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Foundations of the Prescriptive Sciences

Volume I

by Nicholas M. Smith
Milton C. Marney

DRAFT

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13. ABSTRACT

This report, Volumes 1 and 2, is an attempt to formulate adequate conceptual methodological foundations for prescriptive science. Prescriptive science is a mode of rational analysis capable of encompassing valuative as well as factual aspects of optimal decision. The principal problems encountered are essentially metascientific in scope. Major issues are characterised by a degree of generality beyond the immediate concern of any specific scientific discipline.

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INTRODUCTORY NOTE

This research program constitutes an attempt to formulate adequate conceptual-methodological foundations for prescriptive science. By "prescriptive science" we refer to a mode of rational analysis that would be capable of encompassing valuative as well as factual aspects of optimal decision. The principal problems encountered are essentially metascientific in scope. Major issues are characterized by a level of generality beyond the immediate concern of any specific scientific discipline. This is due to the fact that the research objective represents a significant extension of the very aims and methods that direct the conduct of inquiry. In such an enterprise existing regimens of formal and experimental science must certainly be incorporated; but the broader mission of prescriptive science immediately demands metatheoretic innovations that may seem, at first, to pose rather disconcerting departures from the conventional format of objective scientific inquiry.

For this reason we have gone to unusual length in preparing the Preface to Foundations of the Prescriptive Sciences, attempting full disclosures of our aim and strategy, methods and resources. In the course of recent briefings and conferences, an outline of that Preface has provided very helpful orientation for overall review of the research. At the suggestion of the ONR Project Officer, the full text of the Preface is presented here for its service as a research snyopsis.

Nicholas M. Smith

NICHOLAS M. SMITH
Head, Advanced Research Department

Will this world, with its variety, its un-
understood numbers, ever really yield to an
ordered description? We [must be] prepared
for a new and at first almost unrecognizable
kind of explanation. Always in the past
there has been an explanation of immense
sweep and simplicity, and in it vast detail
has been comprehended. Do we have faith
that this is inevitably true of man and nature?
Do we even have confidence that we shall have
the wit to discover it? For some odd reason,
the answer to both questions is yes.
—J. R. Oppenheimer (1956)

PREFACE

The venerable effort of men to extend the scope of reason is the theme celebrated (above) by Oppenheimer [1] in his vision of a continuing advance toward comprehensive physical description and explanation. Because vital human objectives cannot always wait upon advance by regular approaches, the same theme appears here in a more expansive version even before we have seen its fulfillment in the physical sciences.

Several divisions of contemporary behavioral inquiry—the life sciences, the social sciences, the communication-control sciences (cybernetics), and the management sciences—presently tend toward a convergence presaged by the conception of an overarching domain of adaptive systems and the completely general relevance of adaptive control processes. Every attempted breakthrough to a new order of rational comprehension in this sector, however, seems to grind to a halt, confronted by obstructions—primarily methodological in character—at a level of generality beyond the immediate concern of any scientific discipline and hence metascientific in scope. Problems of such generality, occurring only with the frequency of historical eras, have invariably marked critical junctures in the development of the basic aims and methods of scientific inquiry. They apparently represent, quite literally, the initial costs of any concerted movement toward more comprehensive explanation and control. Their rise to contemporary prominence is a sure sign that the historic thrust of rational inquiry is still persistent, still audacious; but the difficulties now encountered are not less troublesome for that assurance.

THE CENTRAL PROBLEM

How is it conceivable that a supremely valuable intellectual motivation—the drive to extend the scope of rational comprehension—should have a welter of methodological problems as its present issue? Briefly, the account runs like this: The methods of analytic and experimental scientific inquiry, first joined in their modern combination by Galilean physics, provided the means to momentous successes in describing-explaining-predicting phenomena of the "geosphere," the domain of inorganic systems. Persistent early attempts to extend the use of this successful mode of investigation in the behavioral sciences, however, foundered on what we might now reasonably term the problem of behavioral inquiry, namely, the modifiability of characteristic response (literally, the adaptivity) of organismic systems typical of the "biosphere" and "sociosphere." In contrast with the unexceptional behavior of classical mechanical systems, organisms under experimental perturbation yielded not only distributions of alternative sequences of behavior, but transformations of these distributions, as in the fixation or extinction of habits under conditioning. The naive expectation that adequate descriptions and predictive theories for behavioral science could be couched in terms of primitive (undefined) concepts developed in deterministic physical theories finally had to be abandoned.

Driven by the demand for comprehension, and usually quite insensitive to methodological consequences, behavioral scientists have since made notable modifications in the basic conceptual format that historically supported the physical sciences. Our understanding of organizational complexes in general could apparently not be advanced without the introduction of concepts that lay outside the scope of the analytic-objective mode of inquiry: structural concepts like organism, individual, institution, social class, nation, society, ecology, culture; functional concepts like life, growth, adaptation, mutation, selection, evolution; and modal concepts like motivation, aversion, need, norm, utility, expected value, subjective probability, preferability, optimality. In broad perspective the principal innovation consists in the injection of *normative* (valuative) aspects of organizational structure and function that have had to be attributed to the total systems that are of ultimate interest in biology, psychology, sociology, economics, and anthropology. Notorious methodological difficulties have attended all subsequent attempts to attain major predictive theories exploiting this new conceptual format. The familiar goals of rigorous description and experimental testing of explanatory hypotheses remain to be served in the behavioral sciences, where values can no longer be discounted, no less than in the physical sciences where eradication of valuative considerations proved historically to be the key to uninterrupted advance.

The difficulties of predictive behavioral science, however, pale by comparison with methodological problems confronting the rudimentary management sciences, or as they are often termed, the "decision sciences." In this tenuous interdisciplinary sector, effort is directed toward bringing the resources and methods of rational inquiry to bear in support of new professional advisory practices that entail the proferring of recommended decisions (i.e., "prescriptions" in the widest sense) purposefully *affecting* the actions—and inadvertently if not knowingly—the strategies, policies, missions and goals of a client-organization. The low estate of methods for predicting-explaining behavior is everywhere admitted and deplored. Yet, in the face of this obstruction, the attainment of warrantable methods for the prescriptive practices of management science poses an even more demanding objective involving the rational control of behavior (in the sense of deliberative decision). This is the apex of ambition to which contemporary men have been brought by the ardent drive toward comprehensive rationality.

It would be entirely bootless to withdraw our commitment, since human decision making must proceed with or without the resources of rational methods. But, in fact, the intention is not so radical as to call for retreat to a more "realistic" ambition. In any statement of the principal objectives of modern inquiry, it is now quite traditional to cite the goals of (1) description-characterization, (2) prediction-explanation and, significantly, (3) prescription-control. Every instance of technological advance provides evidence of the expansion of our rational capability to manipulate physical processes in the service of human ends. It is only a thoroughgoing version of the rational intent, one that explicitly admits of attempting to encompass cognit processes as well as physical processes, that raises the spectre of the verboten. Despite the historic successes of the analytic (formal) and objective (predictive) modes of rational inquiry, there is still a question as to legitimacy of a normative mode of inquiry that could hope to provide an adequate intellectual basis for rational control of practical decisions in general. As we move from the more precise professional practices (e.g., medicine and engineering) toward the demands of administrative decision in complex organizations (government, business, education, military), the status of professional practice admittedly becomes that of an intuitive, artful exercise of creative intelligence. An exercise greatly enlightened by scientific and technological advances, but as unspecifiable in procedural detail and as inexplicit in ultimate justification now as heretofore. Adequate theoretical foundations for systematic control of practical judgment, i.e., general theories of decision and valuation, have yet to be devised; and sufficient metatheoretic directives for the construction of such theories have yet to be advanced.

Inasmuch as earlier scientific methods have been developed specifically to provide a predictive-explanatory capability, they can be shown to be incapable in principle of providing a version of rational control that would constitute a prescriptive capability.

The central problem of investigations reported in this volume may therefore be identified with the pervasive need for a more general rational paradigm—a fundamental schema for the construction of theories admitting of significant interpretation in terms of both predictive and prescriptive aspects of decision, valuation, organization and cognition. This work addresses the task of providing a coherent conceptual-methodological framework for the several allied developments in management science, cybernetics, systems research, and associated sectors of the behavioral sciences that now seem to entail the rise of a legitimate normative version of inquiry.

In this enterprise the more familiar regimens of formal and objective science must necessarily be embedded, but the innovations required will constitute such a significant departure from the traditional format of scientific inquiry that the term "prescriptive science," as applied to this emerging normative orientation, is misleading for any interpreter who may restrict science to the partial objectives and typical accomplishments of previous inquiry. It is of little consequence whether we permit the term "science" to cover the widest range of inquiry imaginable--as imputed by the complete list of traditional objectives—or whether we opt for the use of distinctive terms (say, praxiology or axiology) in special reference to normative inquiry. The significant matter, of course, is the intensification of effort toward the formulation of a more comprehensive version of rationality that would be relevant to the wider range of concerns that we invariably encounter in any attempt (1) to characterize the behavior of adaptive systems, (2) to improve our intellectual control of prescriptive process in decision making, or (3) to understand the creative aspects of cognitive processes in conceptualization and theory-construction.

RESPONSE TO THE PROBLEM—A SUMMARY VIEW

We shall do well to make the personal equation a matter of record from the beginning. Problems that are everyone's responsibility are no one's tasks, until they are appropriated by particular men bearing the stamp of individuality on every aspect of their interest, experience, and enterprise.

In this book the authors presume to mount their own attack on a major problem of inquiry that, by earlier admission, presupposes a coalescence of scientific disciplines still only dimly surmised. They do so from the viewpoint of professional practitioners of management science who, for more than a decade, have been immediately concerned with the conduct of a research program designed to establish fundamental directives for more systematic and warrantable execution of the scientific advisory role of their profession. Significant extension of presently limited technical capabilities in systems analysis, evaluation and design has been the ultimate objective, but it has long been apparent that this practical goal will become feasible only on the strength of success in problems that are logically superordinate. Over time our research program has come to be characterized by an escalade of successively more abstract projects, beginning with eminently practical concerns and terminating only with the patently metatheoretical task of extending the present limits of rational methods. In the endeavor to secure for management science the broader capabilities of a prescriptive science, we are inevitably forced into the region of metascientific (or philosophical) issues. This effect is due to the fact that obstructions to methodological advance themselves form an escalade in which the problems at each level are but consequences of the next higher-order problem. Thus, in ascending order of generality, we have encountered:

(1) intractability of critical decision problems,

(2) inapplicability of existing OR/SA techniques of analysis,

(3) inadequacy of reductionistic decision models,

(4) incoherence of objective v. normative theories of decision and valuation,

(5) insufficiency of traditional rational prototypes,

(6) incommensurability of primitive criteria and incompatibility of primitive commitments.

The "domino-effect" here is unmistakable: each obstruction will yield only to higher order innovations and the modification of rational primitives will therefore produce a cascading result. The potent line of attack is from the general to the specific, from the metatheoretical task to the practical. It is by way of a philosophical reconstruction, and its improved control of the theorizing process, that more coherent theories, more adequate decision models, more relevant techniques of systems analysis/design, and ultimately the resolution of more complex practical decision problems may hopefully be sought.

If the projected philosophical reconstruction is to prove generally persuasive and helpful, it certainly must accommodate an assimilation of the research areas comprising behavioral inquiry in general. The propriety of generating such a project from the perspective of the particular interests of management science might therefore appear to be immediately questionable. In anticipating such an objection, we would maintain that management science necessarily confronts the acute problems of all its companion sciences with respect to the analysis of adaptive behavioral systems and, in addition, certain particularly difficult problems that are unique to its own special province. An attempt to establish a fundamental rationale for applied management science forces us to turn again to the most comprehensive of the domains of traditional inquiry—value theory. Even the most rudimentary analysis will show that this is the appropriate response, since it is all too clear (1) that the central concern of management is decision making and (2) that values constitute the basic determinants of decisions in general. The requirements of rationality in management science therefore generate a demand for a normative-prescriptive mode of inquiry that can properly be conceived as encompassing the total concerns of behavioral inquiry. The central ambition of prescriptive science is the conceptualization of rational principles instituting cognitive control over the processes of valuative judgment in a manner that is comparable, or at least consonant, with the control of factual judgment that we now possess by recourse to objective scientific methods. It is our hope that a delineation of the special role of the prescriptive sciences in the general effort to achieve a coherent theoretic format covering decision, valuation, and organization will contribute ultimately to a successful resolution of the <u>ad hoc</u> separations between knowledge, value, and action that have plagued all earlier attempts to comprehend or control complex behavioral systems.

To encompass, within a unitary rational scheme, the interrelated provinces of acting, valuing, and knowing that have been rigidly compartmented in the interest of early scientific advance: this is the nature of the objective. The ultimate demand of reason for warrantable decisions in all of human affairs sets the visionary goal. This goal is, of course, one of the ancient idealizations of humankind, and one toward which little enough progress has been discernable in the arduous course of civilized development. Among the major enterprises of human intelligence, the attempt to provide a rational basis for valuative judgment has perennially proved to be the most refractory. Fortunately, a contemporary renewal of metatheoretic value-inquiry finds at hand a potent complex of resources that have only recently become available to the scientific and philosophical community. Indeed, one of the principal means of advance in the forthcoming work will depend upon coherent assembly of results from several lines of specialized investigation. But the general problematic situation, now as heretofore, is still best characterized by paraphrase of Wittgenstein's [2] distinctive type-problem for philosophy: One does not know his [intellectual] way about.

Foundations, Logical v. Philosophical

Among seasoned investigators it is almost a matter of scientific doctrine to interpret any concentration of interest on foundations as the beginning of the end. Foundational inquiry is generally construed as the penultimate stage of development in a given discipline because it is motivated essentially by an aesthetic desire for intellectual elegance. Certainly it is feasible to emphasize the criterion of logical elegance only after fruitful conceptions and significant problem solving capabilities have matured in the more exciting growth phases of a new inquiry. For the situation that confronts us in this present work, however, nothing could be more inappropriate than the expectation that foundations of the prescriptive sciences are to be attained by mere refinement of existing, intuitively acceptable theoretical constructions. Here we have to deal not with the logical niceties of initial statements for an already reasonably codified discipline but, rather, with the initiation of a novel mode of inquiry that could hope to provide (1) concepts that are relevant and adequate, (2) methods of inference that are systematic and warrantable, (3) cognitive models that are operationally interpretable and practicable over a more comprehensive domain of experience than any that science has previously essayed. Clearly, the aesthetic orientation of foundational inquiry is still in force; but the quest is for conceptual and methodological rudiments appropriate to philosophical foundations, the primitive components of a new way of thinking. In this usage the familiar aesthetic demand for parsimony must be joined to a veritable battery of additional aesthetic criteria pertaining to the admissibility of any originative organization of ideas as an intellectual <u>modus operandi</u> appropriate to the unusual scope of our present purposes and problems. The full connotations of "cybernetic elegance," in the sense intimated above, will require explicit development in a forthcoming section of the text. It suffices here to serve pointed notice that foundations of the prescriptive sciences must be laid in territory heretofore relatively unexplored from the side of modern scientific temperament, C. W. Churchman's Prediction and Optimal Decision (1961) constituting a notable exception. Foundational issues associated with normative inquiry—though they may have been the ancient ground of moral philosophy—have generally received modern treatment as rudimentary appendages of proposed theories of value (Cf. John Dewey, Theory of Valuation, 1939).

In order to comprehend this seeming lack of drive toward adequate foundations, it is only necessary to consider the very great rarity with which obstructions to theoretical advance ever force the edge of research back to the metatheoretic level of generality. It is only after the intellectual potential of a given set of accepted primitive commitments has been literally exhausted in some historical course of inquiry that metatheoretic reconstruction can assume any plausible status as an objective. Not even the special difficulties encountered with the injection of value considerations in behavioral science would force us to metascientific inquiry were it not the case that similar normative issues have already been fought out to no effective conclusion in the humanities (ethics, aesthetics, and social philosophy) during long periods of investigation under every conceivable orientation permitted by the fundamental dualistic commitment that launched modern inquiry.

The area of foundational research perforce comprises an escalade of theoretical projects that terminates only with the task of reformulating primitive commitments as directives for theory-construction in general. It therefore encompasses a domain of such extreme reach that only very recently have we accrued either sufficiently cogent reasons or sufficiently promising means to warrant systematic rather than merely exploratory investigation. In view of the paucity of systematic research in the metatheoretic area, no survey will be undertaken here. It is very much to the point, however, to review the state of affairs in contemporary value theory that generates the need for foundational inquiry.

Dualistic Impasse

The basic problematic situation has been created by the long-continued existence of a fundamental incoherence between objective (factual) and normative (valuative) versions of rational thought. The dichotomy of factual v. valuative judgment and, consequently, the formal separation of scientific reasoning from axiological (appraisive) reasoning is almost as old as systematic inquiry itself. This early commitment to dualism has been massively reinforced by historic successes in the "value-free" scientific inquiry that it permitted. The original status of this dualistic commitment—it was, after all, a strategic policy for the control of systematic cognition—has therefore been effectively obliterated by the remarkable results that have vindicated the policy so far forth. Thus, the value-fact dichotomy has gradually assumed almost the status of a sacrosanct principle. It is now a thoroughly engrained, thematic feature of thought so pervasive as to be easily mistaken for a necessary condition of rationality. However prejudicial this overcommitment to dualism may be with regard to the possibility of creative modification at the foundations of inquiry, it is clearly the result of a powerful and generally fruitful tendency toward institutionalization.

In this light it is readily understandable that when difficulties began to be encountered with the sub rosa injection of value considerations in behavioral science, the general tenor of methodological research should have been solidly constrained by an almost unnoticed dualistic assumption, just as previous value inquiry in the humanities had long been constrained. The single characteristic that is common to the rather incredible number of diaparate value-decision theories extant, across both the divisions of scientific and philosophical investigation, is their general acquiescence in the adoption of dualism as a point of departure. From this origin two major lines of proliferation issue—scientific naturalism v. axiological idealism—each subsequently admitting of factorization into more specific categories. Thus, a reasonably comprehensive classification of contemporary value-decision theories would comprise a spectrum covering the following range:

(1) Radically reductionistic theories in which the very relevance of value inquiry is disallowed due to such conceptions as

  (a) lack of literal meaningfulness of value concepts,

  (b) voluntaristic, individualistic nature of values,

  (c) revelatory, transcendental, authoritarian sources of value.

(2) Linguistic-analytic theories (nonradical reductionism) in which the only legitimate content of traditional problems in value analysis is attributed to confused and ambiguous interpretation of value terminology.

(3) Formal theories of utility and decision in which observable relative preferences disclosed by an individual's acts of decision are treated as interpretations of an axiomatic system.

(4) Naturalistic theories in which value phenomena are construed as amenable to treatment in the predictive-experimental context of scientific inquiry.

(5) Intuitionistic (non-naturalistic) theories in which values are associated with a non-empirical yet objective domain of entities <u>sui generis</u>, accessible by introspection and susceptible to logical relation, yet unconditional (absolute) with respect to human desires, decisions, or actions.

On either side of the deep fissure produced by objective v. normative dualism, theoretical alternatives have been worked out quite exhaustively. The resulting deadlock among proposed theories admits of only one conclusion: that we are presently confronted with an impasse between basic perspectives of inquiry. A comprehensive rationale for valuation and decision would be required, first of all, to achieve a coherent synthesis of two disparate but equally legitimate theoretical enterprises: (1) objective-scientific inquiry regarding values as hypothetical constructs interpretable in the context of a decision system as an object, where the aim of inquiry is prediction-explanation of the observable behavior of an external somatic system; and (2) normative-axiological inquiry regarding values as norms to be instituted by some decision system as a subject (a "self" or an organization), where the aim of inquiry is a prescription determining a behavioral trend (a program, strategy, or policy) contributing toward the viability of that subject or self-system in a selective environment.

In the face of a complete schism between the concerns of science and axiology, there is no conceivable treatment of valuation and decision that could adequately satisfy our aesthetic, intellectual, and practical demands collectively. The limitations imposed by dualism therefore evoke one very secure conviction: that the appropriate recourse for contemporary inquiry is a concerted attempt to frame an alternative commitment that construes the objective and normative concerns of science and axiology as interdependent in principle.

