agreement at each of these stages.

Third, those who are affected by the actions and regulations of the agencies must accept them as legitimate. Indeed, the law in many countries protects people against arbitrary changes in their rights. Increasingly both people and the courts are judging the legitimacy of bureaucratic actions according to whether they have been developed in a defensible context, in a context consistent with the rationality associated with our beliefs in Western science.

With a commonly held framework of thought, constituents can agree on the nature of the existing and possible worlds, the nature of the mandate, and the powers that must be transferred to the bureaucracy. Officials in the bureaucracy can agree precisely on the nature of the mandate and what must be done. Bureaucrats can justify their actions and regulations to the people and organizations affected.

The belief that bureaucrats are simply objectively applying value-free scientific knowledge helps maintain the bureaucratic system. We believe objective knowledge is independent of the observer and conditions at the time of observation. People supposedly do not change as they seek their objectives. With this belief, the best path to the goals can be presumed to be knowable initially. In fact people acquire information and change

their goals in the process of trying to achieve their goals. If tastes and information, let alone patterns of thinking, were acknowledged to be endogenously determined, no bureaucratic mandate, structure, powers, or functions could be initially agreed upon by the constituents or 'responsibly' exercised by the bureaucracy. Needless to say, objectives and information do change, bureaucracies do adapt, and in this flux the values of individual bureaucrats frequently become enmeshed. But adaptation is typically slow and stilted. It is also reversed when accountability is imposed. The formal incorporation of changes in objectives and experiential learning into the decision-making process would require an evolutionary rationale and a redefinition of responsibility and accountability.

Western science attempts to derive relatively simple, universal truths about complex reality. Simplicity facilitates wide-spread understanding. Universality extends the applicability of knowledge across various cases and geographic areas. Our belief that knowledge can be simple and general justifies extending a bureaucracy across problems and areas. In short, these beliefs about knowledge justify centralization. Conversely, situational specific and complex knowledge is not easily handled by constituents, bureaucrats, or affected parties.

The historic success of atomism in the physical sciences supports the more general belief that problems can be separated out and worked on independently by different bureaucracies or different divisions within bureaucracies. Similarly, many formal models of social and natural systems adopted follow Newtonian mechanics in assuming that systems, whether social or natural, can be shifted in a mechanical manner to any of a continuous array of stable equilibria. Assuming systems have these fea-

tures makes prediction and prescription possible. Political compromise, moreover, is facilitated by the belief that continuous stable equilibria and reversibility hold real complex systems. Any mix is possible, and if the results prove less desirable than expected, all the earlier options remain open.

Western culture assumes scientific knowledge is objective, universal, separable, and tractable. These beliefs are essential both to how we design bureaucracies in the first place and to how we justify the decision process and outcomes. Our epistemological beliefs gird our social organization. The rise of Western science, our increasing belief therein, and systems management bureaucracy have coevolved.

Exposing the relationships between scientific knowledge, its associated belief system, and bureaucracy would be purely academic if there were no other effective types of knowledge. Personal experiential knowledge, group experiential knowledge, and the latter's culturally encoded extension or cultural knowledge are clear -- though much neglected -- alternatives. Unfortunately, bureaucracies structured under current beliefs are not able to effectively utilize these alternatives.

Over the past one and one-half million years people learned how to coax more from the environment, move into new regions, support an expanding population, and live more elaborate lives. Since we began to practice agriculture seven thousand years ago, our population has doubled ten times. Eight of these doublings occurred before the development and use of knowledge that meets current, positivist epistemological standards. The last two doublings, during the past century in which scientific knowledge has had a significant impact on development, occurred over merely one hundredth of

one percent of our total history[14]. The rate of doublings has increased dramatically, but our experience with objective knowledge is still insignificant.

Experiential knowledge works. Encoded in tradition, myth, and art, it passes from generation to generation and from group to group. Experiential knowledge is also disseminated and shared by word of mouth and, more recently, in written tracts. The development of the West was an evolutionary, experiential process. 'Scientific' planning, bureaucracies, and objective knowledge played minor roles until the nineteenth century. 'Learning by doing' is an important, well-recognized process -- so obvious as to seem trivial. The obvious, however, is not integrated in either our formal understanding or epistemological beliefs.

There is also a clear dichotomy in our explanations of social progress. Theories tend to be rational or evolutionary. Rationalists postulate that people deliberately design and implement new technologies and social orders to advance their welfare through more effective interactions with their environment. Evolutionists emphasize how more effective interactions arise through random change and natural selection. Objective knowledge is key to rational theories while evolutionary theories incorporate the cultural encoding of experiential knowledge.