Resolution: Approach and Rationale

It is reasonable to surmise that the more sophisticated inquirer has always intuitively reserved the notion that knowing, valuing, and acting must actually be inseparable in any sense other than as figments. Under sufficient scrutiny, the recourse to dualism might always have been vaguely recognized for what it is, a practicable way of disengaging a feasible region of productive inquiry from a total domain of problems in which normative considerations are generally so complex as to have defied the most strenuous attempts to formalize adequate procedures of investigation. The reductionism that is typical of the objective mode of scientific inquiry has admittedly been responsible for impressive accomplishments; but its employment appears to be obstructive to major advance in the behavioral sciences. To do justice to the complexity of adaptive systems now seems to be the order of business, and it appears that this cannot conceivably be done under the constraint of the reductionist strategy of previous scientific inquiry. We propose to address this requirement for complexity by the introduction of modifications at the metatheoretic level of primitive concepts and commitments.

Our approach may therefore be described as that of philosophical reconstruction. In view of our previous emphasis on the conditions for meaningful work in this area, the credibility of this program of research clearly must depend upon the citation of new sources of insight, new evidences for the present feasibility and timeliness of this project. The approach in philosophical construction is always to frame a scheme of ideas according to the most general intimations attainable and then to undertake the interpretation of experience systematically in terms of that scheme. In this regard, the following major sources of new insight have figured significantly as directives to philosophical reconstruction:

(1) general systems research resulting in the elucidation of desirable connotations for primitive entities, primitive processes, and primitive criteria of optimal organization;

(2) analysis of cognitive processes in the more general context of adaptive control, where relevant considerations have been taken from accounts of the anthropological development of semiosis, the cybernetic emphasis on homeostasis in several modes, certain aspects of research on decidability in formal systems, current approaches in the simulation of intelligence by automata, and not least important, introspective analysis;

(3) methodological study of historic prototypes of rational inquiry, in which the "evolutionary" development of successively dominant prototypes of inquiry provides distinct clues to a more adequate integration of formal, empirical, and axiological methods; and

(4) exploitation of existing mathematical schema that are interpretable in normative terms: abstract algebra of finite fields, first-order perturbation theory, theory of stochastic processes, contemporary mathematics of optimization and its parent discipline, the calculus of variations, as resources for formalization of the verbal-intuitive constructions that necessarily issue first from involvement with specific problems.

The rationale of this approach may be summarized in the following way: (1) that metatheoretic reconstruction can now proceed by recourse to a potent complex of new intimations that issue from assimilation of many separate lines of specialized investigation; (2) that these intimations, cast in the form of primitive concepts and commitments for a systems-philosophy, now entail metatheoretic innovations that have strategic import for the conduct of general inquiry, as well as the advancement of foundations for the prescriptive sciences. The principal innovations are:

(a) systems-theoretic schema: a conceptual format applicable to phenomena associated with organization and transformations of organization in general;

(b) canons of rationality: a systemic collection of formal, empirical, intuitive-aesthetic, and evolutionary criteria as controls affecting the admissibility of alternative cognitive models, i.e., formal, predictive, and prescriptive theories in general;

(c) unified methodology: operational integration of the supposedly disparate methodologies of formal science, experimental science, and axiology;

(d) unitary rational paradigm: a schematic rational format possessing the formal property of duality and admitting of alternative interpretations identifiable respectively as objective and normative prototypes of analysis that are mutually complementary; and

(e) normative mode of inquiry: formalization of detailed procedures for warranting prescriptive (as against predictive or formal) cognitive models and for applying the legitimate variant forms of analysis that ensue from alternative primal-dual rational modalities.

METHODS

The characteristic methods of philosophical inquiry are so generally familiar as to require little treatment. In this brief account we therefore restrict comment to just those procedural aspects that appear to have some claim to originality. The phrase "philosophy in the reflexive mode" provides the essential clue to what is novel about the approach. This key phrase bears the following connotations:

(1) deliberate effort to control the design of a philosophical position in order to assure that principal commitments are made in consonance with actual requirements of the cognitive agent *in situ* and *in actu*; preliminary characterizations of (a) the evolutionary milieu of cognitive-semiotic development and (b) the cognitive agent as a finite adaptive-control system are entailed;

(2) advanced recognition of the necessarily *provisional* character of any philosophical construction, coupled with the explicit realization that a self-correcting and self-amplifying process of iterative reconstruction must exhibit a coherent trend toward stability under confrontation by continuing tests for interpretability, warrantability, practicability, comprehensiveness, and elegance;

(3) insistence on "reflexive correspondence" as a categorical criterion of admissible philosophical construction, i.e., philosophical commitments must entail a cognitive theory capable of accommodating the very activity of philosophical construction that gives rise to the theory itself.

Such a program perhaps signals a resurgence of the methods of systematic philosophy; yet it differs markedly from the efforts of the classical systematists in acceding always to the demand for operational interpretability, testability, and practicability of proposed theoretical models. On a second count, it differs as well from the historic meta-scientific inquiries of practicing scientists in that its methods must reach toward the incorporation of value considerations that are even at this time widely regarded by objective scientists as "off limits" for rational inquiry.

Doubtless a less debatable feature of methods is the attempt to exploit interdisciplinary resources by way of interaction between formal and empirical concerns. The formalization of problems and principles is suggestively controlled by possibilities for assimilation of separate, specialized fields and the implications of generalized trial-constructions are examined for consonance with known experimental results. Iterative refinement of philosophical commitments occurs by construing these exchanges as sources of intimations for a more comprehensive conceptual schema. Specific examples of these effects are: (1) the extension of concepts central to evolutionary biology for a general taxonomy of adaptive systems, (2) the analysis of principal features of scientific advance that are discernable when "science" is construed, in an evolutionary context, as a proliferation of successively dominant prototypes of cognitive organization, (3) the use of generalized concepts of semiotic freedom and decidability for characterization of cybernetic features of organization and control in adaptive physical systems, and (4) the development of systemic-dual primitive entities, primitive processes, and primitive selection criteria.

PRECEDENTS

Attending these choices of aim and methods, a certain general tenor in our investigations will be immediately recognizable. Renewal of David Hume's radical philosophical orientation toward initial concern for the nature of the cognitive process, as well as continuation of similar tendencies of American pragmatism and behaviorism (after C. S. Peirce, John Dewey, and G. H. Mead), constitute one principal motif. Sympathetic though doubtless inadequate appreciation of A. N. Whitehead's philosophy of organism and philosophical extension of relativistic considerations initiated by Albert Einstein mark two others. Prior investigators in the areas of metatheoretic inquiry, history and philosophy of science, evolutionary biology and systems research, cognitive-semiotic studies, and mathematics would comprise an extensive list of predecessors whose motivations and results now make an assimilative effort conceivable. While explicit references will be indicated in the conventional way, it would be misleading to neglect more adequate acknowledgment of major influences of which we have been constantly aware.

Metatheoretic Inquiry

In his Reconstruction in Philosophy (rev. 1949), Dewey envisioned an iterative relationship between theory and practice that is a precursor of our objective. Our insistence on collective biological, psychological, and social aspects of rationality, as well as its evolutionary context, can certainly be viewed as an explicit interpretation of the "existential matrix" that Dewey emphasized in Logic: The Theory of Inquiry (1938), though it does not appear that our elaboration of cognitive controls as canons of rationality was anticipated.

A central theme of pragmatism—the renovation of the concept "truth" and the insistence on "testability" that Peirce initiated in his basic papers—has been incorporated and extended in a more general notion of the "admissibility of a cognitive model" under a holistic collection of formal, empirical, aesthetic-intuitive and evolutionary criteria. Peirce's major contribution to metatheory consists in his proposal of the categories of firstness, secondness, thirdness. Shorn of their radically abstract status, these categories appear in our version as the factual-valuative-formal manifold determinative in any act of conceptualization.

A crucial epistemological innovation lies at the core of Mead's Philosophy of the Act (1938). After Dewey, whose 1896 paper on the reflex arc concept initiated the problem of the "activist" role of the subject in perception, Mead went on to obliterate the notion of a passive organism driven merely by impressed stimuli. His emphasis on selectivity, attention, psychological set, and his analyses of the semiotic process and the social milieu of significant symbolization—along with Erwin Schrödinger's indictment of the "peculiarity" of the objective-scientific world view—are basic resources that support our imputation of a "constructivist" role to the cognitive agent and our conception of the processes of objectification, simulation, and selection as central to the activity of a subject-object dual system.

In these works one observes the interweaving of methodological and epistemological considerations concerning the nature of rationality and legitimate procedures of inquiry. Whitehead's Process and Reality (1929) adds to these themes an ontological component that is required of any systematic metatheory. It is the influence of the organismic cast of this work that leads us to the strategic selection of primitive concepts for a systems-philosophy, a philosophy beginning with the commitment that all "existants" may fruitfully be construed as dual systems involved in selective processes of transformation, subject to criteria of optimal organization. There is perhaps a moot question as to whether the most productive project at this time might not be simply an assiduous attempt to interpret the almost impenetrable terminology of Whitehead's *magnum opus* in terms that might admit of significant applications to the present needs of objective and normative theorists. It is our judgment that the preferable alternative is a parallel attempt in systematic philosophy, with recourse to scientific advances that postdate Whitehead's work, and with concerted attention to the use of more immediately interpretable primitive concepts.

History and Philosophy of Science

P. F. Schmidt, in his paper "Models of Scientific Thought" (read before Section L, AAAS, 1956), and T. S. Kuhn in *The Structure of Scientific Revolutions* (1962), provided very influential overviews of the history of science, with emphasis on major reorientations of accepted paradigms. Schmidt's identification of historic prototypes of scientific inquiry has served as a strategic directive for our methodological survey, and his original project has been extended to include a similar analysis of historic modes of axiological inquiry. Kuhn's book is perhaps our most highly regarded current source in this field, but we do take issue with his emphasis on revolutionary aspects of scientific development, opting instead to construe science as the evolutionary proliferation of a basic cognitive modality of human behavior, when thinking is regarded as a special form of acting.

Two attempts at generalization of the objective scientific mode of inquiry for more adequate coverage of behavioral phenomena are to be noted: from the side of the management sciences, C. W. Churchman's Prediction and Optimal Decision (1961), and from experimental psychology, J. G. Miller's journal publications preliminary to a forthcoming book (cf. Behavioral Science, 10 October 1965). The philosophical basis of Churchman's "science of values" has been the subject of an extensive critique that was important to us for its isolation of the distinctively normative aspects of value inquiry that are neglected under dependence on stochastic-definite models and the positivistic criterion of "verification."

General Systems Research

The remarkable proliferation of special theories in systems research, e.g., the mathematical constructions dealing with information and optimal control processes, presents a punishing reminder that no comparable successes have marked attempts to establish a general theory as a basis for unification. For an account of progress in general systems research we have depended on General Systems, Yearbook of The Society for General Systems Research, 12 volumes to 1967, edited by L. von Bertalanffy and A. Rapoport. The broad themes of speculative and empirical topics considered in a typical systems research symposium (cf. Self-Organizing Systems edited by

M. C. Yovits, G. T. Jacobi, and G. D. Goldstein, 1962) have been complemented by the interests of a relatively small coterie dedicated to an axiomatic approach in the mathematics of general systems. M. Mesarovic, The Control of Multivariable Systems (1960) and the continuing output of The Case-Western Reserve Systems Research Center typify for us the efforts of this contingent.

Any theoretical grasp of the total domain of systems will necessarily depend on evolutionary biology as a progenitor. This is the central emphasis of a recent symposium reported by A. Roe and G. G. Simpson, eds., Behavior and Evolution (1958): "To demonstrate that morphology, physiology, and behavior are aspects of organisms all inseparably involved in and explained by the universal fact of evolution became a principal object of the symposium." With such justification, our own efforts in general systems taxonomy have been shaped primarily by influences from numerous areas of specialization in evolutionary theory. Simpson (1953), Mayr (1963), Oparin (1938), Bonner (1955), Stirton (1963), Clark (1959), Kerkut (1960), and Alee (1949) will be cited for concepts or principles appropriated in an attempt to attain a unitary conceptual format for theoretical treatment of phenomena associated with organization and transformations of organization in general.

Two sources in this sector particularly require acknowledgment: (1) Stephen Pepper's Sources of Value (1955) isolates the connotations of the highly generalized concept "selective system," after earlier work by E. C. Tolman and R. B. Perry on purposive behavior; (2) Melvin Calvin's "Communication: From Molecules to Mars," (cf. AIBS Bulletin, October 1965) supports the conception of emergent "grades" of systemic complexity—the only basis we have found for unambiguous taxonomic distinctions among systems in general when all systems, however rudimentary their ranges and degrees of freedom, are construed as adaptive.

Cognitive-Semiotic Studies

It is to the credit of the principal American pragmatists and social behaviorists that they achieved a skeletal account of the cognitive-semiotic process that is now widely conceded to be essentially correct. Their chief contribution has been the concept of the reprogramming of prior characteristic response via reflective mediation on the part of an adaptive system. On the basis of original work by Peirce, Dewey, and Mead, we undertook an analysis of minimal capabilities for cognitive creativity and control. The emphasis in developmental work has been placed largely on the control component, i.e., the problem of rationality. Here we have attempted to pose the problem in a manner that hopefully avoids two deficiencies that have perennially obstructed adequate treatment: (1) the reductionistic tendency to associate rationality with fractional aspects of categorical and extralogical control; and (2) the absolutist tendency to sever the multiplex process of rational control from its stem in the more general process of emergence. Works by Gödel (1931) and Church (1952) on mathematical logic, Morris (1964) on semiotics, Wiener (1948) and Ashby (1960) on cybernetics, Tolman (1951) and Köhler (1938) on aesthetics, in the sense of species-specific natural norms of purposive systems, have provided resources that admit of associating "rationality" with optimal design of a system of formal, empirical, and intuitive-aesthetic norms expressly designed to foreclose the relativity of cognitive decision. With the further addition of criteria associated with the viability of a cognitive system, the holistic system of cognitive controls may be viewed, like any biological-instrumental control system, as a feature of the overall design of an adaptive system that is subject to evolutionary modification.

This result is a natural extension of the initial undertaking of philosophical behaviorism, inasmuch as G. H. Mead's Philosophy of the Present (1932) expressed the general intent of showing that "social and psychological process is but an instance of what takes place in nature, if nature is an evolution."

Mathematics

Here again, as in the areas of biological and cognitive studies, a complicated skein of influences does not permit discursive acknowledgment. Essentially, we have appropriated mathematical structures from abstract algebra and functional analysis as directives to the formulation of commitments that initiate philosophical reconstruction. As an illustration of the manner in which mathematics enters as a formative element of philosophical development, consider our initial formal principle. It is a commitment to the effect that a complementary dyadic schema characterizes the modality of admissible conceptualization in general. The comprehensiveness implicit in such a categorical commitment would hardly be defensible on any basis other than a realization of existing mathematical structure associated with formal duality, in this case an interpretation in psychological terms having specific epistemological significance. In another isolated example, the abstract algebra of finite fields similarly provides the abstract basis for a reasonable insistence on "operational" testability as a primitive criterion of admissible conceptualization. The promising result that follows from this approach is the possibility of exploiting—in detailed construction of a philosophical system—the correspondences established between certain general features of cognitive constructs and perceptual-conceptual operations on the one hand, and the abstract entities and operations of suitable formal systems on the other.

Further, we have appropriated for use in systematic theoretical development various specialized realizations of analytic structure that have appeared in (1) the mathematics of optimization, (2) first-order perturbation theory, (3) theory of stochastic processes, and (4) relevant portions of relativity and quantum theories. Regarding access to these resources, future citations will principally credit Dickson (1900), Carmichael (1937), and Albert (1956) on the abstract algebra of finite fields; Riesz and Sz.-Nagy (trans. 1952), von Neumann (trans. 1949), and Halmos (1950-present) on functional analysis; Kolmogoroff (1933), Feller (1950), Doob (1953), and Wald (1950) on stochastic processes; Lanczos (1962), Bellman (1957, 1961), Howard (1960), and Pontryagin et. al. (1962) on mathematics of variations and optimal control; Courant and Hilbert (trans. 1953), Glasstone and Edlund (1952), Lindsay and Margenau (1936), Bohm (1957), and Watanabe (1955) on topics from mathematical physics. It will perhaps be immediately evident that formal duality, an invention of mathematical analysis for the calculus of variations, must appear in a strategic role. The formal dual acquired through generalization of the Legendre transformation is always interpretable as a value system and its canonically conjugate variables as value-measures. Note for instance, that the formal dual devised by E. P. Wigner as the adjoint function for nuclear reactor theory is significantly termed an "importance" function (cf. Jeffrey Lewins, Importance: The Adjoint Function, 1965). The Legendre transformation therefore implements the key strategem of general value-decision theory: the conversion of extremalization problems that are time and path dependent in object-space to problems depending only on initial and terminal conditions in phase-space. The Legendre transformation may also be used, alternatively, to transform an object-space representation of an extremalization problem into one expressed solely in terms of a conjugate space—"momentum-space" in physics, "value-space" in general theory.

The basic rationale for our utilization of selected structures from algebra and analysis may be summarized under three theses that dominate this section of the work:

(1) that cybernetic characteristics of the finite cognitive agent entail the relativity and reductivity of all conceptual objectifications—and, hence, the necessity for complementary representations of nonsimultaneous but equally relevant objective v. normative ontological aspects of all existants (enduring "things");

(2) that suitably paired theoretic paradigms, designed specifically to satisfy the conditions of formal duality, are required in order to provide adequate means for rational analysis of the objective v. valuative aspects of practical decision; and

(3) that primal v. dual modes of analysis so formulated can be shown to be *complementary* in general and *correspondent*, i.e., equivalent, under specific conditions identifiable with optimal decision.

As these dominant theses suggest, the long standing dichotomy of naturalist v. idealist value theories need not represent a necessary or irreparable cleavage. A synthesis of traditional perspectives is envisionable in terms of (1) the complementarity of alternative modes of rational analysis and (2) the connectivity of a stable and extendable chain of successively embedded, reductive cognitive models. Here the strategic aim of our inquiry shows most clearly. We hope to accommodate, in a unified conceptual-methodological framework, the supposedly incompatible principles of previously disparate value-theoretic orientations. Admittedly this version of "unification" will not be monolithic in character. Indeed, the principal import of complementarity is that it supports the cogency, if not the necessity, of introducing compound primitive constructs quite unlike the simplistic abstractions of traditional usage: dyads composed of such supposedly antithetical philosophical primitives as being-becoming, individual-universe, self-object, maximal freedom-optimal control; dyads constituting such nonintuitive theoretical primitives as Legendre conjugate variables and adjoint functions, relativistic space-time complements, and group theoretic primal-dual systems. Nevertheless, it is this type of metatheoretic modification, primarily, that seems to afford significant promise for resolving perennial difficulties that have been inherent under the previous conceptual separation of acting, valuing, and knowing.

EXPECTATIONS

While premature assessments have no rightful place, it is incumbent on us to specify the kinds of theoretical and practical advances that would indicate ultimate success. The metatheoretic innovations introduced in this work are expected to establish foundations for the formulation of object-theories, i.e., specialized, content-sensitive, theoretical models applicable to practical decision problems of such scope and complexity that they are not amenable to existing methods of analysis. Example classes of such intractable problems specific to the management sciences are :

(1) interface problems characterized by the general demands for resolution of conflict among components of a complex organization;

(2) appraisative problems concerned with issues of optimal organizational design;

(3) entrepreneurial problems associated with administrative decisions affecting the viability and adaptability of a total organization.

In the interest of behavioral inquiry in general, this research is expected to contribute toward the attainment of (1) a conceptual schema of sufficient generality to accommodate phenomena associated with any sector of the spectrum of adaptive systems: geosphere and technosphere, biosphere, sociosphere, and noosphere (abstract cognitive organizations); and (2) a normative-theoretic paradigm affording methodological capability for more adequate treatment of the central problem of the theorist in behavioral research: namely, the design of models capable of accommodating the modifiability of characteristic response of adaptive systems.

It is now clear that by way of systematic treatment we hope to introduce a significant extension of scientific method; but any claim to this effect, of course, extends only so far as we may actually succeed in bringing the rational control of valuation and decision within the grasp of contemporary inquiry.

Potential Significance

The successful introduction of a new prototype of rational inquiry has been an exceedingly rare historical occurrence. An emergent event of this kind typically represents the culmination of generations of effort toward the gradual refinement of a stable pattern of inquiry. In the entire course of Western science, for example, there are apparently but three major instances: (1) the axiomatic prototype of Greek mathematics, (2) the empirical prototype of early modern physical science, and (3) the conceptual prototype of contemporary formal-theoretic inquiry. Setting aside the hard question of expectations for the ultimate success of our enterprise, we must at least admit that it does aim at precisely that rare type of event described as "the introduction of a new prototype of rational inquiry." One can readily imagine with what diffidence we do so.

Our project of philosophical reconstruction—posed as a basic response to the escalade of problems now obstructing the general advance of behavioral science—has been expressly designed to attempt an extension of the domain of rationality. Surely it is only by some such extension that prediction of normative-adaptive behavior and prescriptive control of deliberative decision and valuation will be, if ever, brought securely within our intellectual grasp. The subtlety and little understood power of intuitive judgment are not in the least depreciated. We may well find at last that there, rather than in vigorous rationality, lies our ultimate dependence. But the insecurity of even the most artful employment of nonwarranted intuition presently allows no rest from the attempt to institute a unified intellectual paradigm, a rational prototype capable of providing the systematic basis for (1) establishment of coherence among scientific and axiological interests, (2) attainment of theoretical models applicable to critical classes of decision problems now amenable only to subjective solution, and (3) improved understanding of aesthetic, creative, and control components of the cognitive process itself.

Part I. DOMAIN

PART I: DOMAIN

PROGRAM—

Introduce the concept of prescriptive science

Counter the notion that valuative aspects of decision making are inherently off-limits to rational inquiry.

Annotate a continually increasing dependence on new scientific advisory practices as aids to institutional decision making.

Establish the essential prescriptive character of these practices as belying professional distinctions commonly drawn between operations research, systems analysis, management science, and their variants.

Secure recognition that further development of such professional practices will entail, not merely innovative techniques of analysis, but belated extension of rational inquiry into the sector designated "prescriptive science."

Demarcate this sector of inquiry as a unified domain encompassing characteristic problems of the behavioral sciences that are distinct but not disconnected from those of the formal and physical sciences.

INTRODUCTION

Every living species is a testament to the unfathomed subtlety of natural selection. Predominant among nature's evidence, however, is the curious fact that Homo sapiens should have been invested with continually broadening mastery of complex mental operations while remaining little capable of specifying how such operations are to be reliably performed. The conundrum has a profound simplicity: We are more than we know. The disparity between what we can do mentally and what we can explicitly "program" is so great that exploration of the inner space of the cognitive agent is a task at least equivalent in scope with that of discovery in the outer space of the physical cosmos.

Yet, if the one accultural species—with its alignment of individuals by responsibility in social institutions—can contrive somehow intuitively to resolve complicated problems of decision, valuation, and organization, the results have hardly been incontestable. Quite otherwise, the most confident employment of unexamined habitual procedures in decision making all too frequently have led men, nations, societies, even civilizations, unwittingly to destruction. Thus, a commitment that must once have been dimly hypothetical has by this time become a common sense maxim: that it is an always cogent enterprise to attempt the formulation of principles that will tend to assure desirable outcomes of decision and action rather than mere chanceful unforeseen results. The strength of this maxim is that it explicitly invokes the principal aim of rationality, namely, the design and institutionalization of cognitive controls that are capable of refining and redirecting the naturally artful but essentially insecure operations of intuitive judgment.

Though we may claim for this book the intention of serving that same eminently acceptable aim, we are not thereby relieved of troublesome problems of communication at its beginning. While there is no longer anything at all novel about identifying science with rationally controlled ways of thinking in general, we must succeed in using this familiar context to establish the acceptability of a notion that is still new enough to be somewhat disconcerting: the concept of *prescriptive* science.

Chapter 1

THE CONCEPT OF PRESCRIPTIVE SCIENCE

It must be admitted at once that even the choice of what appeared to be an apt title, Foundations of the Prescriptive Sciences, had to be made in full realization that a phrase more open to immediate misinterpretation could hardly have been devised. For this reason we have gone to unusual length in the Preface, attempting full disclosures of aim and strategy, methods and resources, in order to provide the reader with two orienting expectations: (1) that prescriptive "science" will not be science as we know it in conventional usage, and (2) that "foundations" here will not refer solely to commitments of the type now familiar as directives to the construction and testing of theories in objective inquiry. The reference of these key terms in our title is to an unfractured total range of cognitive decisions associated with acting-valuing-knowing and to a holistic problematic situation that holds throughout that range: the demand for comprehensive, coherent, systematic procedures for attaining warrantable judgments in all of human affairs.

Perhaps it is now quite obvious that the terminology we employ admits of difficulty not so much from its novelty as from its archaic generality. Such generality has not been the common cast of thought since that time when it was the distinctive mark of the earliest Western philosophical systematists, the Ionian physicists, in their attempt to see the world, at once, clearly and whole. That their grand intent was premature we may conclude from the historical evidence that reductionism and specialization ultimately proved instrumental to the attainment of unchallengable objective knowledge. It is understandable that, in the millenia of readjustment that followed the abortive attempts of these early Greeks, their original conception of science as rationally controlled judgment in general should have been displaced and almost forgotten. But since continually pressing needs now combine with more auspicious modern circumstances, a contemporary renewal of their insistent search for the unifying principles of a more comprehensive rationality ought also to become readily understandable and admissible.

To this end we have been at pains to associate "prescriptive science" with no more than the bare concept of overtly controlled reasoning procedures that yield unambiguous decisions, where justification of procedures and vindication of decisions are conceived as being open to public scrutiny. Assurance has been given that this conception in no sense anticipates, or even admits in principle, the complete control of decision making by deterministic procedures or algorithmic routines. We anticipate, rather, a continuing expansion of decision principles capable of releasing more of the cognitive agent's finite capacities for use in creative attention to problems of ever-widening scope. Extension of the range of decidability, as a contribution to the increase of cybernetic freedom, is central to the concept.

Perhaps no urging is required in order to secure provisional acceptance of the desirability of this goal for the emerging decision sciences. The feasibility of this objective, however, may remain an issue even for those who might willingly concede its desirability. One introductory task therefore remains: to counter the commonly held doctrine that valuative judgment is inherently off limits to rational inquiry. This can be done by showing that the establishment of cognitive control over prescriptive aspects of decision making lies naturally on an escalade of objectives that perennially has guided the advance of inquiry.

OBJECTIVES OF RATIONAL INQUIRY

No serious oversimplification is involved in maintaining that systematic inquiry *per se* is just the advanced stage of an age-old, pervasive effort of men to institute dependable, consciously controlled procedures governing the ever-widening deployment of human mentality. Indisputably the activity of *prescribing*, by which we mean "the deliberate recommendation of a decision for action,"[1] represents but another of

[1] There is no need as yet to develop the connotations of this term at great length. That task will be taken up in a later section in which we deal with the mission of operations research as a professional activity in the service of a client. Everything said there of recommended decisions will serve to further the expansion of the term "prescription." Amplification on one point, however, seems to be immediately required. The notion of a decision recommended for action is meant to cover a range of interpretation that would allow what is being recommended to be not only an action but a program, a strategy, a policy, an organizational

those ephemeral cognitive operations that carry us forward so compellingly in behavior, even while awaiting the injection of rational control as the necessary condition of any marked improvement in stability and adequacy. To envision the attainment of a warrantable mode of prescription is to do no more than apprehend the full significance of a long-standing collection of successively more complicated goals, whose adoption is implicit in man's rationalizing tendency. Under the heading of several cryptic but utterly commonsensical questions, we can lay out enduring demands that have persistently confronted the creative cognitive agent from primitive beginnings to the present. The history of inquiry in brief amounts to the iterative reworking of these basic issues, as inherent limitations of once-acceptable modes of response have invariably been disclosed in wider experience:

<u>What is to be expected?</u>

The problems of prediction, explanation, anticipatory response, and providential planning. Essentially a question of constructing conceptual models adequate for some form of detailed simulation (conceptual, linguistic, graphic) of an object or field of attention.

<u>What is to be done?</u>

The problems of prescription and dependable control of decision and action directed toward purposive goals. Essentially a question of attaining conceptual models relevant to selection among alternative actions, strategies, policies,

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format, or an ultimate value commitment. In any of these instances the implementation of a recommended decision by an autonomous client entails an action; but the action may alternatively involve a change in operations, the establishment of a policy, a modification of organizational structure or function, a course of entrepreneurial activity, or the adoption of a belief as a habit of action.

and values—whose vindication in experience will be subject not only to the pragmatic criterion of immediate effectiveness in problem-solving but to multiple criteria of long range viability as well.

<u>What is to be conceived?</u>[3]

The problems of objectification, description, specification, characterization, classification. Essentially a question of the attainment of coherent primitive concepts.

<u>What is to be believed?</u>

The problems of demonstration, deduction, derivation, implication. Essentially a question of securing warrant-preserving transformations of primitive statements as assumptions or commitments, i.e., a question of deriving conclusions admissible by principles.

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[2]A certain transparency characterizes most of these elemental questions. Their significance and relevance can therefore be easily surmised. The case is somewhat different, however, with regard to the third question, that is, the question of what is to be conceived. An example that helpfully reveals the implications of this question has been given by G. L. Farre in his address to the American Association of Physics Teachers, Georgetown University, 2 April 1966: "Let us imagine that on a hilltop, watching the sunrise one bright morning, stand Kepler and his master Tycho Brahe. Imagine further that, seeing them there, you ascend the hill and upon joining the two astronomers, you inquire of them what it is they are seeing that so enthralls them. Tycho Brae may answer something like 'I am watching the rise of the earth's largest satellite'; while Kepler might say that 'The earth having completed one full rotation since yesterday morning, I am watching the sinking eastern horizon bring the sun back into view!'"

The disagreement between Brahe and Kepler is not of what the givens of experience are (presumably their eyes <u>see</u> the same things...) the disagreement is on the ordering principle <u>for</u> these givens—that is, on the perspective in which they are [to be] viewed. The difference between the two astronomers is not centered on what they see in a physiological sense, but rather on what they see it <u>as</u> [i.e., on what is to be conceived, or what is <u>conceivable</u>, under <u>given</u> prior cognitive commitments].

A great cycle with periods as long as historical eras appears to bring up these original themes in a slow recurring shift of priority and emphasis that now strongly indicates the propriety of attempting to incorporate rationally controlled prescriptive judgment as a legitimate sector of science.

Expectation and Anticipatory Behavior

Apparently it is to the purpose of achieving human ends in the face of frustrating failure that the cognitive process has always moved into action. This begins with the need to anticipate the course of surrounding events and to employ expectations to advantage in selecting or effecting just those forthcoming alternatives that represent purposive goals.

To say that cognition begins with such relatively advanced considerations is, of course, to speak under strong qualifications. First, we do not conceive it necessary to our interests here, or even possible at present, to pursue the long trace of the emerging cognitive capability as it is only now being freshly reconstrued under the new topic of the evolution of behavior. Second, any mention whatever of "beginnings" must have a very loose construction indeed. The elemental tasks of cognitive behavior—conceptualization, simulation, evaluation, selection, and decision for action—are admittedly interdependent; and they are iteratively performed. How shall this iterative relationship be broken into for purposes of analysis and discourse? What point of entry can legitimately be elected? There are confusing alternatives. In contrast with the order in which primitive cognitive problems are considered in our list above, for example, an ordering by logical priority would surely require that concept attainment and commitment precede expectation and anticipatory action.

The reasonable option, so we suppose, is to choose, as an arbitrary but promising point of entry, the first appearance of awareness of thought consciously undertaken in the face of practical necessities, thus presupposing an indefinite succession of prerequisite mental attainments in anthropological development predating any possibility of meaningful reference for our interest in purposeful "objectives" of inquiry. Based unconsciously on more primordial capacities and acquisitions of human intelligence—perceptual discrimination, concept attainment, symbolic representation, and linguistic simulation—trial procedures for classification of objects and correlation of events that later lend themselves to successful action tend to become established as behavioral habits, forming the basis of uniform approach to problems of a given kind. In both individual and anthropological development, this is the foundation of primitive rationality: that by habituated mental procedures, particular objects and events can be subsumed under a class or kind and thereafter confronted with anticipatory responses that prove to be appropriate.[3] The codification, later the institutionalization, of innovative cognitive procedures that we associate here with the acquisition of a rudimentary rationality is the elemental *modus operandi* of later systematic inquiry. Its early effectiveness in the satisfaction of needs can be appreciated in its contribution to the great neolithic cultural

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[3]cf. Jean Piaget, The Construction of Reality in the Child, trans. Margaret Cook, Basic Books, New York, N. Y., 1954, pp. 380ff.

breakthrough: the sheer lore that guided the fabrication of tools and shelter, the conduct of the hunt and of tribal defense, the domestication of plants and animals, the sophistication of artisanship.

As argued persuasively by Lévi-Strauss [1] in cultural anthropology and by C. S. Smith [2] in studies of archaic technology, the pre-civilized mind totalizes. It is primarily sensitive to the complex wholes and intricate relationships of immediate experience. In its intransigent refusal to allow anything of human interest to remain unassimilated, there is no trace of the modern abstract separation of expectation from valuation and action—as we would say, no separation of predictive from prescriptive judgment. As lore is built up by intelligent but uncritical empiricism in practical arts, so are custom, rite, taboo, and magic build up as codified directives in art, religion, and social practice. Such holism is the principle characteristic of the early dialectical version of rationality that exhibited astounding success in its first major function—that of promoting the attainment of foreseeable human ends, both material and emotional, by means of thinking for the sake of acting.

Coherent Conceptualization and Logical Inference

It was precisely the unforeseeable ends newly opened by primitive rationality that were to disclose the ultimate power of cognitive control and to bring round the first full cycle of rational development in a sweeping reconstruction of the conceptual groundwork on which early rationality had unconsciously depended.

The great counter-theme to the intuitive-holistic mode of dialectical reasoning is the abstract-reductionistic mode of analytical reasoning that has constituted, from its inception to the present day, the framework of both formal and objective inquiry. Not only the limitations but even the successes of primitive thinking for the sake of acting conspired to shift the emphasis in intellectual activity toward self-critical, analytical thought. Thinking itself is, after all, only a special kind of acting; and it can be readily seen that an increasing freedom from immediate stress, gained through cognition, could only afford new opportunity for the reflective cognitive agent to turn attention inward toward improved control of the kind of acting that is thought itself. The dual capability peculiar to _Homo sapiens_—to think directly about how to act and to think reflexively about how to assess, to exploit, to improve the process and results of thinking—once acquired, would find no convenient termination but only limitations that have invariably proved to be temporary, or so at least in terms of the history's long time scale. Arising in echelon from the advent of socialized rationality in neolithic times, successive demands for more general and more adequate principles for control of _thinking for the sake of thinking_ have gradually built up the hierarchy of cognitive pursuits that we now associate with the distinct objectives of practical, theoretic, philosophical, and thematic inquiry respectively.

Two motivational aspects of this spiraling cognitive enterprise are equally apparent and equally relevant to the attainment of human values. First, the obvious pragmatic motive of problem solving: the need to resolve ambiguities, to remove anomalies, to overcome failures in application of an existing mode of thought. Second, the more sophisticated motive of aesthetic goal-attainment: the drive for elegance, generality, comprehensiveness of conceptual resources. While these motives obviously may shade one into the other, the first of them, as the more immediately pressing, was undoubtedly the spur to the first general revision of thought that marked the origins of a critical, analytical mode of rationality. Karl Jaspers' Vom Ursprung und Ziel der Geschichte[4] (1949), details the bewildering incoherence that became forcefully apparent during what he terms the "axial period" of prehistory (c. 1st Millenium, B.C.). The naive animistic and spiritist conceptual basis of pre-civilized rationality, assumed unconsciously and employed innocuously enough in earlier contexts of ruder social life, was confronted by a dawning cultural self-consciousness, an increasing awareness of the complexity and subtlety of human experience, a tendency to take account of human freedom in reflection and action. When human motives and values began to be projected through imagination to the status of ideals, the resulting ethical and aesthetic criticism, emerging first in new religious dispensations, initiated a general criticism of habitual cognitive commitments, thus sweeping whole cultures of that period toward innovations that were to lay the foundations of future philosophy, science, and art on the conceivability of humanly comprehensible order in nature, of

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[4]This work may also be seen in English translation by Michael Bullock under title, The Origin and Goal of History, Yale University Press, 1953.

discoverable temporal, causal, aesthetic, and ethical relations, of means and ends, origins and goals, motives and values.

The attitude of critical thought nowhere exhibited its fruitfulness more impressively than in its ultimate production of an impasse of its own kind during the later flowering of Greek philosophy. Criticism, when turned upon the epistemological problems of the origin, nature, and reliability of knowledge *per se*, became the rampant skepticism of Protagorean times. The resulting pervasive intellectual "crasn" that came near to vitiating Greek society will more fully occupy our interest in a forthcoming survey of historic prototypes of inquiry. For the present it is only required to emphasize the dominant theme of rational development: that creative reaction to an apparent failure of the rational enterprise supplied the motivation and the means of subsequent reconstruction and successful advance. On the combined accomplishments of Greek philosophy and Greek mathematics, the normative disciplines of semantics and logic, and the formal methods of axiomatic construction of cognitive models, arose in response to the question "What is to be believed?" —the question that had previously generated widespread consternation by the confusing array of conflicting, ambiguous, incoherent answers that it had received from self-critical minds.

The conscious being, in becoming aware of itself, had posed problems for which intuitive, dialectical reason could provide no solution: the problems of (1) accounting for its own capacities, (2) discriminating preferable alternatives from among the myriad conflicting insights of creative but uncritical intelligence, and (3) instituting dependable, unambiguous control of its own cognitive processes. These standing requirements relentlessly forced the invention of a complementary analytical mode of rationality, a mode of thinking characterized by decomposition of the immediate totality of experience and its recomposition in terms of more comprehensible—though necessarily more abstract—reductionistic models. With the first tenuous attainment of an analytical version of rationality, the cognitive adventure had come through its first full circle of the successive problems of intelligent behavioral self-control. Only through subsequent centuries of development—the documented periods of relatively sophisticated rational inquiry comprising the "history" of science—would a clear appreciation of appropriate interplay between the intuitive, formal, and empirical resources of human mentality be achieved, if indeed this may yet be claimed. But the very appearance of axiomatic method discloses, from our vantage point, the presence of a second major function of rationality: its service toward attainment of the idealized goals of systematic, comprehensive, elegant cognitive models and warranted, rigorous control-principles in deliberative judgment via the self-correcting strategem of <u>thinking for the sake of (improved) thinking</u>.

<u>The Refinement of Balanced Objectives</u>

As if in the ancient pattern of yin v. yang, all subsequent efforts to reconcile the seemingly antithetical modes of dialectical and analytical reason have been plagued by tension and lack of balanced emphasis.

efficacy of objective-scientific inquiry in the value-free province it claimed, however, <u>exclusive</u> dependence on its specialized abstractions, theoretical constructions, and confirmation procedures represents a warping of attention toward only a partial implementation of the total resources of rational thought. On this point Whitehead [3] warned, in the Lowell Lectures of 1925: "A civilization which cannot burst through its current abstractions is doomed to sterility after a limited period of progress." We therefore maintain here what could only be intimated in the Preface: that the valuational issues now being encountered generally in the behavioral sciences, and particularly in new scientific-advisory practices, do not even admit of adequate representation—much less resolution—by recourse solely to the present analytical basis of objective scientific inquiry. A theory relevant to valuation and decision requires the following significant extensions of the characteristic structure of objective theories:

(1) addition of a decision-parameter space to the conceptual model,

(2) construction of an adjoint formal system,

(3) assumption of a set of hypotheses constituting terminal value posits, and

(4) recourse to tests for admissibility that are sensitive to criteria for vindication rather than confirmation of the theory.

In answer to the charge that such a theory could not be a "scientific"

This is hardly surprising, since experience is approached from opposite perspectives in the two cases: one is supremely concrete and holistic, the other supremely abstract and reductionistic; one proceeds on the basis of synoptic hypotheses, the other on commitment to arbitrary formal properties. Presumably the habitual human uses of dominance and suppression in the resolution of conflict carry over from emotional to intellectual life, so that dialectical and analytical reason were almost automatically placed in opposition as truth v. error, or at least as sources of subjective v. objective knowledge competing for supremacy.