Rational models assume social values and specific objectives are exogenously determined. Bureaucracy developed through the rational application

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14. D. B. Grigg (The Agricultural Systems of the World: An Evolutionary Approach. Cambridge, Cambridge University Press, 1974). Norgaard (Coevolutionary Agricultural Development, Economic Development and Cultural Change, 32:3(April 1984):525-46).

of scientific knowledge to reach objectives. Technological advance both provides the opportunities for reaching new objectives and explains the necessity for more bureaucracy. Western science developed through analysis, looking at smaller and smaller pieces of the world while holding, or assuming, related phenomena constant. Social organization consists of linkages between an increasing number of people with increasingly specialized knowledge of parts. These linkages are both positive and corrective. Some bureaucracies, especially in the private sector, combine specialized knowledge to produce products and services. Other bureaucracies, largely in the public sector, monitor, regulate, and correct the social and environmental consequences of the secondary effects of specialized knowledge. Thus the nature of advances in science helps explain the process of bureaucratization[15/].

Evolutionary models postulate that the form of social organization evolves through random experimentation under changing environmental conditions. Fit forms survive. Fitness, however, is a function of the particular social and environmental conditions at the time. With each step in the evolutionary process, social conditions change and the ways in which society relates to its environment change. With each change, new conditions arise which determine the fitness of surviving innovations and set the stage for subsequent experimentation with social organization. Evolutionary explanations are case specific. The random nature of new innovations and selection under changing conditions limits the usefulness of evolutionary explanations for prediction or prescription.

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15. See La Porte (ed) and Skolnikoff, op.cit.

Evolutionary models and rational models of change are as different as serendipity and design. Despite the incongruities, individuals practice pluralism. Individuals are able to combine conflicting formal and experiential knowledge as befits the situation, able to switch between different formal models, to experiential knowledge, and back again. Informal social groups, those that are relatively unconstrained by a structure based on a particular formal model, can also learn from experience and combine this learning with formal knowledge. While much of the progress of the past one hundred years is rooted in scientific knowledge, the application of this knowledge has greatly benefited from experiential learning.

Bureaucracies, especially those which interact with or manage economic or environmental systems, are not as free as individuals or small groups to combine the insights of alternative formal models with experiential learning. The use of a particular formal model, or monism, is essential to their establishment, to the elaboration of their mandate, to internal communication, and to the justification of their functioning. The stronger the formal basis, the more difficult it is for a bureaucracy to be pluralistic or to 'learn by doing'. Yet pluralism and experiential learning are as critical to bureaucratic success as they are to the success of individuals and informal groups.

From here, the argument is straight forward. It is commonly argued, ex post, that bureaucratic failure results from insufficient attention to the design and implementation of the mandate. Scientists testify in Congress for improvements in the mandate and the stipulation of more scientific procedures. In court, the same experts testify to the scientific merits of bureaucratic decisions on behalf of plaintiffs or defendants. More attention must be paid to various details, more information should

be incorporated in analyses, the bureaucracy must be better structured to handle scientific intricacy, better experts must be employed, and further research is essential. Such prescriptions stem entirely from belief in the efficacy of scientific rationality. Partly because these prescriptions have been followed, bureaucratic failure and the resulting social and environmental problems have been accentuated and become more complex. And the greater the complexity of problems, the greater is the likelihood that monistic rational design will fail.

The U.S. Environmental Protection Agency was established in the early 1970s on the belief that complex questions had scientific answers. EPA Administrator William Ruckelshaus has provided a cogent summary of the difficulties this belief has caused in an address to the National Academy of Sciences[16]:

> But EPA's laws often assume, indeed demand, a certainty of protection greater than science can provide with the current state of knowledge. The laws do no more than reflect what the public believes and what it often hears from people with scientific credentials on the six o'clock news.
>
> One thing we surely need to do is ensure that our laws reflect these scientific realities. The administrator of EPA should not be forced to represent that a margin of safety exists for a specific substance at a specific level of exposure where none can be scientifically established.

By mandate the EPA 'scientifically' determines, and defends in hearings and in court, which toxic substances and industrial practices under which regulatory schemes have benefits greater than their costs. Neither natural science nor economics are up to the task.

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16. William D. Ruckelshaus, Science, Risk, and Public Policy, Science, vol 221 (September 9, 1983) quotes from pp 1026 and 1027. See also: Nicholas A. Ashford, C. William Ryan, and Charles C. Caldart, Law and Science Policy in Federal Regulation of Formaldehyde, Science, v222 (November 25, 1983) pp 894-900 and comments by Aaron Wildavsky and others v224 (May 11, 1984) pp 550-555.