With the advantage of hindsight, we can see that a dangerous imbalance was precisely the result of the spurious "competitive" success of the newer analytic mode. For the joining of formal and empirical methods in early modern physical science was marked by a provisional exclusion of normative-valuative considerations that was to become, in the contemporary scientific temperament, a thoroughgoing excoriation of any introspective, speculative, holistic approach whatever. Depending, as they supposed, solely on the laboriously perfected analytical mode, investigators in the great age of classical physical science and mechanical technological development turned to a newly effective attack on the oldest of problems, a recurrence of the cycle of intellectual priorities in which the attainment of rigorous predictive-explanatory theories and prescriptive control in the practical arts now represented refined versions of two ageless goals: (1) the securing of appropriate expectations and (2) the design of adequate anticipatory responses. Despite the impressive theory, one can only answer that the extensions envisioned can be achieved in no way other than by continuation of the basic project of rationalization that created science. And that project, as we have tried to show in this rudimentary account of historical development, essentially consists in the iterative reworking of elemental cognitive problems that alternately bring into priority the fundamental counter-themes of dialectical and analytical rational modes. If the analytic of objective science is incapable of providing warrantable control over the full range[5] of prescriptive judgment, the promising course surely is to reemphasize the attainment of intuitive-holistic commitments and concepts that might hopefully admit of fruitful reconstruction of paradigmatic analytical structure itself, and therefore of what we are prepared to call "scientific" theories. To counter the imbalance among intellectual objectives that has been produced by tension between dialectical and analytical reasoning seems the cogent strategy. In

[5]By this veiled reference we mean to do justice to the fact that technological capabilities stemming from objective inquiry, as in engineering and certain aspects of medical therapy, do represent instances of rational control of prescriptive judgment. But these accomplishments are possible just because the valuative aspects of decision making in some cases may be essentially nonproblematic due to the nonambiguity and stability of elemental commitments to, say, the value of human life or the value of control over efficient cause as a sine qua non of purposive action. In the professional practices of psychiatric, legal, or ethical counseling, scientific-advisory services, and administrative decision in complex organizations (government, business, education, military), the distinctively valuative aspects of decision are never so restricted in type. Critical problems of decision, valuation, and organization in these sectors, along with those of personal-emotional and creative intellectual life, fill out the "full range of prescriptive judgment" which cannot be accommodated by the existing analytical format of objective science.

the principal thesis of The Savage Mind (1962), Lévi-Strauss argues for the propriety and the significance of balanced emphasis.

> . . . The opposition between the two sorts of reason is relative, not absolute. It corresponds to a tension within human thought which may persist indefinitely de facto, but which has no basis de jure. In my view dialectical reason is always constitutive: it is the bridge, forever extended and improved, which [creative intelligence] throws out over an abyss . . . . The term dialectical reason covers the perpetual efforts analytical reason must make to reform itself if it aspires to account for language, society, and thought; and the distinction between the two forms of reason in my view rests only on the temporary gap separating analytical reason from the understanding of life. Sartre calls analytical reason reason in repose; I call the same reason dialectical when it is roused to action, tensed by its efforts to transcend itself.
>
> . . . I do not regard dialectical reason as something other than analytical reason, . . . but as something additional in analytical reason: the necessary condition for it to venture to undertake the [representation and comprehension] of the human.
>
> . . . Scientific explanation consists not in moving from the complex to the simple but in the replacement of a less intelligible complexity by one which is more so . . . . No doubt the procedure would go astray if it were not, at every stage and, above all, when it seemed to have run its course, ready to retrace its steps and double back on itself to preserve contact with that experienced totality which serves both as its end and means.
>
> . . . We have had to wait until the middle of this century for the crossing of long separated paths: that which arrives at the physical world by the detour of communication [i.e., conceptual objectification and linguistic simulation], and that which arrives at the world of communication by the detour of the physical. The entire process of human knowledge therefore assumes the character of a closed[6] system. And we therefore remain faithful to the inspiration of the savage mind when we recognize that the scientific spirit in its most modern form will . . . have contributed to legitimize the principles of savage thought and re-establish it in its rightful place. [4]

[6] Possibly this reference to "closed system" bears the connotations of mathematical closure, that is, the notion of a transformation yielding

In this light any presupposition to the effect that the enterprise of prescriptive science is off-limits[7] to rational inquiry must be viewed, at best, as vaguely expressing the realization that the tasks at hand are not initially those of the working scientist, but rather of the philosopher. And this is quite true. Philosophy is the perennial antagonist of accepted abstractions; its principal business is the dialectical task of continually attempting the foundations of novel <u>modes</u> of conceptual objectification in the interest of more fully accommodating the concrete, complex totality of experience to which its allegience is given. Thus, the issue of disciplinary responsibility may be readily conceded.

But if an attempt to extend the objectives and to redress the balance of emphasis in contemporary rational inquiry is not properly subject to the charge of being "off limits," it is certainly sufficiently

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only images that are elements of its domain. It seems more likely, however, that Lévi-Strauss here refers to the notion that in the attainment of human knowledge the formalized manipulation of symbols generates novel concepts and the intuitive manipulation of concepts generates novel symbols in an iterative, mutual causal process inseparably linking thought, language, and action.

[7]The rare type of aesthetic "solipsism" that despairs at the nature of the source of values, rather than at the question of rational method, does not seem to require any extended reply. The very possibility of intersubjective factual judgment clearly rests on the presumption that psychophysical responses, effectively invariant with respect to individual subjects, characterize certain human reactions to physical stimuli. In the main this presumption lies easy on most critical conscience. That no comparable aesthetic invariants of emotive response should exist to admit of intersubjective valuative judgment is a commitment that is difficult to take with any seriousness; for while one's feelings are—fortunately or unfortunately—forever one's own, the whole of cultural intercourse denies the radical notion that human individuals are, each one, sentients <u>sui generis</u>.

forbidding in difficulty. The realization is now inescapable: that when our objectives are extended to include <u>prescription</u>—so as to end the divorce of science from the aesthetic and ethical—the entire escalade of rational objectives must perforce be reconstrued as a system of mutually affective ends and means. Just as there is no version of voluntary action that is insensitive to prescriptive directives, there is no version of deliberative thought that is insensitive to modification of prior normative commitments and alternative criteria of admissibility. Conversely, as there exists no version of normative-adaptive behavior that is independent of some context of interaction, there is no version of conscious institution of values as norms in decision making that is insensitive to knowledge of causal relations between present states of affairs and outcomes contingent on strategic options. To say that acting, valuing, and knowing are to be taken as inseparable and interdependent would be a plainer way of speaking; but it would mask the actual complexity that is entailed in adding, to the present objectives of rational inquiry, the further goal of prescriptive control of decision, valuation, organization, and cognition.

In the face of a new order of difficulty, we can hope to approach this further goal by no means except that of trying to think about our world and ourselves in a new way, trying to rework once-acceptable but invariably foreshortened answers to the old question What is to be conceived? or What is conceiv<u>able</u>? This was the question of the first <u>self-consciously</u> entrepreneurial thinker. Its earliest answer marked the beginning of self-transforming cognitive creativity. Eliciting gradual refinement of progressively more holistic criteria of admissible conceptualization, this elemental issue persistently reappeared—as if from some philosophical underworld—throughout the history of science; and it confronts us now: the "omniverous" problem in philosophical reconstruction, that is, the problem that takes in all the other elemental ones. As we have tried to indicate in Figure 1.1, to open to question the regimens of admissible conceptualization in general is to reopen all the elemental cognitive problems at once. For above the rudimentary level of deterministic and automated processes at the chemical-biological basis of life, there is no expecting, valuing, acting, believing—in short, no practical or theoretic or aesthetic activity whatever—that does not first arise from conceptual objectification and later issue in decisions subject to cognitive control of the relative admissibility of alternative objectifications.

It would be a serious misapprehension to suppose that, when all the elemental questions are reopened, all the work of reason stands to be redone. As always in cultural development, the sound strategy calls for a hopeful attempt to embed the traditional in a more comprehensive structure whose design-innovations will more fully exploit past accomplishments, even while leading on to newly possible ones. On still another count we would reassure anyone who might be disconcerted by the supposition that the philosophical cast and complexity of problems at the foundations of prescriptive science must immediately

OBJECTIVES of RATIONAL INQUIRY

Sub- process	Criteria
DESCRIPTION, unambiguous	semiotic
DEMONSTRATION, valid	logical
PREDICTION, warranted	perceptual aesthetic
PRESCRIPTION, vindicated	pragmatic evolutionary synaesthetic
CONCEPTUALIZATION, admissible	holistic

Figure 1.1

plunge us into an intellectual netherworld where all principles come unsecured and the confidence of habitual, practical life dissolves. In the forthcoming chapters our course will be, rather:

(1) to begin precisely with the confident initial development of existing resources of scientific inquiry as aids to improved rational control of practical decision making;

(2) to show how an eminently practical aim—to extend the scope of technical capabilities in the "decision sciences"—forces us inevitably toward confrontation of metascientific issues that pose obstructions to our practical aim;

(3) and only then to struggle with the task of philosophical reconstruction that has been merely broached here.

One may be forgiven the intellectual heresy of conceiving this task as a spectre attending the concept of prescriptive science. No man ventures comfortably beyond the present reaches of his rationality; but an extension of the rational domain is what the practical aims of our time demand, even if we were disposed to neglect the aesthetic aims that demand this in all human times.

Chapter 2

THE RISE OF DECISION SCIENCE

THE CHALLENGE OF CULTURAL COMPLEXITY

Administrative decision making in the several institutional sectors of modern society has until only recently maintained a style bequeathed from perhaps the earliest forms of civilized social organization. In a triumph of cultural conservatism, and apparently in defiance of the hard rule Adapt or die!, managerial method successfully persisted in the old ways of the deft compromise, reconciling conflicting interests in tenuous equilibrium by trial and error adjustment to immediate stress, and the calculated risk, exploiting the parlay and the hedge indifferently as opportunities might dictate to the intuitive entrepreneur.

As to specifics, the tactical treatment of complicated administrative problems has been the laboriously refined procedure of "staffing the decision"—a technique that in concept could not have been unknown to any governor of the Minoan civilization. From mere observation of its early invention and time-honored use, however, there is no inference that the staff-decision procedure is a simple one. The very great durability of this tactic is due, no doubt, to the fact that its commonsense aspect hides a marvelously subtle process so complicated as to defy explicit description. Its principal features are clear enough: traditional dependence on (1) insight and intuitive judgment on the part of responsible individuals of proven talent, and (2) intensive though necessarily informal exercises of reasoning and deliberation in which both criticism and justification of contingent plans are derived from many sources of specialized interest and competence. But coupled with this basic procedure in unspecifiable ways, there are innumerable subsidiary factors of organizational decision making: for example, the ethical authority of long standing cultural commitments, the pragmatic assessment of past decisions and their consequences, the expertise of professional advisors, the exploitation of critical and constructive insights elicited from every sector of intellectual activity, and certainly not least, the interplay of leverage and influence in the economic and socio-political arenas at large.

The sustained impetus of the modern industrial states in their drive toward international preeminence attests the notable skill and acumen by which institutional decision can be maintained as a high art in the face of confusing circumstances. Yet even the most generous assessment of the viability and organizational effectiveness that can be achieved by informal-experimental decision procedures admits of a disquieting aspect. The generations since World War I have been witnessing, in the impact of a "scientific revolution," perhaps the most spectacular and violent perturbation of the cultural human context that has ever been recorded. It is now clear that an inevitable concommitant of scientific and technological sophistication is a drastic increase in the complexity of institutional decision problems, an increase characterized moreover by a dismaying rate of acceleration.

To appreciate this situation in depth we need only secure a clear recognition that the basic conception of control over a production-allocation process,[1] a notion so familiar and cogent for the ordinary uses of practical management, is simply inadequate to present demands in administrative decision. The essence of the contemporary cultural enterprise is the creative refinement or reconstruction of existing knowledge, techniques in practice, services and commodities in use, and life-styles in fashion. The ultimate social impact of a science-based technology is not specifiable in advance; its primary control principles are heuristic; its entrepreneurial thrust derives from the insight and imagination of innumerable individual innovators; and its accomplishments ultimately issue in practical outcomes by way of chains of social and ecological relationships so complicated that only extensive analysis could establish their eventual contribution v. cost in terms of human welfare. A society in the era of scientific revolution is therefore more adequately construed

[1]One admits that ordinary usage must be violently strained in order to reach the meaning intended for "production process." The term as used here refers to the Aristotelian bare notion of any process whatever that yields a predesignated outcome. Thus, it applies to governmental administrators, business executives, educators, and military commanders as well as to industrial managers, insofar as they may have been thought capable of completely predesignating their goals and correctly anticipating the nature of resources relevant to their respective sectors of decision making.

as an evolutionary proliferation of successively modified ways of thinking and living, where creativity, aesthetic-rational selection, and learning represent advanced analogs of biological mutation, natural selection, and instrumental adaptation. Thus, there can be little wonder at the trend toward crisis for institutional decision making. Cultural complexity superimposes on traditional tasks a new demand at the furthest reach one can conceive for the administrative function: literally, a demand for "management" of an evolutionary process.

This reconstitution of the administrative function must give pause to any credulous projection of the adequacy of present practices in administrative decision making. It is apparent that demands incomparably greater than any previously experienced are being placed on the essentially intuitive methods of traditional institutional decision. Intuitive judgment can be a superb instrument of organizational control in a context that admits of cumulative experience and gradual change. But its reliability deteriorates markedly—if not disastrously—when confronted with drastic modifications of environment that nullify the major features of familiar experience and the habitual strategies that traditionally have assured social viability.

THE NEW SCIENCE OF MANAGEMENT DECISION

It is, of course, greater capability for rational control of organizational decision making that is wanting. The ordinary connotations of the term "rational" yield, as something very like a tautology, the notion that rational determination of action maintains viability. For the viability of any organization finally consists in just the continuing selection of actions that do in fact secure future states that are at least admissible, if not preferable, in terms of the following minimal considerations:

(1) utilities of outcomes, as well as present states,

(2) conditional probabilities of events contingent upon strategic options, and

(3) constraints imposed by limited resources.

A great deal more than this is involved in rational decision. But even in this simplified sense of selecting courses of action that "get there from here," rational decision in the complex organizations of a technologically sophisticated society would prove to be a highly elusive ideal. These pristine factors of rudimentary rational analysis—utilities, probabilities, constraints—can hardly be construed as stable parameters of institutional decision problems in a context that admits of (1) innovations possessing such staggering potential v. liability as nuclear armament, automation of logical as well as physical processes, induction-selection of genetic modifications, cybernetic control in man, machine, and society, and (2) issues of immediate practical import for government, business or industry that technically involve the predictive-explanatory scope of such advanced theories as relativistic and quantum mechanics, mathematical theories of optimal control, and physiological-psychological-economic theories of behavior. The decoupling of technical aspects of decision making from ordinary practical comprehension is described by Snow [1] in this jarring passage:

> One of the most bizarre features of any advanced industrial society in our time is that the cardinal choices have to be made by a handful of men: in secret: and, at least in legal form, by men who cannot have a first-hand knowledge of what those choices depend upon or what their results may be. . . . When I say the "cardinal choices," I mean those which determine in the crudest sense whether we live or die. For instance, the choice in England and the United States in 1940 and 1941, to go ahead with work on the fission bomb: the choice in 1945 to use that bomb when it was made: the choice in the United States and the Soviet Union, in the late forties, to make the fusion bomb: the choice, which led to a different result in the United States and the Soviet Union, about intercontinental missiles.
>
> It is in the making of weapons of absolute destruction that you can see my central theme at its sharpest and most dramatic, or most melodramatic if you like. But the same reflections would apply to a whole assembly of decisions which are . . . made, or not made, in legal form, by men who normally are not able to comprehend the arguments in depth.
>
> This phenomenon of the modern world is, as I say, bizarre. We have got used to it, just as we have got used to so many results of the lack of communication between scientists and nonscientists, or of the increasing difficulty of the languages of science itself. Yet I think the phenomenon is worth examining. A good deal of the future may spring from it. . . . All societies, whatever their political structure or legalistic formulations, are going to be faced with this same type of choice so long as we have nation-states, and the results are going to be not only significant, but much too significant.
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> . . . "We must learn to think," Don K. Price has written, "without making use of the patterns or models taken for granted by most of the text books." It is harder than it sounds. . . . No one that I have read has found the right answers. Very few have even asked the right questions.

If a sense of mounting incomprehensibility should lead us to despair of rationally directing contemporary human affairs, that conclusion might not be totally unfounded. But it would have been reckoned without proper regard for the record of unceasing efforts to repair the breakdown and to extend the adequacy of habitual ways of thinking and acting. The threat of intellectual impasse has never failed to call out the best that men are capable of; and so with this present threat. Even before its dimensions could quite have been appreciated, the intuitive grasp of responsible men had begun to fasten on at least the rudiments of a promising strategem.

From the perspective of roughly three decades of its development, we can recount the insights[2] contributing to that stratagem:

(1) that science itself constitutes a para-institutional decision system characterized by the employment of inquiry as a strategy for the fixation of belief and the control of action, that its inquiries are means and its works resources for purposeful transformation of society and civilization;

(2) that it is possible to turn the view of scientific inquiry upon its own effects in a manner roughly analogous to the development of human self-consciousness, to appropriate the fundamental stratagem of

[2]A forewarning is in order: In facile statements we are setting down realizations only very recently and very hardly won from a welter of confusing activities. These are our realizations, or more accurately, our convictions as to the ultimate nature and significance of what a vast number of highly individualized people have been doing. It is doubtful that any appreciable number of them would be inclined to agree that such is their collective tendency and effect, since they have no awareness of any such personal aim or design. Despite all this we maintain that an important development, occurring unnoted because of its societal scale, is adequately interpreted only by the explicit "realizations" attributed above.

self-organization that is, so far, characteristic only of the human individual as an organism and to exploit that stratagem in the wider context of social organizations;

(3) that such a stratagem would be implemented by inducing in rational inquiry a specialized concentration on methods for assessment and optimal utilization of the total range of substantive innovations now cascading from the pursuits of science as a whole; and

(4) that this reflexive employment of science prescriptively, for attainment of improved methods of analysis and principles of rational decision, might hope to provide—especially for administrative decision making in complex social organizations—improved capabilities for comprehending and regulating the effects of technical developments now issuing primarily from rampant advance of the predictive physical sciences.

In the face of impending crisis, unvoiced awareness of both overwhelming difficulty and massive opportunity has given rise to new disciplines of inquiry—the decision sciences. They address the scientific-advisory task of contributing toward improvement of rational control in organizational decision making, so far as that may be possible in an environment where the pace of natural change is explosively accelerated by the creative drive of rational inquiry itself.

It is not to be supposed that clear strategic directives, like those falling so patently into order on the page above, have been instrumental in shaping this response. There is always a temptation in reflection from a vantage point in time to think of men in an earlier period as proceeding under sophisticated directives that are only lately seen with simple clarity. The fact is that the decision sciences—like any innovation in kind—were begun in the dark by men tangled in immediate responsibilities, sensing crisis only in terms of recognizable present threat, and thinking purposefully only of improving the capabilities of their particular organizations to attain the most obvious of practical goals: victory in war. Realism here requires us to cite Romer's Rule,[3] a proper antidote for overreaching uses of keen hindsight:

> The initial survival value of a favorable innovation is conservative, in that it renders possible the maintenance of a traditional way of life in the face of changed circumstances. [2]

Later on, of course, the innovation of decision science admits of exploitation in unforeseen developments that are sufficient to suggest explicit long range goals and to justify our imputation of a concerted strategy; but this is a consequence, not a cause. In order to provide adequately scaled appreciation of a continuing social-intellectual response to complexity and crisis, we have attempted to overlay the rise of decision science not only with the significance of what it was, but with the significance of what it would become.

As with any trend that runs toward really massive social change, the multifarious development that we term "the rise of decision science" resists the efforts of contemporary historians to fix its domain or characterize its nature. Its interdisciplinary bent alone is sufficient to insure that some of its dimensions will escape attention or exceed

[3] So called in the referenced article by C. F. Hockett and R. Ascher after the paleontologist A. S. Romer, who applied it in his own work without giving it any name.

the limits of competence professed by observers who know themselves to be too near in time to a revolutionary phenomenon. Beginning with research on military operations in World War II, decision science moves—under continual demands for more extensive scope and more sophisticated methods—to the consideration of total-systems in strategic problems of post-war national defense, economic problems of optimal resource allocation and optimal process-control in business and industry, and issues of contingent planning and long-term development in public-interest activities of governmental agencies; meanwhile, it encompasses the initiation of attendant nonprofit research installations, learned societies, and educational curriculum developments required in support of new technical-professional specialties engendered by its advances. From dependence primarily on physics and engineering in early operational studies, its characteristic team-research approach has broadened to appropriate special disciplines of mathematics, the biological and social sciences, and most recently, the communication-control sciences now frequently designated by the term "cybernetics."[4]

Our concern with conceptual-methodological foundations for prescriptive science obviously presupposes some familiarity with this prior course of historical development in the scientific sectors successively known as operations analysis, operations research, and management

[4]Our preference is to reserve this term for application to the much broader area associated with the concept of prescriptive control <u>in general</u>.

science.[5] To this end we call attention to the early account of Trefethen[3], the continuing record of the series, Progress in Operations Research [4], and an excellent recent review by Page [5]. Not in any formal sense as history, but merely as an informal attempt to assure every reader at least a brief exposure to the inimitable variety of problems and techniques that have evolved, we present here just an abstract of record for a line of development that is well known to every first-generation practitioner of the new science of management decision.

Historical Abstract

Military Operations Analysis (World War II). Operations analysis or operational research, as it was first termed by P. M. S. Blackett [6], began in Great Britain just prior to World War II. Its first use, as a form of analysis distinct from preceding versions of industrial engineering, was by the Royal Air Force on problems involving choice of radar sites and effective tactics for aircraft interception. Applications by the British Navy in anti-submarine defense studies, by the British Army on anti-aircraft gunnery, and by the British Army Operational Research Group on air bombardment soon followed.

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[5] As one might expect of an enterprise so multifaceted, a terminological "explosion" has accompanied its development, the introduction of each new class of problems or techniques serving to suggest a modification in nomenclature. This situation has been further complicated by a parallel development involving biological and sociological sectors of behavioral science and, particularly, the communication-control sciences. An increasing tendency toward the study of multivariable, mutual causal complexes has resulted in the emergence of "system" as the key concept of a newly prominent organismic conceptual basis in behavioral inquiry. The result is a

Footnote 5 - continued

collection of related terms—systems analysis, systems research, and systems science—that, by virtue of their non-specific reference, would clearly encompass the particular line of decision-oriented inquiry that we are recounting. Such overly general terms have often been used as variant designations for operations research and management science. Our placement of the decision sciences in the larger context of (behavioral) systems research will occur as a matter of course in the section "Current Tendencies in Decision Science." For the present we need only indicate here that we shall later settle on the term "management science" as an arbitrary species-designation covering the entire range of research and professional practice devoted to improvement of rational control in organizational decision making. As already suggested, it is only by successfully embedding the formal and empirical disciplines of management science in the more comprehensive normative mode of a prescriptive systems science that we can conceive of an actual realization of the term "decision science" as a generic description for rationally controlled judgement in general.

In the United States the first formal operations research activity (c. 1942) was that of the Antisubmarine Warfare Operations Research Group (ASWORG)—later the Operations Evaluation Group of the Navy Department. During this same period the U.S. Air Force initiated a civilian operations research group attached to the 8th Air Force and subsequently instituted similar groups in all its major bomber and tactical commands of World War II. Principal naval problems were the effectiveness of mines versus sweeping and degaussing countermeasures and logistic viability in the face of surface and submarine attacks on naval transport. Air Force interest centered on improved planning of bombing strikes by quantitative comparison of bombing damage, as assessed by photo reconnaissance, under alternatives of force composition and tactics.

Though some attention to engineering design was permitted by the schedule of U.S. preparations for total war, both British and American war-time research generally was concentrated on efforts to maximize the effectiveness of equipment and force structures already in use. It was this feature, of course, that gave the sense of Blackett's original term "operational" research. From its earliest inception, operations research—however academic its scientific resources—featured two initial considerations that were quite foreign to the normal academic pursuit of objective knowledge: (1) recognition of the purpose of an operation or organization, and (2) identification of a performance criterion, a measure of effectiveness, appropriate for comparison of alternative operational results, i.e., a value parameter defined in terms of approach toward an ultimate goal or an "error-signal" admitting of successive reduction with improving performance.

The nature of objectives and measures of effectiveness typical of military operations in World War II, however, permitted relatively straightforward treatment of these novel requirements in analysis. Attrition of enemy forces and destruction of his strategic resources were goals that then readily yielded explicit interpretations; the fraction of enemy aircraft shot down by an air-defense system, bomb damage achieved per aircraft lost, and shipping tonnage delivered through submarine blockade were measures of effectiveness that did not strain the ingenuity of the operations analyst, even though they could not be safely taken as obvious.[6] This fact, along with the revolutionary effect of introducing even elementary procedures of systematic method into an arena never before treated, gave great scope for successful contributions from operations research. Systematic collection of operational data, consideration of alternative probability distributions, rudimentary statistical analysis—with critical review and intuitive appraisal of traditional military objectives and measures of effectiveness—frequently led to improved strategies and decisions by quite ordinary forms of quantitative analysis.

In two important instances, however, military operations of this period were couched in terms of wide-scale, complex interactions that

[6]The latter of these examples is, in fact, a reminder of perhaps the most notorious misconstruction of a measure of effectiveness known to operations research. The criterion earlier in use—number of enemy submarines destroyed per month—would have tended invariably toward indications of ever-poorer performance just when the Battle of the Atlantic was turning most strongly toward Allied victory.

called for resort to more sophisticated techniques of analysis. In contributing to the formulation of optimal strategies for (1) Allied convoys to Britain (1943-44) and (2) mine blockade of Japan (1945), U.S. scientists devised complex computational models that permitted the simulation or "gaming" of outcomes of interaction between air and naval elements of the Atlantic battle and offensive v. defensive elements of mine warfare, in both cases considering not only purely military aspects of engagements but economic, geographic, meteorological, and oceanographic complications as well. While these advanced-style war games[7] were perhaps distinguishable from traditional forms of military gaming only by their employment of mathematical formulations that required the expertise of scientists in combination with that of military staff, the success of this new feature was sufficient to initiate a tendency toward increasingly sophisticated decision models that marks the later development of operations research generally.

Military Operations Research/Systems Analysis (Post-war). The contributions of operational scientific research under emergency service in wartime were not lost on U.S. military planners. Project RAND (1946) was established by a contract under which Douglas Aircraft Corporation undertook a sustained program of research on the broad subject of air warfare.[8] Later this program was placed under the direction of a nonprofit organization, RAND Corporation (1948), apparently initiating a

[7] Page [Ref. 5, p. 13] terms them diagnostic war games and places their origin as early as a "replay" (December 1941) of Pearl Harbor in which he participated, apparently at Naval Ordnance Laboratory.

[8] Interestingly enough, its first publication was entitled "Preliminary Design for a World-Circling Spaceship," cf. R. D. Specht, "RAND—A Personal View of Its History," Operations Research, 8, 825-839, 1960.

general swing toward this new institutional format in the process. The U.S. Army instituted its Operations Research Office in 1948, providing for the academic orientation of its civilian professionals by relegating management first to The Johns Hopkins University and later to the non-profit Research Analysis Corporation created for that purpose. Operations research requirements of the Joint Chiefs of Staff were served by the Weapons System Evaluation Group organized in 1947, its civilian staff-component furnished under the U.S. Civil Service. Following a period of operation under contract with the Massachusetts Institute of Technology (1954-56), its function was absorbed by the Institute for Defense Analysis incorporated as a nonprofit organization and sponsored by a consortium of universities.

An indication of the diversification of problems that accompanied this shift toward semiacademic organization for operations research is given by Table 2.1, a representative list of subjects treated in post-war military studies. In contrast with wartime demand for constant involvement of analysts with imminent military actions, or those actually in progress, this era permitted distinct separation between the functions of staff officer v. operations analyst. Relieved of direct responsibility under crisis conditions and day-by-day decisions, the practice of operations research was reserved for problem areas permitting months or even years of study. This relaxation of time requirements conferred on operations research a characteristic scientific-advisory status it has since preserved, the more so since greater scope could now be given for

REPRESENTATIVE SUBJECTS STUDIED AT RAC

1. U.S. as a Target
2. Defense of Continental U.S. Against Nuclear Attack
3. Bioligical Effects of Fallout
4. Civil Defense
5. Effects of Military Spending on Civil Economy
6. Tactical Use of Atomic Weapons
   (Effects, Requirements, Weapons, etc.)
7. Costing of Specific Weapons Systems

Table 2-1 (a)

8. Infantry Hand and Squad Weapons
9. Fatigue and Stress of Combat Infantryman
10. Use of Negro Manpower in U.S. Army
11. Over the Beach Logistics
12. Range of Armored Units
13. Equipment Maintenance and Reliability Criteria
14. Field Experiments of Combat Effectiveness

Table 2.1 (b)

15. War Gaming and Simulation of Air Assault Concept

16. Communication Requirements in Future Battlefield

17. Modulation Techniques for Tactical Communications

18. Low Level Navigation System

19. Guerrilla and Counter-Guerrilla Operations

20. Transportation Systems in Thailand

21. Implications of Sino-Soviet Strategic Trends

Table 2.1 (c)

utilization of time-demanding aspects of scientific method that earlier had been necessarily sacrificed: literature search, design and conduct of field experiments, theory formulation, programs of detailed analysis and computation, instrumental and even methodological development.

Inevitably the academic norms of thoroughgoing, comprehensive scientific investigation began to be asserted, appearing in the guise of two requirements that are now counted among the essential features of operations research: (1) the demand for recognition of all relevant factors affecting a decision, and its corollary (2) the demand for consideration of a decision-context sufficient in scope to obviate the danger of suboptimization. Sensitivity to these two norms strongly influenced the nature of the problems undertaken, and therefore the disciplinary composition of the typical OR staff, in this period. The subjects listed in Table 2.1 indicate, first, the incorporation of additional scientific specialties in OR team research—chemistry, biology, medicine, economics, sociology, psychology, political science, and the whole of engineering technology. Second, such subjects as continental defense against nuclear attack, civil defense, and military v. civil allocations and economics, indicate that this increasing diversity of decision factors was accompanied by increasing demand for analysis of total-systems interactions in strategic problems of national defense. It was this development, presumably, that gave meaning to the term "systems analysis" as a specialized designation for decision-oriented research of this new order of scope and complexity. Page [5] characterizes one of the most significant of these total-systems studies in this way:

> By this time [the latter half of the 1950's] the effects of thermonuclear weapons were fairly well understood. The "nuclear exchange game" depended on combining these data with others on methods of delivery, possible defenses, time intervals, political limitations, and economic effects. Of course, the cost and effectiveness of defenses were involved, and the strategic decisions of surprise attack, size of nuclear stockpile, choice between strike forces, defenses, and industrial targets, and the use of radioactive fallout versus shock and fire damage . . . All [of these considerations] have been used over the past ten years in formulating U.S. national policy.[9] [Ref. 5, p. 14]

The expanding domain of decision science thus had begun to exert opposing requirements that tended to produce professional distinctions based on methodological characteristics. On the one hand, operations research as "the science devoted to describing, understanding, and predicting the behavior of . . . man-machine systems . . . ," [7] was understood to proceed classically by selecting a suitably restricted operational subsystem and subjecting it to scientific investigation. As indicated by Figure 2.2—the distribution of a typical staff of OR professionals by training in original disciplines—such investigations might now involve the methodological features of any of the formal and empirical sciences plus those of certain humane studies, e.g., history or political science. On the other hand, systems analysis—which Kahn and Mann [8] characterized as being to operations research what strategy is to tactics—was associated with the decidedly artful enterprise of formulating wide-scope analytical structures suitable for representation

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[9] Cf. Herman Kahn, <u>On Thermonuclear War</u>, Princeton, 1960; and "An Appreciation of Analysis for Military Decisions," E. S. Quade, ed., B-90, The RAND Corporation, Santa Monica, 19 January 1959.

DISTRIBUTION OF RAC/ORO PERSONNEL
By Original Discipline

While an increasing number of persons are currently entering the OR profession with formal training in this field, the greater number have been drawn from traditional academic disciplines. In 1965, for instance, 33 professions were represented on the RAC staff. The compositions of the 111-member technical staff of 1953 and the 259-member staff of 1965 are shown here. In large measure the changes in proportional representation reflect changes in program emphasis. With regard to categories showing considerably increased representation, mathematics and statistics are included in the Formal category; engineering and earth sciences in the Physical Sciences; economics, military science, and management science in the Prescriptive Sciences.

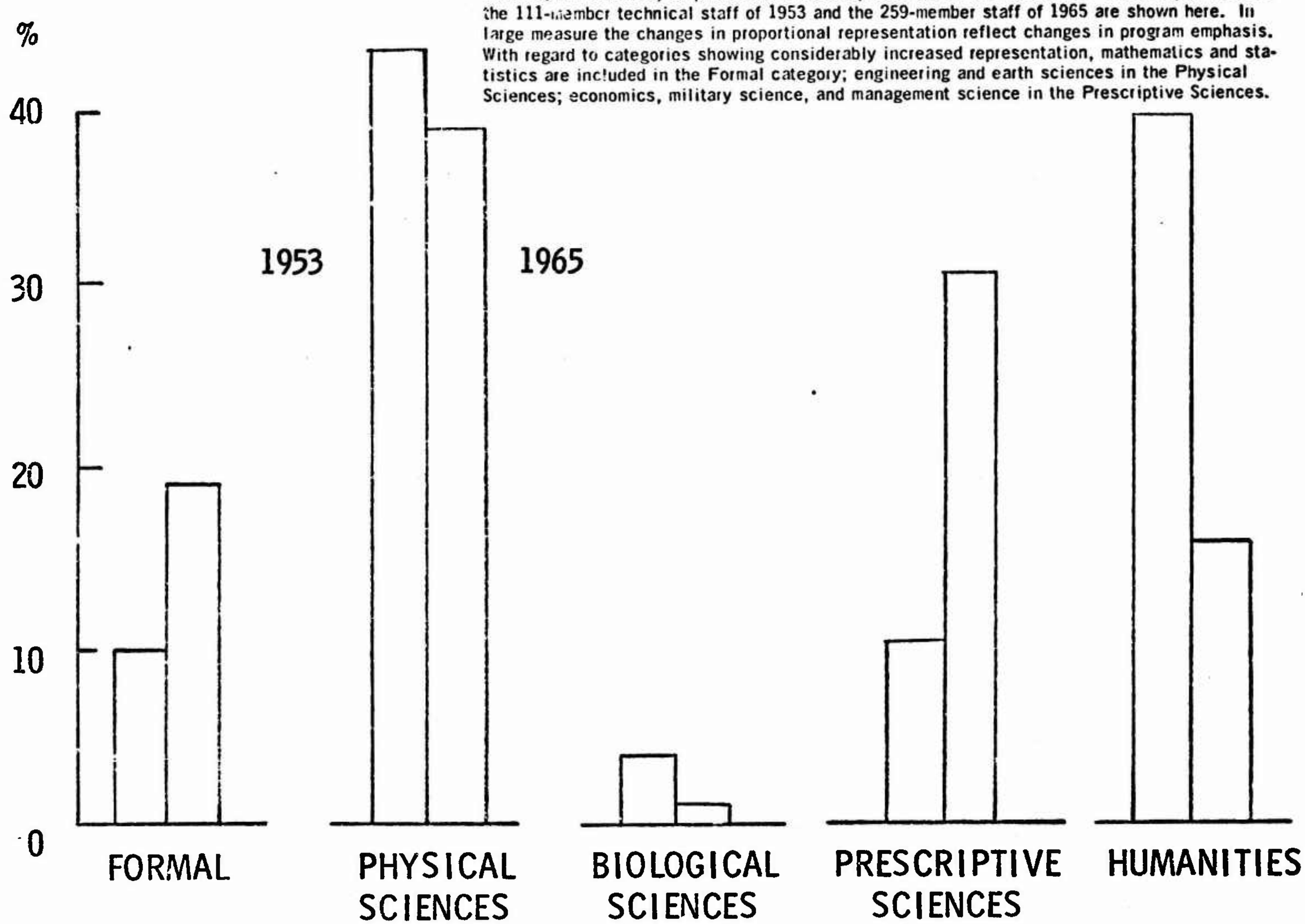

Figure 2.2

of major issues in institutional choice of program, strategy, or policy. Perhaps a more adequate way of viewing the tendency toward methodological distinctions is to couch the issue in terms of an inevitable tension that is certainly not peculiar to operations research v. systems analysis. This is the tension that tends to develop between the simultaneous but sometimes antithetical demands for both rigor and comprehensiveness in general inquiry. In the development of decision science this tension has sometimes been misconstrued in hard and fast distinctions between the objectives of micro v. macro-model construction or insistence on methodological separation of simulation and gaming[10] v. analytical formulation, as if these were alternative rather than supplementary objectives and techniques.

Increasing sophistication in both computing equipment and programming led at first toward euphoric expectations that (1) simulation of problem-solving aspects of human intelligence by heuristic programming or (2) general dependence on an incorrigible stratagem of exhaustive parametric examination of outcomes in gaming would ultimately result from clever exploitation of sheer representational capacity and computational speed. However, more realistic appraisals and cautionary papers, notably

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[10]The term "simulation" here refers to an operational model that is homomorphic to some domain of experience, that is, the characteristics of the model are in one-to-correspondence with some subset of characteristics abstracted from the "real world"—usually characteristics of interaction between observer and environment. When sequential operations of the model depend upon decisions of two or more human observers competitively manipulating the model according to different value systems, the simulation is referred to as a "game."

those of Thomas and Deemer [9] and Bellman [10], showed such expectations to be premature if not, indeed, ultimately groundless. The limitations of simulation for use in prediction and decision making—limitations of scope, predictability, retrodictability, and practicability—gradually came to wide recognition; and the complex interplay of simulation and gaming with the formulation of analytic models began to receive more balanced emphasis, not unlike that obtaining in the earlier development of micro and macro-theories in the physical sciences.

An example of the effective combination of these supplementary methods is given by the following account of successive simulations and analyses culminating in a study of continental defense conducted by Operations Research Office in this period: The first phase consisted of detailed simulations of air v. surface-to-air battles. In the second phase a set of elemental battles, highly aggregated, was designed to simulate the whole continental SAM defense in response to an integrated air attack. Problems of allocation of defensive strength as well as the effects of attack allocations were studied. These first two types of simulation consumed thousands of hours of computer time. On the basis of these detailed simulations, a greatly simplified analytic model was then conceivable. Outcomes of nuclear exchange between opponents (Red v. Blue) were represented in terms of fractional exchange between Blue cities and Red cities. National values and national military strategies were interpreted in terms of indifference conditions (equal pay-off) in the value-exchange comparison. The establishment of indifference conditions allowed the selection of a balanced mix of offensive-defensive weapons systems and left free a number of degrees of freedom in the design of the military systems. These degrees of freedom were consumed by imposing minimum cost requirements. Thus a strategic decision problem, initially quite imposing both as to scope and complexity, was ultimately representable in mathematical form as a nonlinear dynamic programming problem. Under suitable interpretation, the optimal solution for this abstract extremalization problem specified a unique mix of offensive-defensive weapons systems designed to accomplish the military task of continental defense at minimal cost.

The important realization was that simulation and gaming could achieve pay-off without being extended to impracticable conditions of realism that would generally be required to support explicit directions for decision making. Micro-models, and especially the intuitive experience and training derived from their construction and operation, were found to be most productive as sources for the insight necessary to the formulation of mathematical macro-models that admit of optimization by analytical procedures.

Management Science—Technological and Theoretical Variations. The termination of World War II constitutes a definite historical marker that we have not hesitated to use in distinguishing two stages of development in military operations research/systems analysis. It should be made clear, however, that the rise of decision science, in general, does not admit of segmentation into successive periods. The headings of our historical abstract denote—not periods of development—but, rather, synchronic lines of development that comprise a singular but complex evolutionary phenomenon. All of these lines of development originate together in considerations that were present, though not fully appreciated, in the beginnings of operations research. But they have come to prominence in successive periods, by differing processes and rates of growth; and they have been characterized by terminological distinctions that serve very well to elaborate the several principal features of decision science, however spurious such distinctions may prove to be on principle.