The belief system associated with the formal basis of bureaucracy conflicts with the use of alternative scientific models and of the experiential learning essential for bureaucratic success. Pluralism baffles bureaucracies. The befuddlement is a product of the scientific beliefs on which bureaucracies are created, function, and are monitored. It is not simply due to the pernicious behavior of the bureaucrats in charge. The vicious circle of ever increasing failure corrected by ever more scientifically structured bureaucracies even more prone to fail can only be broken through new beliefs about the nature of knowledge and an appreciation of the messages inherent in contradiction.

SCIENCE: MYTH AND REALITY

Our beliefs about the nature of science are sufficiently consistent and strongly held to bureaucratize systems management. At the same time, we retain considerable common sense from our cultural past and personal experiences and judge, or at least become frustrated with, bureaucracy from this second basis. Thus both the rise and the paradox of bureaucracy are rooted in our beliefs about knowledge. But philosophers no longer accept the positivist epistemology associated with our beliefs in Western science. The cacophony of their arguments undermines our myths and the foundations for systems management bureaucracy.

Popper advanced the philosophy of knowledge with the argument that proof comes through the testing of the null hypothesis. This improvement on the dominant epistemology since Bacon is conventional wisdom among scientists and an important basis for social beliefs[17/]. Within the field

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17. (on next page)

of philosophy, however, agnosticism is well defended. Feyerabend has effectively argued that theories cannot be tested because data, measurement, and methods of testing are inextricably linked to the theories themselves[18]. Models pattern observation and thereby define data. Hence models cannot be independently tested against data. Whether data comes before theory or theory comes before data has been pondered before. Einstein, for example, wrote[19]:

> But on principle it is quite wrong to try founding a theory on observable magnitudes alone. In reality the very opposite happens. It is the theory which decides what we can observe.

Feyerabend twisted this "chicken or the egg" quandary into a critique of knowledge. Furthermore, he stressed that the method whereby science supposedly advances merely validates existing knowledge to the exclusion of novelty. For Feyerabend, understanding theories comes through comparison and no theory can or should be rejected. He acknowledges the value of other forms of knowledge and relates this to the weaknesses of science[20]:

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17. Karl Popper (The Logic of Scientific Discovery New York, Basic Books, 1959, originally published in German in 1934). His most recent full elaboration acknowledges that scientists rarely test the null hypothesis yet argues that sufficient testing in the laboratory and in practice occurs over time that accepted knowledge is objective (Objective Knowledge: An Evolutionary Approach (Oxford, Oxford University Press, 1972, revised 1979). The importance of public consensus to science is developed by John Ziman (Public Knowledge: The Social Dimension of Science, Cambridge, Cambridge University Press, 1968).

18. Paul R. Feyerabend (Against Method, London, New Left Books, 1974 and Science in a Free Society, London, New Left Books, 1978).

19. From a letter to Werner Heisenberg in 1927 (quoted in William Broad and Nicholas Wade, Betrayers of the Truth, New York, Simon and Schuster,1982, p. 138). Einstein elaborates on the relationship between theory and observation in Physics and Reality, Journal of the Franklin Institute, vol 221, no 3, March 1936, reprinted in Albert Einstein, Ideas and Opinions, New York, Crown Publishers, 1954.

20. Science in a Free Society, op cit, p. 89.

> How is it possible that the ignorant, or ill-informed can occasionally do better than those who know a subject inside out? One answer is connected with the very nature of knowledge. Every piece of knowledge contains valuable ingredients side by side with ideas that prevent the discovery of new things. Such ideas are not simply errors. They are necessary for research: progress in one direction cannot be achieved without blocking progress in another. But research in that 'other' direction may reveal that the 'progress' achieved so far is but a chimera.

The idea of objectivity also runs afoul of "the chicken or the egg" quandary. How the world is cannot be determined. Functional theories determine the nature of what is observed or seen to be; alternative functional theories exist; and one cannot be proven better than another. For the past century, the behavior of light has been explained by both wave and particle theories. When a wave hypothesis is tested, wave theory is confirmed. When a particle hypothesis is tested, particle theory is confirmed. Later another phenomena devastating to our mainstream epistemology developed. The Heisenberg uncertainty principle states that the greater the certainty with which the position of a subatomic particle is known, the less is the certainty of its momentum and vice versa. In both of these cases, the question asked determines the possible answers. In physics it is well established that observations are not independent of the observer and the questions asked[21].

Thus by the turn of the century, theoretical physicists began to abandon their earlier positivist epistemology with its notions of objectivity. Popper's falsification test, based supposedly on how the most pure of sciences operated, maintained and reinforced positivism. For a variety of reasons, the scientific community chose to believe that their methods led to

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21. Fritjof Capra, The Tao of Physics, Boulder, Colorado, Shambala, 1975, and Ilya Prigogine, op. cit. footnote 12.

objective knowledge. The social science community, not to be less scientific, officially adopted positivism with a vengeance[22]. Yet social scientists had always sensed that choosing one model over another entailed a preference for that models categories of phenomena, relationships, and conclusions.

Schrodinger, a physicist turned philosopher, presented the flip side of the argument in 1952 by noting that culture's influence on method was both positive and necessary[23].

> ... there is a tendency to forget that all science is bound up with human culture in general, and that scientific findings, even those which at the moment appear the most advanced and esoteric and difficult to grasp, are meaningless outside their cultural context. A theoretical science unaware that those of its constructs considered relevant and momentous are destined eventually to be framed in concepts and words that have a grip on the educated and community and become part and parcel of the general world picture - a theoretical science, I say, where this is forgotten, and where the initiated continue musing to each other in terms that are, at best, understood by a small group of close fellow travellers, will necessarily be cut off from the rest of cultural mankind; in the long run it is bound to atrophy and ossify however virulently esoteric chat may continue within its joyfully isolated groups of experts.

Though not well received at the time when positivist epistemology was the only acceptable one, Schrodinger's position reflects current thinking by philosophers of science. But the loss of objectivity with the introduction of relativism is not simply due to our inability to separate science from

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22. Mark Blaug documents and defends positivist epistemology in economics and chides his colleagues for not following the methods they espouse (The Methodology of Economics: Or How Economists Explain, Cambridge, Cambridge University Press, 1980. Donald N. McCloskey provides a delightful expose and defense of how economists really operate (The Rhetoric of Econonics, Madison, University of Wisconsin Press, 1985).

23. Erwin Schrodinger, Are There Quantum Jumps, The British Journal for the Philosophy of Science, VIII, 1952, pp 109-110.

culture. Our reasoning processes themselves are limited. We can start from a variety of points but never know the whole. Feyerabend, once again, summarizes the situation most directly with his reference to how "progress in one direction cannot be achieved without blocking progress in another".

Feyerabend argues against limiting the options of individuals through social decisions rationalized by narrowly perceived science. His attack on positivist epistemology is the most radical, but numerous other philosophers have questioned where hypotheses arise in the first place, have argued that scientists rarely test null hypotheses, and have pondered whether science progresses or what progress even means[24].

While philosophers are casting doubt on how we think we know, scientists themselves are questioning our ability to know whole systems. Commonly held epistemological beliefs seem to be rooted in the concept that the whole is the sum of the parts. Certainly when we have trouble knowing the whole we often attribute this to our ignorance of the parts and call for further analysis. By pursuing many narrow courses we believe we will ultimately know the whole. But three decades ago Warren Weaver argued that science

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24. Michael Polanyi emphasizes the role of direct observation and personal knowledge in the development of hypotheses and interpretation (Personal Knowledge, Chicago, University of Chicago Press, 1958). Others have cast doubt on our beliefs in scientific knowledge by noting how the socially regulated processes of science dramatically differ from Popper's model of science and the impact of these on the development of knowledge (Thomas S. Kuhn, The Structure of Scientific Revolutions, Chicago, University of Chicago Press, 1962; Imre Lakatos, Falsification and the Methodology of Scientific Research Programmes, in Criticism and the Growth of Knowledge, Imre Lakatos and Alan Musgrave (eds), Cambridge, Cambridge University Press, 1970; Larry Laudan, Progress and Its Problems: Toward a Theory of Scientific Growth, Berkeley, University of California Press, 1977; Stephen Toulmin, Human Understanding: The Collective Use and Evolution of Concepts, Princeton, Princeton University Press, 1972; and John Ziman, op. cit.) William Broad and Nicholas Wade, op cit, document fraud and deceit within science and present summaries for the layman of the epistemological debate.

deals successfully with a few variables, with many variables related mechanistically, and with many variables behaving randomly, but that science is not set up to work effectively in the middle ground of organized complexity. He also noted that our understanding of methodology and proof is inadequate for this territory[25/]. Bateson, Bertalanffy, Weiner and others have stressed that in organic systems modeling it is a distortion to hold one thing constant and observe the relationships between specific parts[26/]. In reality, everything changes together. In particular, the independence of variables on which statistical methods of testing rely is not a property of complex systems. Validation comes through comparing repeated runs of the model with observed behavior, yet one is never confident of predictions of behavior not yet observed.