A proliferation of decision science, a "fanning out" of variations specially adapted to different contexts of decision by articulation and exploitation of numerous methodological resources: this is our impression in the large. With the introduction of still another designation, "management science," we therefore mean to delineate merely the particular form[11] that decision-oriented research has taken under adaptation to the context of managerial decision making specific to the industrial, military, and governmental institutions of a society in which technological progress is supported by professional organization and academic programs of instruction and research. Under this heading we review, essentially,

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[11] Regrettably it is necessary to keep abreast of what must seem an interminable succession of qualifications on terms. We use "management science" throughout this section in the sense intended by those who first espoused this designation for a particular professional specialty distinguishable from operations research. Our appropriation of this term for broader use as a species-designation will be reserved to later use after some justification has been offered.

just the trend toward technical and theoretical specialization entailed by attempts to apply decision science, as a new management technology, throughout an advanced industrial society.[12]

The progressive attitude of American business and industry, the traditional emphasis on increased productivity and efficiency, and particularly the familiar uses of industrial engineering studies, served to make operational research an activity almost immediately acceptable to industrial management. In certain respects its application in this sector seemed particularly promising: the purpose of an industrial organization is readily definable and measures of effectiveness—in this case, measures of efficiency, profit, proprietorship, and the like—have long standing identification. Table 2.2 lists typical subjects of early successful studies indicating that in a wide variety of applications operational analysis could yield impressive pay-off. But one of the most significant functions of this type of research, namely, the isolation of previously unrecognized problems, tended to yield an embarrassment of riches. In each of three major sectors—optimal allocation of resources, maximization of effectiveness, operational planning and control—problems that were technically formulable turned out not to be at all tractable

[12] One might reasonably attribute advanced industrial status to all countries that now have OR-related professional societies. This would include, at least, all the major countries of Western Europe, Canada, India, Japan, Australia, and Greece. The USSR also is known to have comparable professionals whose activities are usually subsumed under economics or cybernetics. We undertake only a provincial view limited to the U.S. alone; however, this country is admittedly the leading exponent of the practice of management science.

TYPICAL SUBJECTS[13] OF EARLY COMMERCIAL-INDUSTRIAL OR STUDIES

Inventory Control: Smoothed Purchase and Production Rates
Distribution of Shipments in a Small Mail-Order Business
Effect of Night Openings on Department Store Sales
Department Store Newspaper Advertising
Effect of Promotional Effort on Sales
Optimal Factory and Warehouse Location
Optimization of Chemical Plant Outputs
Reliability of Airborne Radar
OR in Agriculture: Planting-Harvesting Programs
Strip and Underground Mining Operations
Failure Analysis for Complex Equipment
Traffic Delays at Toll Booths
Influence of Vehicular Speed and Spacing on Tunnel Capacity
Road Safety and Traffic Research
Ore-Handling by Port Facilities
Freight Car Distributions in Classification Yards

Table 2.2

[13] For detailed accounts and bibliographic information on specific studies under these topics, see McCloskey and Trefethen [3] and *Operations Research for Management*, vol. 2, J. F. McCloskey and I. M. Coppinger, eds., Johns Hopkins Press, Baltimore, 1956.

to simple or straightforward techniques of analysis and, indeed, sometimes not amenable to treatment by any existing methods whatever.

In large measure this situation, so different from that experienced in early military operations analysis, was attributable to a basic disparity between military v. corporate decision systems. Among the more obvious factors of this disparity are (1) comparative hierarchical complexity of structures, functions, values, norms, goals and (2) comparative variability of environment, continuity of experience, degrees of risk, and efficiency of operations. Table 2.3 outlines a comparison of these disparate types of organization in terms of such a factorization. The inference is plain: to undertake continuing improvement of operational decisions in the highly codified, competitively developed context of comerce and industry is to enter a new game—a less desperately risky one than the military, but certainly one in which continuing pay-off demands successively more specialized elaboration and refinement of methods and techniques. Essentially the shift is toward emphasis on marginal economic and operational analysis, and thus toward formulation of rigorously detailed mathematical models, decision theories and algorithmic procedures of optimization. Toward this effect the development of professional societies and academic programs of instruction and research contribute by mutual reinforcement, the societies serving to evoke awareness of multitudinous possibilities for implementation of advanced decision-theoretic techniques and university curriculum development and research tending to produce new professionals oriented toward the exploitation of technical specialties.

DISPARITY IN PROBLEMATIC SITUATION

Military	Civilian
Hierarchical (systemic) complexity	Aggregational/Combinatorial Complexity
Values/Norms varied and intangible; complicated by peace-war transitions	Values strongly polarized on ~~monetary~~ monetary gain
Decision strongly coupled to variable environment	Weakly coupled, environment less variable
High risk at all levels, institutional & individual	High risk only for some corporate levels
Low efficiency (wartime) and preparedness overhead in peacetime	High efficiency

Table 2.3

As early as 1952 operations research was a recognizable component of the American business and industrial enterprise, though the professional nature of this activity was obscured by differences in job classifications keyed typically to distinctions between production, distribution, marketing, and sales. Unifying professional structure began to develop in that year with the organization of the Operations Research Society of America (ORSA). The early growth of that society is displayed in Figure 2.3; its membership has approximately doubled thus far into its second decade, and since 1957 it has participated with similar societies of some 20 foreigh countries in The International Federation of Operations Research Societies (IFORS).

The Institute of Management Science (TIMS)—a professional society whose history is comparable with that of ORSA in terms of growth of membership, journal circulation, and international affiliations—was founded in 1954. The sense of necessity for a society (TIMS) differentiated from its parallel (ORSA) primarily by an explicit management-decision orientation might, of course, be immediately regarded as exemplifying the specialization in decision science that we emphasize in this section. The initiation and growth of TIMS does indeed confirm the tendency toward specialization; but it does so precisely because the rationale of that organization features, along with more technical aims, the <u>need</u> for counter-emphasis on (1) mutual accommodation of executive and scientific-advisory roles, (2) adequate understanding and effective managerial implementation of scientific techniques that must

ORSA MEMBERSHIP

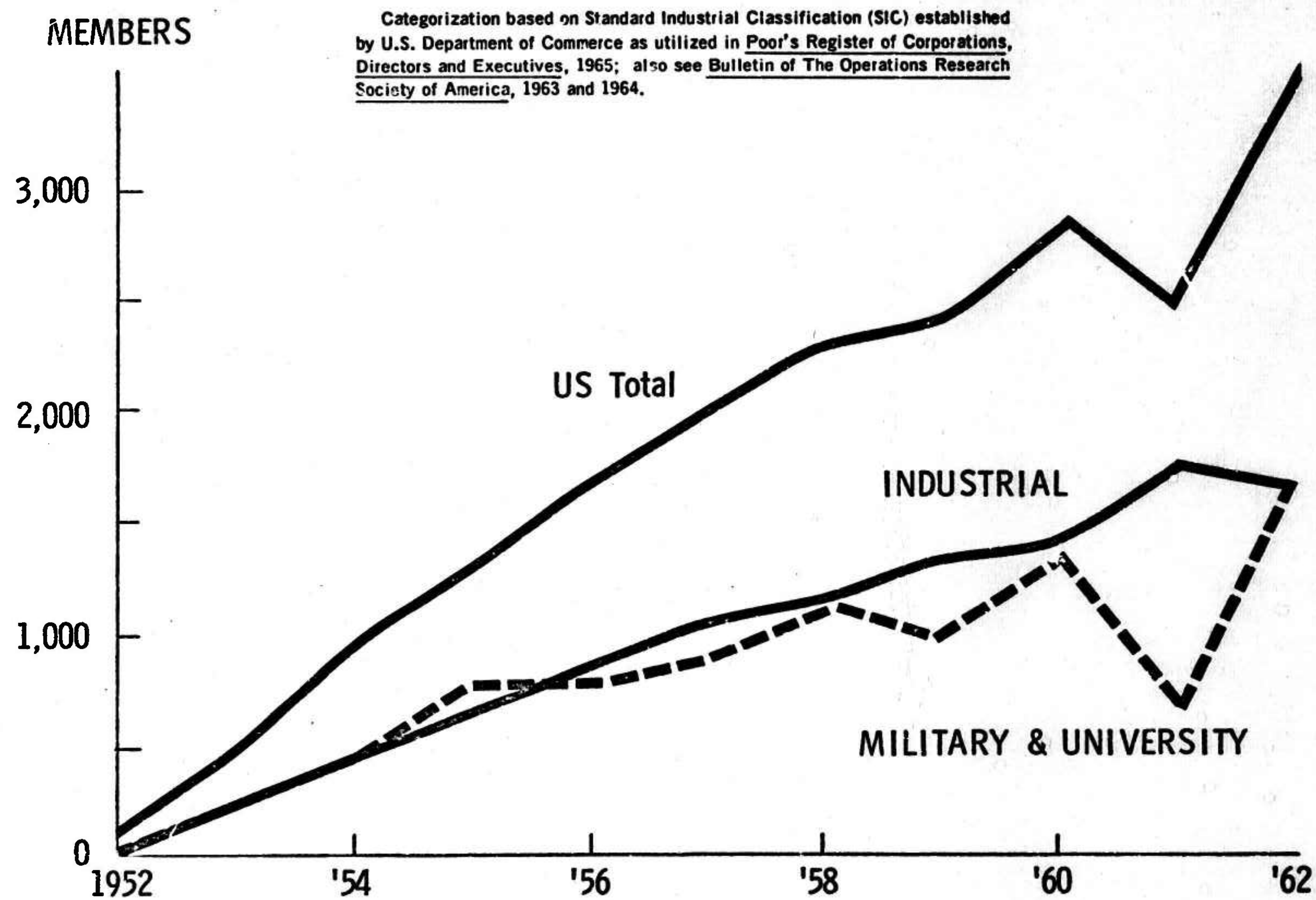

Figure 2.3

often seem esoteric, and (3) motivation of methodological research on critical management decision problems that, because they can be only poorly structured, are normally anathema to the scientific purist. Such a countertrend, while eminently sound in concept, nevertheless makes headway only very slowly in the face of quite legitimate requirements for specialization and the overwhelming preference of the scientific temperament for the more technical emphasis.

Meanwhile, the very locution "management science" has served admirably to secure accommodation for essential tasks of theoretical development and technological implementation within traditional corporate and academic departmental structures. Under this head the novel character of decision science could somehow be construed as a known quantity. Research personnel assignment by familiar managerial provinces and curriculum development within established academic sectors of business management, industrial engineering, and the like, could thus proceed under the controls of a respectable professionalism.

At the time of the earliest recognition (1952) of operations research/management science as an established profession, three universities (Johns Hopkins, Massachusetts Institute of Technology, and Case Institute of Technology) were already offering related seminars or special training programs. Curriculum development had proceeded by 1963 to the extent that courses of undergraduate instruction were offered in this area of study by more than 30 colleges and universities.[14]

[14]Cf. "Special Report of the Education Committee," Bulletin of the Operations Research Society of America, Spring 1963 and Spring 1964; Clarence Lovejoy, Lovejoy's College Guide, Simon and Shuster, New York, 1961; The College Blue Book, Christian Burckel, ed., Yonkers, New York, 1962.

Pioneers in granting Ph.D. degrees in operations research were The Johns Hopkins University with its first in 1954 and Harvard University with its first in 1955; in addition to these, graduate training in OR/MS is now offered by Case Institute, Carnegie Tech, Cornell, MIT, Northwestern, Stanford, and the state universities of California, Maryland, Michigan, New York, North Carolina, and Pennsylvania.

The mark of established professionalism is always an elaborate structure of specialized technical capabilities. Consonantly the developing professionalism of management science—supported by concerted methodological emphasis in corporate-industrial, semi-academic nonprofit, and university research—has been displayed in a burgeoning collection of analytical techniques that can be assembled under the general rubric of decision theories and procedures. The entire complex of decision-theoretic disciplines may be understood collectively as representing the maturation in operational research of the general scientific dependence on abstract, quantitative analogs—usually formal mathematical models—that admit of interpretation in innumerable particular contexts of practical experience. An infantry company, an air squadron, a factory, a sale organization, a traffic control system, a data processing system—various as they may be in substantive terms—nevertheless are each characterizable by some pattern of operations. Insofar as subsystemic similarities of operational patterns legitimately admit of a singular abstract characterization, a given technique of mathematical modeling and analytic simulation may conceivably prove applicable and fruitful for understanding, and hence improving, control or design in any number of particular instances. The great range and variability of specific applications of decision-theoretic techniques, in fact, makes the output of applied technical papers in this field the despair even of the bibliographer much less the historian. The usual way of categorizing this complex of technical capabilities is by parent disciplines such as economics, applied mathematics, or control engineering. For our purpose, however, the principal research areas of management science serve better, as in Table 2.4, to distinguish three principal classes of decision theories and procedures that have been brought well toward maturity from barely rudimentary beginnings that existed some 15 years ago. As the most spectacular development in this sector, mathematical programming particularly illustrates the tendency toward proliferation of related types of analysis following initial success. Table 2.5 shows the predominance of variant forms of mathematical programming among existing algorithmic decision techniques, and Table 2.6—taken from our technological forecast for management science (c. 1963)—gives some appreciation of the combinatorial features of variant decision procedures, with updated subjective estimates of their comparative states of advance relative to an arbitrary scale (0 - 10).

The generalized managerial functions of resource allocation and operational planning/control, to which this battery of decision techniques has been chiefly addressed, are not endemic to commercial-industrial enterprises alone. These functions, as well as the characteristic

DECISION THEORETIC DEVELOPMENT IN MANAGEMENT SCIENCE

Research Areas	Relevant Disciplines
OPTIMAL ALLOCATION	Plan-Program-Budget Technique; Cost Analysis; Microeconomics; Utility Theory; Mathematical Programming; Program Analysis Resource Management Techniques
MAXIMAL EFFECTIVENESS	Markov and Queuing Processes; Sequencing Theory; Statistical Decision Theory; Mathematics of Optimal Control; Systems Engineering/Analysis; Cost-Effectiveness Analysis; Mathematical Programming
OPERATIONAL PLANNING/CONTROL	Inventory, Production, and Quality-Control Models; Distribution and Service Systems; Macroeconomics; Input-Output Tables; Graphs and Network Flow Models; Game-Theoretic Models; Program Evaluation Review Techniques

Table 2.4

Decision Algorithms in Management Science

- Linear programming
- Non-linear programming
- Stochastic programming
- Interger programming, linear
- Interger programming, non-linear
- Dynamic programming
- Combinatorial programming
- General programming
- Logistics theory
- I/O analysis, linear
- I/O analysis, non-linear
- Graph theory
- Queueing theory
- Communication theory

Table 2.5

RESEARCH TASKS

THEORY OF DECISIONS

Symbol	Common name	Status of Exploitation
$\overline{P}, S, \overline{G}, \overline{T}, F, \overline{C}, \overline{N}$	linear programming	9
*$\overline{P}, S, \overline{G}, \overline{T}, F, \overline{C}, N$	non-linear programming	4
$P, \overline{S}, \overline{G}, T, F, \overline{C}, \overline{N}$	Markov dynamic programming	2
$\overline{P}, \overline{S}, G, T, F, \overline{C}, \overline{N}$	dynamic (mono-spatial) programming	7/3
$\overline{P}, \overline{S}, \overline{G}, T, \overline{F}, C_1, \overline{N}$	traveling salesman	4
$P, \overline{S}, \overline{G}_1, T, F, C_0, \overline{N}$	queuing	6
$\overline{P}, S, \overline{G}, \overline{T}, F, C_3, \overline{N}$	graphs	3
P, S, G, T, F, C_i, N	general	0

Table 2.6 (a)

THEORY OF DECISION

SYMBOLS

P = probabilistic	$\overline{P}$ deterministic
S = multidimensional decision	$\overline{S}$ mono-dimensional decision space
G = multiplayer	$\overline{G}$ single player
T = dynamic	$\overline{T}$ static
F = functional restraints	$\overline{F}$ functional restraint not in effect
C = combinatory restraints	$\overline{C}$ combinatory restraint not in effect
N = non-linear	$\overline{N}$ linear

Table 2.6 (b)

problems of logistics, scheduling, equipment acquisition by research and development, utilization of manpower and facilities, are also common factors of economic existence for military and governmental agencies, which in this sense are "big business." By far the most extensive implementations of new technical capabilities in management science have occurred in managerial versions of military command: for example, Army logistics and equipment maintenance scheduling; Navy ordnance-acquisition, as in the POLARIS weapons system development that occasioned the invention of PERT-type analysis; optimal design and cost-effectiveness analyses for Air Force continental defense systems. In one extremely significant prototype-problem—the military managerial experience no doubt anticipates the forthcoming need of industrial and governmental administrators for advanced decision models and analytic procedures capable of treating the replacement scheduling of entire complexes of systems simultaneously, as in sectional or national problems of transportation, urban planning, medical services. One indication of the leading role of military managerial problems is the activity, now of several years standing, known as the Joint Study Group on Military Resource Allocation Methodology. Despite the purposeful informality of its organizational structure, this specialized working group has consistently maintained all the internal technical functions of a full scale professional society.

The introduction of management science in U.S. Government agencies other than the Department of Defense has been accepted relatively slowly.

Recent developments, however, indicate rapidly increasing emphasis in this field. The institution of nonmilitary operations research groups in government occurred earliest (c. 1964-5) in the Bureau of Standards, Census Bureau of the Department of Commerce, Social Security Administration, U.S. Office of Education (HEW), Budget Bureau, Internal Revenue Service, and Bureau of Labor Statistics. Early specific applications of operational research to governmental problems, as noted by the Deputy Director, U.S. Bureau of the Budget,[15] include TVA use of alternative power sources to meet fluctuating demands, the Interstate Commerce Commission's translation of national transportation policies in individual rate cases, and acceleration of Post Office mail handling operations. Page [Ref 5, pp. 16-20] reports that a conference in April 1966 disclosed 52 government offices or agencies with operational studies underway; and he provides a complete list of those agencies with some indication of problem areas. This new trend in government was brought to the level of national administrative policy by President Johnson in his press conference of 25 August 1965, when he issued in part the following statement:

> This morning I have just concluded a meeting with the Cabinet and heads of each of the federal agencies, and I have asked each of them to introduce a revolutionary system of planning, budgeting and programming throughout the vast federal government . . . . Under this new system, each Cabinet and agency head will set up a special staff of experts who, using the most modern methods of program

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[15] See Staats, E. B., "Applying Operations Research and the Management Sciences to the Problems of Government," Management Science, 11: 4, February 1965, pp. 6-12.

> analysis, will define the goals of their department for the coming year. Once these goals are established, this system will permit us to find the most effective and least costly alternative [in] achieving American goals.

The utilization of management science now extends also into other public service agencies of local, state, and sectional scope. In the medical services sector, Flagle, et. al. [11] have reported impressive work in hospital management at The Johns Hopkins University Hospital. Related potential areas show at least the beginnings of effective use: public health, disease prevention, pollution control, traffic accident prevention.[16] Problems in urban affairs—law enforcement, waste disposal, environmental control and design, transportation and traffic control—generally require at least state-wide coordination; and to this end several state governments, notably California and Colorado, have recently supported scientific-advisory studies. Perhaps the most technically sophisticated effort on a public interest problem thus far is the Northeast Corridor Transportation Study, jointly conducted by a number of government agencies by virtue of its sectional scope. In this connection Aronoff and Levin [12] of the National Bureau of Standards described a multistage computer simulation of a network involving aircraft, railway, bus, and private car transportation for the megalopolis now developing in northeastern U.S. Interdisciplinary studies combining economic, engineering, demographic, and geographic aspects of optimal design for future social-industrial needs have been required in obtaining relevant input.

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[16]Cf. Progress in Operations Research, vol. 2, D. B. Hertz and R. T. Eddison, eds., listed as part of Ref. [4].

In all public service problems, of course, the practice of management science encounters difficulty with the very characteristics of decision-oriented research that the term "management science" emphasizes: that is, (1) sensitivity to the actual exigencies specific to a given context of administrative decision and (2) consideration of the values of a client-organization as represented by its responsible officials. Purposes and goals for governmental or other public service activities are frequently only poorly defined. Political and ethnic factors, which the scientist might be prone to regard as extraneous to "rational" problem solving, prove to be distressingly significant. Effectiveness measures, or even more generalized measures of merit for public services, are difficult to identify unambiguously and particularly resistant to quantification.