Complex systems are difficult enough to understand when their components and relations are constant. The most interesting systems, however, evolve new components and relations over time. The accuracy of predictions has been the ultimate test of scientific knowledge. But evolving systems keep changing in unpredictable ways. Random innovations occur, some are naturally more fit, and with the selection of new components in the system, the criteria of fitness themselves change. Evolutionary models describe historical processes and account for present

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25). Warren Weaver, Science and Complexity, American Scientist, 36, 4(October 1948): 536-44. Weaver seems to be the first to have used the term "organized complexity".

26.) Gregory Bateson, Mind and Nature,(New York. E. P. Dutton, 1979); Ludwig von Bertalanffy, General Systems Theory (New York, Braziller, 1968, rev. ed.), Norbert Weiner, Cybernetics (Cambridge, MIT Press 2nd ed. 1961, especially page 25), Albert Wilson, Systems Epistemology (in The World System: Models, Norms, and Applications, Ervin Lazlo <ed> New York, Braziller, 1973)

phenomena but are frustratingly useless for predictions or specific prescriptions[27].

While our beliefs in objective knowledge are in decline, advances are being made in our understanding of subjective knowledge. Psychologists are pursuing how individuals learn functional patterns and make decisions long before they receive the 'imprint' of objective knowledge[28]. Anthropologists and others are developing ever more satisfying models of how knowledge is encoded in and applied through cultural systems[29]. Our expanding understanding is beginning to gird, in the archaic sense of to mock or sneer at, the myths which gird, in a conventional sense, our bureaucratic structure.

Now let me simply argue that our dissatisfaction with bureaucracy stems from the conflicts between the still dominant publicly expressed beliefs in the nature of Western knowledge, our understanding as individuals of experiential knowledge, and our growing social awareness complemented by scientific documentation of the process by which individuals learn and the role of cultural knowledge. We design bureaucracies around our dominant public beliefs about science, these beliefs conflict with the actual nature of science and ignore other bases of knowing critical to decision-making, and our bureaucrats get caught in the middle in institutions which are inappro-

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27. Michael Scriven, Explanation and Prediction in Evolutionary Theory (Science, vol 130 <August, 28, 1959> no 3374 pp 477-82).

28. Robert J. Sternberg, Human Intelligence: The Model Is the Message, Science, V230 No 4730 (December 6, 1985) p.1111-1118; and Bateson, op.cit.

29. H. Ronald Pulliam and Christopher Dunford, Programmed to Learn: An Essay on the Evolution of Culture, New York, Columbia University Press, 1980, Charles J. Lumsden and Edward O. Wilson, Genes, Mind, and Culture: The Coevolutionary Process, Cambridge, Mass. Harvard University Press, 1981, and William H. Durham, Toward a Coevolutionary Theory of Human Biology and Culture, The Sociobiology Debate: Readings on the Ethical and Scientific Issues, Arthur L. Caplan (ed), New York, Harper and Row, 1978.

priately structured trying to make decisions which are indefensible. The contradiction between the success of and our dissatisfaction with bureaucracy is due to the contradictions in our understanding of knowledge.

It is not clear at this time whether 1) the conflict will continue because we retain our current mix of beliefs, 2) the conflict will continue but with a switch in our mix of beliefs toward experiential and cultural of knowledge at the expense of Western science, 3) the conflict will resolve through the development of a new epistemology which is consistent with respect to both types of knowledge, or 4) the conflict will resolve through pluralism, through the equal acceptance of various epistemologies. The third case would be ideal, but the fourth is probably the best we can hope for. The argument is pursued in the next section in the context of resolution through pluralism.

IMPLICATIONS OF THE ARGUMENT

The hypothesis that our epistemological beliefs structure bureaucracy has branching arguments as far reaching and threatening as the tentacles of Jules Verne's giant squid. The following seem the most important.

SCIENTISM. There is an expanding literature on how scientific arguments are inappropriately being used to persuade the public, delude Congress, or justify decisions already reached or action already completed[30]. Beliefs in the nature of scientific knowledge are exploited to

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30. Nancy Cochran, Grandma Moses and the Corruption of Data, Evaluation Quarterly, v2, 1978, pp. 363-373; Ida Hoos, Systems Analysis and Public Policy, Berkeley, University of California Press, 1983; Brian Wynne, Rationality and Ritual: The Windscale Inquiry and Nuclear Decisions in Britain, Bucks, England, British Society for the History of Science, 1982; (cont).

limit the scope of inquiry, the range of evidence, and the forms of knowledge used in social analyses. These misuses of process are typically explained either as naivete or as abuses of power. In the latter case the bureaucrats are either committed to an answer or committed to an interest group and play on the public's scientific mythology to defend their actions. But if bureaucracies are structured around our beliefs in the objectivity, universality, separability, and tractability of scientific knowledge, we should expect bureaucracies to function on these myths as well. If they do not behave in accordance with these myths, they contradict the basis of their mandate and the rationale for their organization. Scientistic behavior stems from the scientistic beliefs of those who structured the bureaucracy in the first place.

DECENTRALIZATION. Development plans for the Third World rarely meets our expectations. One explanation of failure is that centralized planning by multinational agencies and national governments prevents tailoring projects to meet local conditions and needs. This sparked considerable interest in the possibility that decentralization is the key to development. The literature provides an excellent taxonomy of the advantages and disadvantages of large and small bureaucracies[31]. This literature, however, fails to address the reasons behind the continual replacement of smaller by larger scale institutions over the past century.

(30, cont) Mary Douglas and Aaron Wildavsky, Risk and Culture, Berkeley, University of California Press, 1982; Bill Keepin, Brian Wynne, and Michael Thompson provide intriguing analyses of the development and use of the world energy model at the International Institute of Applied Systems Analysis in Policy Sciences, v17, 1984, pp.199-329.

31. Dennis A. Rondinelli, John R. Nellis, and G. Shabbir Cheema, Decentralization in Developing Countries (Washington, D.C. World Bank Staff Working Paper #581, 1984), David K. Leonard and Dale Rogers Marshall (eds), Institutions of Rural Development for the Poor: Decentralization and (cont.)

Western knowledge is held to be universally true. Particular knowledge or knowledge that is only applicable to a specific culture, situation, time, and place is disdained. It is inefficient to clutter our minds with particularisms when we could be learning universal truths. Indeed, one of the goals of science is to provide general explanations for numerous particular phenomena[32/]. The success of this approach in the physical sciences over several centuries has encouraged belief in the possibility of universal models of complex, evolving systems.

Now, think of bureaucracy as a hierarchy of wastebaskets. At each level of the bureaucracy, observations and formal data must be synthesized into information and passed on to the next higher level. Inevitably, some observations and data do not fit the universal model to become information for the next level up. To the extent bureaucrats believe in the universality of knowledge, they quietly toss these into the wastebasket. But to the extent they believe in particular knowledge, they clog bureaucratic communication channels with 'indigestible' data and observations.

Belief in universal truth also facilitates the flow from the top of the bureaucratic pyramid down to the field. Mandates must be translated into

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(31, cont) Organizational Linkages, Berkeley, Institute of International Studies, University of California, 1982; Lenore Ralston, James Anderson, and Elizabeth Colson (eds), Voluntary Efforts in Decentralized Management: Opportunities and Constraints in Rural Development, Berkeley, Institute of International Studies, University of California, 1983; Robert Chambers, Managing Rural Development: Ideas and Experience from East Africa, Uppsala, The Scandinavian Institute of African Studies, 1974. Donald Michael presents one of the few metaphysical analyses of alternative forms of governance (Neither Hierarchy nor Anarchy: Notes on Norms for Governance in a Systemic World, in Rethinking Liberalism, xxxx <ed> New York, Avon Books, 1983.

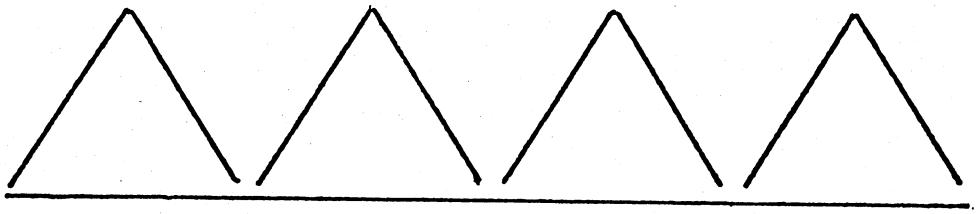
32. This goal is stated explicitly for particular development knowledge by Bruce F. Johnston and William C. Clark, Redesigning Rural Development: A Strategic Perspective, Baltimore, Johns Hopkins University Press, 1982.

action in the field. Because models are thought to be universal, they are applied everywhere. Though each case and area may differ, the model contains variables thought to reflect the difference and appropriate actions for different conditions still derives from the model by tuning the variables. To the extent that bureaucrats believe in universal models, they blithely generate mandates for those beneath them. To the extent they believe in particular knowledge, they struggle with divisional mandates and find themselves unable to justify applying the mandate of one division to the administration of other divisions. And their power soon loses legitimacy.