In the extreme these difficulties sometimes limit systematic analysis to the most rudimentary cost-effectiveness comparison of alternatives for executive decision. However, the full spectrum of technical capabilities in management science, and the varied applications reviewed here, indicate that management science must rightfully be construed in terms of (1) a new technology that increasingly tends toward envelopment of all the major institutions of practical life and (2) the exploratory development of novel analytical modes that such a technological advance requires for its support in formal scientific inquiry.

Interim Characterization of Management Science

At this stage we reach a plateau of development in the science of management decision, something like an end to the beginning. The maturing of professionalism marked by an impressive range of technical capabilities indicates the completion of at least a distinguishable phase of growth. Summarization of first-generation characteristics at this point will admittedly be provisional, but some such half-way house is an obvious requirement; we must try to provide a reasonally stable perspective from which both the confusing past and the unfolding future of management science can be comprehended.

It will not have gone without notice that while we have engaged at some length as if in reply to implicit questions such as Who does management science? What has been done? Where and how? What is the current state of the art?, we have nowhere undertaken any response to the first question that would normally be raised: What <u>is</u> management science? This omission, of course, has been intentional. Premature attempts to fix the domain and characterize the essential nature of management science have created a literary constellation of definitions whose actual service—though not an inconsiderable one—has been mainly to disclose additional innovative features of the science and its relevance in common to a wide variety of interests and approaches extant in specialized types of investigation. It is for this reason that we have thought it preferable to attempt first the development of an intuitive sense of the whole by a sheer account of many different types of problems and practices, theories and techniques of analysis that have evolved. There is no thought of shifting the burden of specification to the reader by invoking some vacuous "operational" characterization as a ploy, e.g., management science is what management scientists do. We have a responsibility to proffer in turn our own explication of the term "management science," but short of dependence on some prior intuitive grasp of the phenomenal complex that it denotes, it is improbable that any definition could be persuasive.

Among those practitioners who have participated in the experience of raising and attempting to codify this multidisciplinary sector, our sense of discretion in the matter of definition will have become instinctive. There is little doubt, however, that discretion will have been acquired rather quickly even by those whose appreciation of the new science of management decision may have been based solely on our previous account. First, the several shifts in nomenclature that have been noted indicate that, in terms of content, there are a great many possibilities, each of which might with good reason be featured. If it seemed promising to do so, one could construct a two dimensional array of terms, on one axis listing key substantive terms such as analysis, research, engineering, science, methods or methodology, and on the other, key qualifiers, e.g., operational, economic, industrial, systems, and the like. Practically every possible combination resulting would then be found in use in some association with the areas of investigation we have treated under the term "management science." Table 2.7 lists the principal labels that

THE TERMINOLOGY EXPLOSION

Operations Analysis	Industrial Engineering
Cost-Effectiveness Analysis	Systems Engineering
Systems Analysis	Value Engineering
Operations Research	Resource Allocation Methods
Systems Research	Optimization Methods
	Macroeconomics

Table 2.7 Activities Grouped Under the General Term "Management Science"

have had some claim to fashion at one stage or in one phase of development. Attempts have sometimes been made to differentiate among these as specialized but related terms. This is especially common in industry, where sharp distinctions among job specifications are made in order to maintain a corporate order of dominance. Elsewhere certain of these designations have been treated as synonymous; frequently, particular ones have been used locally as a covering term for all the related activities suggested by connotation.[17]

Second, the rise of management science is clearly marked by successive eruptions of tension between supposedly antithetical aspects of mode, method, professional competence or responsibility, and scope of research. Controversies have opened, for example, between proponents of a formalist orientation, in which mathematical modelling would be viewed as the only legitimate role of the analyst, as against other groups of professionals advocating the empiricist orientation of objective-predictive physical science or even a synoptic orientation toward treatment of the fullest range of social and political problems under the guise of a frankly artful rather than a scientific approach. Other sources of incipient controversy are recognizable in the tensions we noted between approaches emphasizing (1) holistic v. marginal analysis, (2) analytic macromodelling v. detailed simulation and gaming, (3) limitation of professional advisory services to the formal structuring of alternatives for executive decision as against the proffering of a predictive model or, even further, explicit recommendations for management decision. In this context of bewildering counter

[17]We have earlier had occasion to indicate the arbitrary character of our own decision to use the term "management science" in this way.

claims, it is certainly not surprising that early definitions of management science have been notable primarily for their extremely short half-life. It remains to be seen whether a latter day definition, with discussion of the general method and the unique character of management science, can even yet attain to a comprehensive characterization. That the result will be at best an interim characterization we can be sure, inasmuch as it will have been constructed to admit of amplifications that we already expressly intend.

What Is Management Science? In the existing literature one has access to a dozen or so authoritative definitions of management science by early commentators—each one different in some respect. Collectively, the mounting number of distinctions testifies to an extremely rapid revision of perspective as additional aspects of decision-oriented analysis, disclosed initially in specific problems, have been progressively incorporated into the general notion of a "science" of decision. In any search for landmarks, two earlier definitions of operations research would be obvious candidates due to their enunciation of fundamental innovations in scientific mission and mode respectively. Morse and Kimball [13] in 1951 characterized operations research as "a scientific method of providing executive departments with a quantitative basis for decision regarding the operations under their control." The traditional idealized detachment of scientific investigation from practical decision and action could not, thereafter, be a credible feature of inquiry conducted under an explicitly advisory scientific mission. Rumbaugh [14], on the later occasion of the 20th anniversary of the Operations Evaluation Group, defined operations research as the study of "interactions between men and things, operating in concert or conflict, concerning present and future competitive systems in complex fluctuation experience." Here the idealized mode of empirical science, i.e., the insistence on replication of controlled experiments, is disclaimed—not indeed, as undesirable but as generally unattainable—in management science.

Embodied in many further elaborations on distinctions of mission and mode—each of which has at some time been separately codified in one or another characterization of management science—there are definitive features which practically all practitioners would now admit as common to their respective activities:

> A client who is the commander or manager of an organizational unit involving both human and material resources;
>
> The client's decision problems relating to his goals, values, policies, and organizational mission;
>
> A professional contribution to the client's decision which may range from assisting the responsible administration to an outright recommendation for an action—all agree, however, that the management scientist does not make decisions for the client, that is, he has no delegated responsibility. He acts as an advisor.
>
> A method which the professional analyst brings to bear on the decision problem which purports to lead to better decisions, i.e., to decisions which increase the client's chances of achieving his goals. Although many in our profession call this method "scientific," we shall claim later that this is not quite apt but that the method constitutes an important innovation in the basic mode of rationality itself—one which the scientist has learned in part from the manager.

The improvements claimed in the client's decisions are made at the expense of time (in addition to payment for professional services).

Dispensing with the hope that any succinct definition could cover all these considerations unambiguously, we try in Table 2.8 to weld them into some passable linguistic whole, however unwieldy. It is clear that no such compendium-definition can serve effectively as an immediately interpretable synonym. We intend it to serve more as an exercise which, when worked through, will at least fix the scheme of related ideas that we think important to have in mind as a basis for detailed comprehension of all that the term "management science" signifies in our usage.

General Description of Method. The composite method of management science, as we ve intimated already, essentially comprises orderly procedures analogous to those that we have come to associate with responsible and competent technical practices in general—modified, however, by certain aspects unique to this newest of the professions. Described in terms specially appropriate to management science, these procedures may be grouped into six categories:

(1) diagnosis of a client's decision problem(s),

(2) formulation of a decision model,

(3) quantification of the model,

(4) identification or selection of relevant measures of effectiveness, i.e., value-parameters appropriate to the model,

(5) manipulation of the model (experimental simulation, analytical derivation, computation) in a search for solution,

DEFINITION OF MANAGEMENT SCIENCE

Management Science: a technical-advisory activity, a	PROFESSIONAL PRACTICE
providing the executive officer(s) of a	CLIENT ORGANIZATION
with assistance in their determination of	INSTITUTIONAL DECISIONS
relevant to a specific (though provisional)	PROBLEM CONTEXT
by professional application of a	COMPOSITE METHOD
incorporating selected regimens of scientific investigation with deliberative value-judgment in programs of	MULTIDISCIPLINARY RESEARCH
aimed at the prescription (conditional specification or explicit recommendation) of	"BETTER" DECISIONS
i.e., decisions that tend to increase the probability of the client's attainment of	IMMEDIATE OBJECTIVES
while being (1) ADMISSIBLE with respect to the client's	VALUES, POLICIES, LONG RANGE GOALS
and (2) PRACTICABLE with respect to the client's	RESOURCE CONSTRAINTS

Table 2.8

(6) communication of conclusions to the client and, sometimes, assistance toward their effective implementation.

The basic similarity of this format to that which we ordinarily attribute to, say, a medical practitioner is quite obvious. With even the most casual examination of the content of these general categories in the two cases, however, it is almost equally obvious that strikingly novel considerations have been introduced in the practice of management science: for example, formalized cognitive models replacing expert intuitive grasp of a total problematic situation; encounters with extremely controversial valuative issues as against the clearly dominant value of human life; massively detailed and imposingly expensive programs of multidisciplinary analysis and research versus the relatively well established repertoire of medical therapy; communication and implementation of recommendations without recourse to the rather absolute technical authority that the physician usually commands in his professional relation with his patient.

In view of the injection of so many innovations of practice peculiar to management science—and significant modifications in addition to those suggested will be readily discernable—it will be helpful to have at least a brief commentary on method specific to management science, under each of the procedural categories above.

(1) Diagnosis. We have emphasized in defining operations research that its practice hinges on specific decision problems. Every analysis must begin with a statement of the decisions being faced. The situation, however, is not always this simple. Frequently the client is unaware

of the decision area that is actually most appropriate. A classic example of this situation in diagnosis is given in Thornthwaite's [15] analysis of the operation of Seabrook Farms, a large-scale vegetable growing, packing, and distributing company. Thornthwaite was engaged by the company to study a labor relations problem brought about by the necessity for employing large numbers of transient workers during short peak harvest seasons. These transient workers raised numerous social problems among the permanent settlers in the community. The client asked for solutions to these social problems. Thornthwaite did not, however, apply himself immediately to the indicated problems. Instead, he identified and solved an underlying problem: the scheduling of fruition in such a manner that harvests were spread out over a much longer season. With employment of a stable work force, the previous labor and social problems disappeared.

At present there exists no straightforward technique that could be regarded as an adequate directive in diagnosis. This stage involves information gathering and tentative factorization of the problematic situation, performed iteratively with feedback from the next stage (model building), the whole process comprising a creative act that places great demand on intuitive insight. It is for this reason that the professional analyst, by virtue of this very lack of indoctrination, can often produce a correct diagnosis of a situation to which the client management system has been blinded by its own bias. In illustration of this effect, Figure 2.4 is a schematic representation of an organization, typically designed to enable a group of persons to execute collectively a very complicated

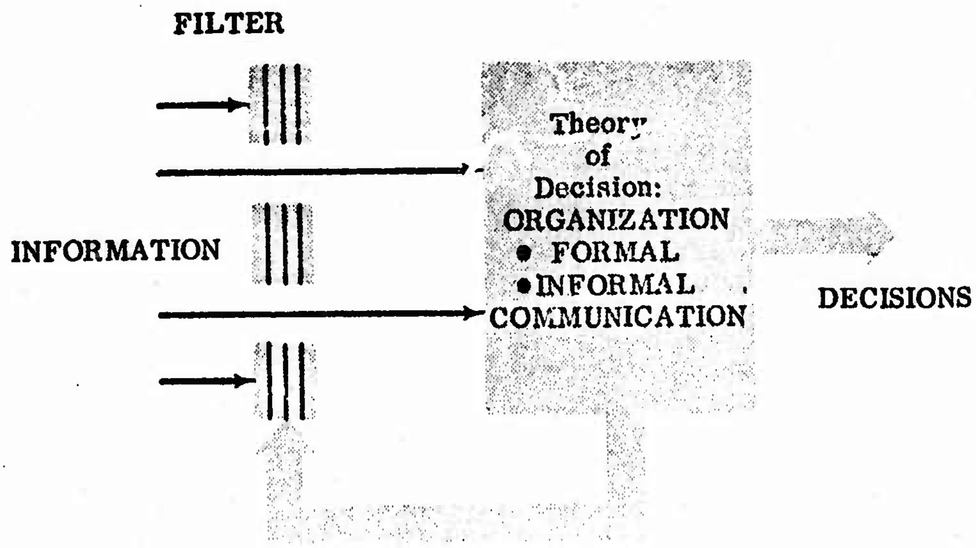
FILTER
INFORMATION
Theory
of
Decision:
ORGANIZATION
• FORMAL
• INFORMAL
COMMUNICATION
DECISIONS

Figure 2.4

process of decision making. For this purpose it is structured as a hierarchy with specialized functions and responsibilities at each level. Suppose that, in order to operate as efficiently as possible, each component of the organization is constrained so as to receive just that type of information needed to perform its function and no other; the organizational structure will then be interleaved with information filters (represented collectively as one filter in the figure). A destructive self-reinforcing situation then becomes all to readily conceivable: The adequacy of the filter must be judged on the basis of the information it allows to pass. This information may indicate that the filter is properly designed—precisely because the filter happens to let through only the kind of information that substantiates this conclusion—while the organization may be making decisions, on the whole, leading toward potentially disastrous consequences that cannot be detected except by modification of the filter. One of the most important functions performed by the management scientist engaged in diagnosis is a purposeful, or even random, relaxation of such organizational filters in order to ascertain whether the decisions being made are stable under confrontation by additional information that is presumed to be extraneous.

The analyst, however, is not immune to the very danger that he descries. Since any decision model that he later constructs will necessarily constrain the types of information that are acceptable, his hypothesis (model) and its characteristic types of "relevant" (filtered) information may objectionably reinforce each other. Against this possibility he must continually bring to bear a self-critical awareness; but, in addition, he has the resource of bringing many viewpoints to bear through the technique of the open conference. In such conferences, as employed in both diagnosis and model building, individuals with diverse claims to expertise and experience are encouraged to relax habitual constraints of technical rigor and to take a "think-piece" approach to a given problem area.

(2) Decision Model. The idealized objective in formulating the model is (1) to incorporate all those factors which significantly affect the outcome of decision (2) without overloading the limited capacity of investigators to comprehend and manipulate even a simplified representation of an actual decision situation. The problems faced usually involve a very great number of factors with complex interrelationships; the first necessity therefore is that the model be kept as simple as possible. The exclusion of properly negligible factors is perhaps the most familiar strategem of systematic investigation; it is, in fact, the principal strategem that has made objective science possible. For example, in the Newtonian characterization of the motion of an object under gravity in a vacuum, this strategem results in a legitimate abstraction that disregards all of the properties of the object except mass and position. (Later refinements, of course, did require the inclusion of other properties, e.g., the distribution of the matter compromising the object.) The management scientist naturally attempts to secure this powerful advantage of abstraction. All to frequently, however, the nature of his problem will not admit of adequate representation

in terms suitable for abstract treatment even by the formal disciplines specially developed in the decision-theoretic sector; the main chance in model building then devolves upon the technique of operational systems simulation.

The attempt in operational simulation is to design a model each component of which is the logical counterpart of an important subprocess of an actual operation. These components are related in the model by formal-procedural analogs of operations that occur in the real situation. The formulation of such models involves the orderly sequential arrangement of these formal operations in the form of a flow chart. Wherever the operation being simulated involves a stochastic process (for example, the striking of target aircraft by surface-to-air missiles), branching is introduced into the flow chart and a particular outcome is simulated by making a random selection from a probability distribution of the chance factor. One can thus simulate an entire sequence of elemental actions that result in a particular over-all outcome. Repetitions of the simulation beginning each time with the same initial conditions will, in general, lead to a different outcome. From the distribution of outcomes, the average or the expected outcome can be determined, as well as the probability with which the expected outcome will be more or less desirable than any predesignated result.

Operations simulation is rendered feasible only through the application of large scale digital computers capable of high speed execution of the massively detailed logical operations required. To study many different factors and the effects of their variation, it is necessary to make approximately the same number of repetitions—usually of the order of a hundred—for each correction studied. A complete analysis of this type, then may very well entail computational demands that begin to approach what Ashby [16] has termed the "number barrier." Figure 2.5, after Ashby, presents numbers of elemental operations associated with various kinds of sequential or aggregate processes; the numbers are scaled by a rough log log plot. Numbers of operations ranging from 10^1 to 10^{15} might be termed the "computational range"; from 10^{15} to 10^{100}, the "astronomical range"; and from 10^{100} up, the "combinatorial range." A simple simulation involving all the details of men, weapons, and terrain of a battalion-sized unit can, in principle, be loaded on a computer that is big enough. However, anyone committed to finding the best tactic by the simple-minded procedure of investigating all the possible histories of engagements has selected a program involving calculations numbering in the combinatorial range, e.g., 10^{500}—which, as Ashby says with notable understatement, is a very large number indeed. (The number 10^{100} represents perhaps the actual barrier, since it is inconceivable that one could even approach this number of calculations—let alone exceed it.) Obviously this is not the way to solve problems. A present-day computer can produce 10^9 calculations/hr. The very fastest computer foreseeable in the future of hardware technology may produce about 10^{15} calculations/hr. The gap between 10^9 or 10^{15} and 10^{500} indicates the futility of any hope for overcoming the fundamental difficulties of model building by brute force

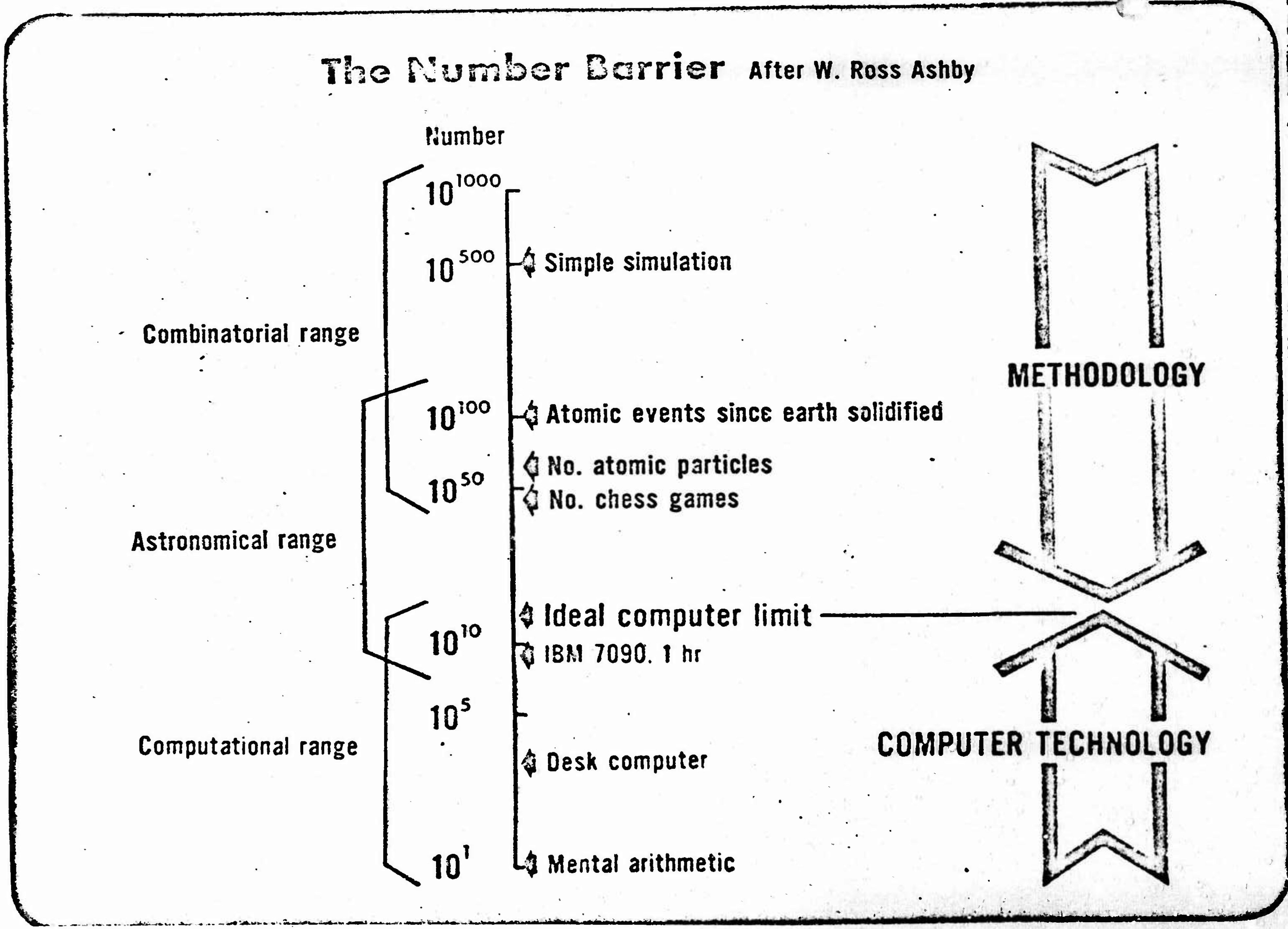
The Number Barrier
After W. Ross Ashby
Number
10^{1000}
10^{500}
10^{100}
10^{50}
10^{10}
10^{5}
10^{1}
Simple simulation
Atomic events since earth solidified
No. atomic particles
No. chess games
Ideal computer limit
IBM 7090. 1 hr
Desk computer
Mental arithmetic
Combinatorial range
Astronomical range
Computational range
METHODOLOGY
COMPUTER TECHNOLOGY

Figure 2.5

of technological development. The number barrier must either (1) be accommodated by strict reduction of the scope of decision problems accepted—a consequence that does not promise much for the future of management science—or (2) be circumvented by a more sophisticated methodology.