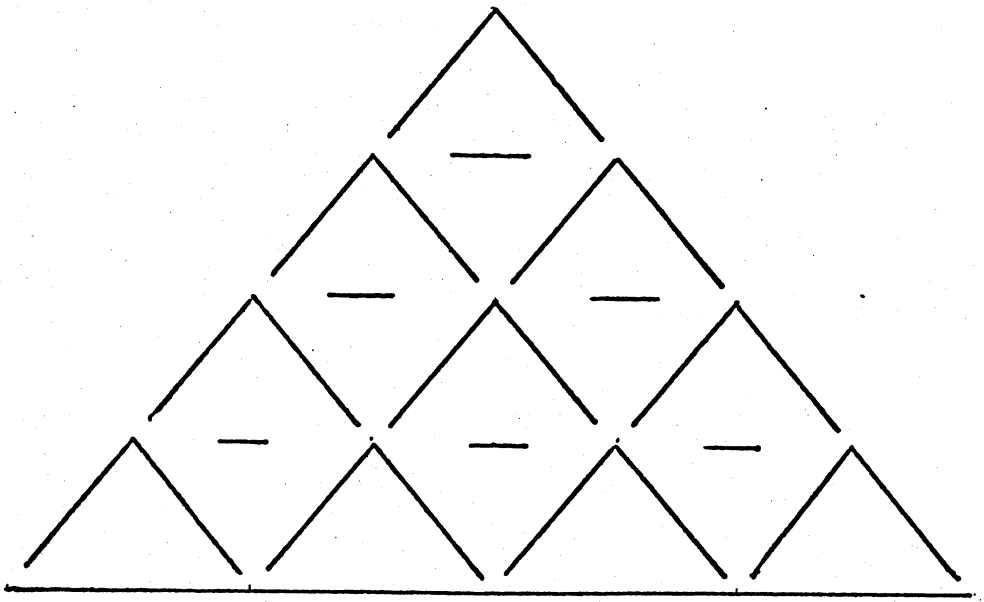
An agency with clogged channels or administrators without authority cannot act, let alone grow. To the extent that constituents believe in universal truth, the agency will be judged a failure. Faith in the universal nature of Western knowledge has led to centralization and fuller waste baskets. Those agencies which unclogged their channels and empowered their administrators appeared to become more effective while those agencies that did not do so had their roles reduced by their constituents.

The relationship between centralization, decentralization, universals, and particulars can be illustrated. The base of the diagram in Case 1 of Figure 2 might represent a collection of geographical areas, cultural groups, or problems. The bases of the little triangles represent specific areas, groups, or problems. Now, let's contemplate the situation of many cultural groups with each depending on their own knowledge and bureaucracy. As long as they retain their own particular models, data only translates into information within their culture, knowledge cannot be shared, and decisions cannot be reached at a higher level. But as various cultural groups adopt the Western faith in universals or have this faith imposed upon them by their national government, they can be administered by a central

agency. This process, of course, has been accelerated by tempting promises from international and regional banks and aid organizations. As faith becomes more complete, tempting, or mandatory, all cultural groups can be administered by the central agency and communications flow up and down the hierarchy of the overall triangle illustrated in Case 2.



Case 1



Case 2

Figure 2. A model is used to synthesize data transmitted up and to derive mandates sent down the bureaucratic hierarchy. With a universal model, the hierarchy can encompass the full triangle of Case 2.

Consider another example. The Consultative Group on International Agricultural Research establishes priorities for the various International Agricultural Research Centers. The Group and the Centers seem to envision themselves as an overall triangle, receiving information from and making decisions for all ecosystems and cultures. During the past decade they have been extensively criticized for assuming that farmers in all areas desire crops with certain characteristics[33]. While they have made a noble effort to respond to the needs of farmers in specific ecosystems and to some extent specific cultures, their strong faith in Western science, the very basis of their existence, justifies the centralized structure that prevents them from effectively hearing and responding to particulars.

PLURALISM AND STRUCTURE. There is no basis for arguing that international agricultural research, or any other social order, should be characterized by the small triangles at the base of Figure 2 rather than one large one. Western science has certainly produced results in the case of agriculture. But the results are not widely accessible through a centralized research and extension structure. A decentralized structure may be able to translate modern technologies to local needs. Second, the centralized structure cannot foresee the secondary consequences of modern technologies that might be foreseen through decentralized agencies. And so I am arguing for both centralized and decentralized structures.

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33. Keith Griffin, The Political Economy of Agrarian Change: An Essay on the Green Revolution, London, Macmillan, 1974; Paul Richards, Indigenous Agricultural Revolution: Ecology and Food Production in West Africa, Boulder, Colorado, Westview; Richard B. Norgaard, Traditional Agricultural Knowledge: Past Performance, Future Prospects, and Institutional Implications, American Journal of Agricultural Economics, December 1984.

Centralized structures are justified by objective knowledge while decentralized structures are justified by the nature of complex, evolving systems and cultural knowledge. Neither type of knowledge is right or wrong. Both have strengths and weaknesses, successes and failures. But for both types of knowledge and structures to coexist and overlap without one dominating the other, we need a pluralistic epistemology. Feyerabend's critique of objective knowledge is a start[34]. But Feyerabend is characterized as an anarchist, and for good reason in light of the argument of this essay. The relatively recent tendency to interpret the 'rightness' of objective knowledge in an evolutionary and cultural context can be interpreted as giving the knowledge of other cultures some of the same 'rightness'[35]. And yet we seem a long way from accepting all forms of knowing equally.

METHODOLOGICAL PLURALISM AND PLANNING AS MULTIPLE SIFTING. Methodological pluralism is being considered in the planning literature. The profession which mistakenly accepted the challenge to rationally look into the future, determine the best general courses of action, and optimally design policies to coordinate the activities of shorter-sighted bureaucracies, is now humbly reforming around the theme of planning as social learning[36]. 'Blue print planning' and optimization has been rejected

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34. op. cit.

35. Karl R. Popper, Objective Knowledge: op. cit. and Donald Campbell, Evolutionary Epistemology, in Paul Arthur Schilpp, The Philosophy of Karl Popper, LaSalle, Illinois, Open Court, 1974.

36. Edgar S. Dunn, Economic and Social Development, A Process of Social Learning, Baltimore, Johns Hopkins University Press, 1971; Donald Michael, On Learning to Plan and Planning to Learn, San Francisco, Jossey-Bass, 1973. John Friedman, Retracking America, Revised Edition, Emanaus, Pa, Rodale Press, 1981; David C. Korten, Community Organization and Rural Development: A Learning Process Approach, Public Administration Review, September-October 1980, p 480-510.

through recognition that complexity and evolution cannot be handled by Western science. Alternative methodologies and forms of knowledge are now being accepted. Brunner defends a pluralistic methodology[37]. John Friedman has paid the most attention to the methodological issues of social learning[38]. He presents epistemological arguments for building the planning process around small study groups in which personal knowledge can be shared, synthesized, opposed to objective knowledge, and resolved in a dialectical process. Kant's understanding of practical knowledge is developed by Churchman and Ulrich who see planning as a process of critique[39]. These same arguments extend beyond planning to management and the design of bureaucratic structures.

CONCLUSIONS

We are currently questioning the fitness of the myths surrounding Western science. We are also questioning the appropriateness of our social organization both with respect to the political and equity implications of technocracy and with respect to detrimental interactions with environmental systems. This essay argues that there is a structural linkage between these two lines of questioning. The argument has been rational in nature, hence predictions logically follow. And yet, I hesitate. The argument suggests that to the extent the linkage is increasingly realized, the two lines of

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33. Ronald D. Brunner, The Policy Sciences as Science, Policy Sciences, V15 p115-135, 1982.

34. John Friedman, op. cit. and The Epistemology of Social Practice: A Critique of Objective Knowledge, Theory and Society, V6 p75-92, July 1978.

35. C. West Churchman, The Systems Approach and Its Enemies, New York, Basic Books, 1979, and Werner Ulrich, Critical Heuristics of Social Planning: A New Approach to Practical Philosophy, Bern and Stuttgart, Paul Haupt, 1983.

questioning will synergistically reinforce one another. The current social malaise and susceptibility to itinerant old dogmas will go on, but not forever. The tentative, grasping for a new laissez faire, a new state capitalism, a new welfare state, a new populism, and a new federalism will continue until something truly new -- a new epistemological mythology -- evolves, proves fit through outcompeting the old, and reinforces new directions in both science and social organization.