Two major lines of development that have been envisioned are (1) creative conceptualization of macromodelling approaches and (2) heuristic method. The first of these was advanced by Lanchester [17] as early as the World War I period; and it has been a mode used with some success in tandem with preliminary operations simulation, as we noted in describing a continental defense problem studied by Operations Research Office.[18] Heuristic method, also known as "importance methodology," is associated with devising a strategy of search for sulution (among combinatorial possibilities) that utilizes experience gained to improve the strategy, so that the strategy becomes more efficient as the goal is approached. The number of computations ensuring an optimal solution can, in principle, be reduced to essentially the logarithm of the total combinatorial possibilities, as in dynamic programming. Alternatively, a strategy of calculation may be pursued that guarantees only an improvement over the previous "solution" for the combinatorial model but has a finite chance of finding the optimal solution.

As in the matter of achieving a "correct" diagnosis, there is no simple directive for conceiving a decision model that is at once sufficiently comprehensive and computationally practicable. There do exist,

[18] See Military Operations Research (Post War), pp. 2-23,24.

however, systematic means of testing the validity of a model in the interest of revision. In the first place, the investigator can determine whether unimportant factors have been inserted into the model. He determines these through a variation of each factor. If the final decision is sensitive to this variation, he knows the factor is important and it must be estimated with great accuracy. On the other hand, if the decision indicated is indifferent to a large variation of the factor he knows that its numerical evaluation need not be attempted with very great accuracy. Variational techniques permit the simultaneous analysis of several factors, with determination of their individual effects.

Occasionally the analyst will find that in order to produce results that are intuitively acceptable, he must introduce intangible quantities into his analysis. As an example, in making a comparison of tactical aircraft in close-support role with artillery, additional intrinsic value might be assigned to the aircraft because of its capability to do reconnaissance. The use of such a device, however, is merely symptomatic that the model has not been formulated with sufficient scope and generality. Although one does have some indications of the omission of important factors from his model, there is no means of being completely certain that all important factors have been included in the model. This possibility is inherent in any scientific investigation. As a scientist tests his theoretical model in the experimental laboratory, the operations analyst must test his against historical data.

(3) Quantification. Since the analysis of practical decision problems is always stringently limited by the requirement for timely conclusions,

the iterative process of revision and selection among alternative schematic models cannot be indefinitely prolonged. At some point relatively early in the investigation, the crucial decision must be made to "freeze" the current model, accepting the attendant risks of foreclosure, and to proceed to the determination of numerical coefficients, i.e., the quantification of the model, so as to convert it from a mere schema to a specific representation. We have already indicated that part of this factual content may need to be obtained with great precision, whereas other measures may require only approximation. In the case of an on going operation, quantification may be achieved empirically by the conduct of systematic observations under an experimental design or by acquisition of data already collected and processed by the client. For an operation in the development stage, one can make use of test data—but with somewhat less confidence. If the operation is still in the conceptual stage, there is no choice but to base estimation of numerical coefficients on design data and theoretical derivations. In any case the reliability and realism of conclusions from the model must be assessed in terms of the servicability (the accuracy, precision, accessibility) of factual information as determined by the procedures used in quantification.

The two considerations that are of overriding importance in quantification are (1) the possibility of erroneous information and (2) participant or observer bias. With regard to the first, well developed controls (replication, multiple observers, control of extra-experimental variables) exist as part of standard scientific practice. Observer bias, however, has received much less attention in physical science than it properly demands in the context of social-behavioral inquiry. By "observer bias" we refer to the effects of an investigator's attitude, attention, psychological set, perspective, and interest. It is now generally conceded that the human observer—particularly in the face of a very complex perceptual field—exhibits a crucial selectivity. That is, his attention fixes as selectively upon those characteristics which command his interest and sense of importance, automatically excluding as irrelevant others that may fail to meet his *a priori* expectations about what is to be taken as a fact. Even before the advent of modern psychology, Goethe had early noted that a "fact" is already a theory—meaning, that the very determination of fact is fundamentally a decision process guided necessarily by some preliminary version of theory: about what observations to make, what standards of measurement to establish, what means of normalizing off-standard observations.

It is doubtless an unusually hard requirement to place upon the management scientist already hard pressed by complexity: that his sector of inquiry should be the first to incorporate even stronger safeguards against unconscious prejudgement than scientific practice has generally invoked. But the painful disparities that have occurred, say, between actual operational outcomes v. those anticipated on the basis of spuriously precise quantification of stochastic definite models in terms of "true" probabilities, indicate that the assumption of an absolutist type of objectivity is quite untenable. In this area above all others there is a necessity to undertake the quantification of models in terms that reflect the uncertainty that is inherent in decision making processes—particularly those "once-removed" processes pertaining to decisions that must necessarily be taken by <u>investigators</u> in order to formulate theoretical models intended for later use in determining practical decisions. Outside the context of a strictly formalized game, decision making under uncertainty is the only kind of decision making there is. No test of a decision model by comparison with experience can do more than demonstrate the <u>sufficiency</u> of the model so far forth. There is no way of demonstrating that given axioms are "true of nature" or that the implications of a given model are "necessary" conclusions with regard to experience. The uniqueness (completeness) of empirical theories cannot be established logically by tests for confirmation by experience; the quantification of a decision model is inevitably subject to provisionality and uncertainty that should properly be made explicit features of the decision model <u>prima facie</u>. With regard to effective ways of making these considerations explicit, the utilization of the stochastic indefinite format constitutes a recognized, though frequently ignored, means of accommodating uncertainty. Provisionality is a still more difficult consideration to make explicit inasmuch as the principal sources of bias that make such a stance imperative are precisely those valuative prejudgments which scientific investigators are most disposed to regard as off-limits for scientific discourse. In principle, however, a means for meeting this requirement too has been advanced, perhaps most clearly in the regimen of "axiological specification" as enunciated by Tooley and Pratt:

> . . . Striving for an impossible objectivity, [scientists] have made every conceivable effort to "include the observer out" of the observed system. An alternate point of view . . . entails a thorough reconceptualization of "scientific objectivity . . . ." From our point of view the investigator is inextricably involved in the system which he studies as a participant-observer; he therefore is considered one source of variance among others to be accounted for within the experimental system. In some experimental systems, depending upon the purposes of the particular study, it might be desirable to minimize the investigator's influence by programming his participation in a highly structured fashion. In other participant-observer situations, e.g., psychotherapy, education, action research, [management science], the purpose might be to influence the system under investigation as much as possible, but still accounting for (though now exploiting) the variance attributable to the investigator's participant-observation. The question becomes then, not how to eliminate the "bias" (unaccounted for influence) of participant-observation, but how to optimally exploit and account for the relevant participant-observation variables in terms of the purposes of the research.
> . . . Due largely to the strong influence of classicism and neo-positivism, with its overdetermined insistence upon value-free inquiry, scientists have for the most part ignored the axiological elements [implicit assumptions, a priori expectations, and values] . . . that each scientist wittingly or unwittingly superimposes upon his empirical data and theoretical constructs . . . . We offer the following principle as an effort toward dealing constructively with bias emanating from implicit axiological assumptions: Every scientist is responsible for identifying and specifying the assumptions and values underlying his investigations and accounting for their possible effects upon the outcome of his inquiry. [18]

(4) Value-Parameters. All decisions involve, at the least, two types of concepts: (1) the kinds of outcomes that decisions can lead to and associated probabilities with which these outcomes can occur;

(2) the desirability or value of these outcomes respectively. The values of outcomes weighted by the probabilities of achieving them determines the course of action to be taken. The decision maker is always interpreted as attempting to maximize expected value; thus, management science—in attempting to assist in the formulation of decisions acceptable to the client—must be fully as concerned with values as with the probable distribution of outcomes. The analyst necessarily becomes involved in the crucial selection of measures of effectiveness for the actions under consideration.

While it is generally recognized that valid measures of effectiveness must be coherently related to basic values and over-all goal, a lack of specificity usually haunts the level of fundamental value judgments. Normally the situation is not unlike that encountered in problems of ethical conduct, where one may be unquestionably committed to honesty as the best policy, while being quite unclear about what action (in the present instance) "honesty" requires. Attempts to identify appropriate value-parameters for a specific decision problem therefore tend to be addressed to factors less fundamental than basic values. Such factors must, of course, possess some claim to be extrinsically related to nominal ultimate values and goals. Ideally this relation should be expressible in linearly proportional measures, but only with extreme rarity can such measures be unambiguously defined. In general the only recourse is to depend upon the assignment of intuitive measures of merit as representing the contribution of actions, programs, strategies, and policies toward an outcome conceived as preferable.

Typifying the value-conflicts that can immediately arise from this procedure, The Tank Commander's Dilemma, has become a minor classic by virtue of its pungent realism. Referring to Figure 2.6, a tank commander has been ordered to proceed through a mine field in order to assist in a battle that is developing in a field beyond. The decision problem concerns the appropriate strategy of search of mines, and it is complicated by the requirement that the tank must arrive at the field of expected battle within one hour if it is to have effect. The commander knows from past experience that a complete search of a path through the mine field will consume two hours. In order to traverse the mine field within one hour, he will have to adjust his search tactics in a manner that will markedly reduce the probability of detection. Over some portion of the traverse there will be a consequent increase in his chances of being blown up. He recognizes three potential outcomes: (1) he gets through the mine field without getting blown up in time to assist the battle—an outcome to which he assigns the highest military value; (2) he gets through the mine field safely, but consumes so much time searching that he is too late to have any significant effect on the battle—and this is of approximately no military value; or, (3) he may be blown up in the mine field, in which case the military value is some negative quantity, since his heirs must be compensated and his tank replaced.

While the commander is considering these value commitments, he begins to look at the problem from the viewpoint of his personal interests. He

The Tank Commander's Dilemma

	SYSTEM	
	MILITARY	SELF
Tank gets thru on time	+ a	o
Tank OK but too late	o	+ a′
Tank blown up	− b	− b′

MINEFIELD

BATTLEFIELD

Figure 2.6

realizes that if he does get through the mine field safely and in time, he must engage in a very hazardous battle, one in which his chances of becoming a casualty are appreciable. Thus, he begins to take a rather dim view of the military values and devaluates this outcome to something nearing null value. If he can search very diligently for mines and take the two hours necessary for careful search, he not only insures that he does not get blown up, he also insures that he is too late to fight in the battle to come. This begins to appeal to him and he values that outcome highest. He agrees with the military experts and operations analysts, however, that if he does get blown up in the mine field, there will be some net loss. A specification of the relevant courses of action possible to the commander now completes this rudimentary decision model: (1) search for mines part of the time at slow speed and risk barging through at high speed part of the time (or any comparable compromise)—total time consumed to be one hour or less; (2) search for mines under normal procedure all the way through—total time consumed will then be two hours or more.

Since the given situation exists simultaneously in two distinct value systems, and neither of the possible courses of action will maximize values in both systems at once, the commander faces a problem that, on its face, is "undecidable" because of ambiguity as to which assignment of intuitive value measures is to control decision.

As an instance of value conflict, this illustration is trivial in that the dominance of one value system could readily enough be rationalized.

The significance of this example lies rather in the fact that even an elementary hypothetical decision problem immediately generates a cascade of valuative issues (Table 2.9) that are all too realistic, in the sense that they typify difficulties that in fact seriously obstruct the efforts of management scientists to secure systematic and warrantable procedures for selection and quantification of value parameters. One theme runs throughout the list of questions comprising Table 2.9: an implicit demand for coherent relation of valuative considerations associated with:

(1) a range of consecutive situations from immediate state to alternative "terminal" states,

(2) a hierarchy of organizational units with their respective missions, goals, strategies, operations, and assigned resources,

(3) an intersection-set of simultaneously relevant value systems, and

(4) incommensurable sets of value measures intuitively assignable to materiel, ordinary commodities, resources in scarce supply, time, effort, individual lives, military posture, national welfare, and the like.

While these issues are raised here in terms specific to the tank commander's dilemma, their relevance to decision making in general will not be difficult to surmise.

The truistic observation that valid measures of immediate operational effectiveness must be related to ultimate values and goals in a total situation therefore has a seeming simplicity that is misleading. In the practice of management science there is at present no significant capability for achieving this sine qua non of thoroughly "rational" decision because the decision theories extant—by virtue of their

VALUATIVE ISSUES

(The Tank Commander's Dilemma)

Assuming military values and course of action #1, what is the optimal strategy of hunt and barge for the tank commander?

What decision operator applies? Why?

How are the relative magnitudes of values a, b, c and a′, b′, c′ determined?

> What is the value of one more tank to the battle? What is the contribution of this battle to the war? What are the comparative values of winning v. losing states of the war? In "peacefare" v. warfare what national values hold.
>
> What is the value of the tank if it is not available for this battle?
>
> What is the value (to the enemy) of an hour's delay in bringing weapons to bear in battle? How are time factors to be evaluated?
>
> In case of loss of the tank, what is the cost?
>
> In case of loss of life in the tank, what are the costs? How does this compare with tangible costs of the tank?

What is the value of the tank commander's own life in his self-system? Is it infinite? Why not?

Which course of action maximizes military values? Which maximizes the tank commander's self values?

Which course of action should the tank commander take? Why?

In general, what are the means of resolving conflicts; in particular, value conflicts between hierarchical levels?

Table 2.9

scrupulously objective orientation—do not even address such issues as (1) coherent relation of value parameters, (2) normative procedures for value measurement, or (3) commensurability of disparate types of value measures. While no analyst could fail to appreciate the critical role of valuation in the decision making process or to participate as helpfully as possible in exercises of informal reasoning or valuative problems, an open escape route too often seems inviting: to load onto the conscience of the responsible decision maker all the qualitative aspects of decision, along with the significance of everything other than the abstract objects of a rudimentary model of the decision maker's real-world situation. As an alternative, the formulation of value-decision theories that would rationally accommodate valuative aspects of decision making constitutes a methodological challenge that must be considered paramount for any activity that could properly be styled "the science of management decision." Indeed, it is by way of this line of reasoning that the methodological orientation of this volume originated. The original context, to be sure, was an actual rather than a hypothetical decision problem, namely, the design of a mixed-weapons continental defense system to achieve an "optimal" national military posture (post WW II) at minimal cost. But this tremendous difference in criticality of problems aside, the Task Commander's Dilemma serves well enough in motivating a basic methodological objective that (1) stems from the general necessity for introducing value parameters into any comprehensive decision model and (2) establishes our principal line of specific effort throughout this present work.

(5) Search for a Solution. The last of the technical phases of research that we term the search for a solution is essentially an optimization process. The analyst attempts to manipulate the decision model, by adjustment of variables within the constraints imposed, in such a way as to yield a maximal measure of effectiveness, or equivalently, an extremal value of some "objective function" as an abstract representation of a goal-state. The simulated courses of action or the analytical procedures which lead to optimization must then be translated into the terms of actual executive decisions that can be proffered to the client as recommendations or perhaps as mere inputs to an administrative decision process. This phase is somewhat more complicated in gaming situations. A game exists when two or more organized groups exert divided control over the variables of the decision model, i.e., each side will control certain factors independently of the other. The concepts of the formal theory of games yield straightforward procedures for resolving conflict of interest situations involving competitors acting under certain stylized regimens of "rational" decision under uncertainty. Most frequently, creative modification of higher-order strategies or even the caprices of gamesmanship, rather than the rigid formalizations of game theory, are characteristic of actual decision situations; and in this event operational simulation is the more appropriate recourse, despite all the attending questions of practicability and realism.

The entire battery of algorithmic procedures and analytic techniques that have previously been mentioned in connection with decision-theoretic development applies to this stage of search for an optimal solution. Numerous variants of increasingly sophistical mathematical programming techniques make optimization by far the most rigorously developed of all the procedural phases of management science in practice.

Technical virtuosity in optimization, however, is not sufficient to insure smooth accomplishment of an acceptable final outcome of investigation. This phase too has its own characteristic pitfall: an inevitable tendency toward the forcing of a realistic but demanding problem formulation into a form that may be of questionable relevance but is amenable to familiar techniques of solution. One then may acquire an elegant solution—to some "other" problem. In accepting a client's problem, the analyst places himself in the role of an intellectual impresario, which is to say that he undertakes the design of a total "performance" that will exploit his own resources for creative and rational response. As Figure 2.7 suggests, he faces a second-order decision problem of his own concerning optimal selection among (1) alternative strategies of reduction, (2) alternative schematic models, (3) alternative parametric specifications, (4) alternative decision algorithms and operators. In the culminating stage of search for a solution, above all, it is necessary to remain alert to any indication of inadequacy in the over-all design of his cognitive response to the client's practical problem.

(6) Communication of Conclusions. When the technical procedures of an analysis have led finally to definite conclusions or recommendations for proffered courses of action, these must be effectively communicated

SEARCH FOR A SOLUTION

(The Analyst's Decision Process)

(In Preparation)

See notes and diagram, NMS, S-28 Sept 67, on hierarchical levels of objectification.

Figure 2.7

to an executive holding responsibility—or else the analyst labors in vain. Only executive authority can implement the proffered recommendations; the management scientist assumes none of the prerogatives of the decision maker. With status approximating that of executive staff, he presents findings for acceptance or rejection. The executive may agree or disagree with any assumptions that appear as conditions of the analysis; he may agree or disagree as to whether all of the requisite factors have been included, whether the recommended actions are provident or practicable. The systematic aspects of scientific investigation, which constitute the primary advantage of management science in technical phases of the search for an improved mode of organizational performance, by their very technicality often represent the most serious barrier to effective communication of results. Moreover, to just the extent that such an approach does succeed in discovering means for improvement, this may be taken as tacit criticism of the existing state of arrairs. For these reasons the successful communication of results to policy makers becomes an exercise in the artful employment of imaginative, tactful persuasion. The diffidence and detachment that are generally thought befitting to the scientific professional can easily become liabilities for the task of getting his conclusions studied, understood, and translated into the terms of practical action.

The analyst generally finds that the acceptability of his recommendations involves not only the excellence of his technique, but also the degree of confidence that he has earned in his relations with his client. In this it is necessary that he constantly maintain sensitivity to the aims and aspirations of the client and to the ethical requirements of his own privileged access to the client's information, plans, and strategies.

If there is any really insightful analogy between the practice of management science and the more traditional professional practices, the choice would fall upon psychotherapy. Such a comparison would at least properly suggest the subtlety and depth of personal interaction between client and consultant, cooperatively engaged in problem solving that may ultimately entail far reaching modifications of a self-organizing system.

The Essential Character of Management Science. We have previously tried to relate management science to more familiar disciplines, emphasizing particularly those similarities of aim, systematic method, and intellectual resources that would tend to place it in a recognizable framework of rqtional inquiry. Now we approach the matter of differentiae, the essential characteristics that make management science a distinguishable activity. What, if anything, is unique about the science of management decision? As a source of clues we can summarize, as follows, the several novel aspects that were brought to light incidentally in the course of the previous historical abstract:

(1) explicit dedication of effort toward improved organizational performance by way of rational control in practical decision making,

(2) recognition of the purpose of the operations and the overall mission and goal of the organization being served,

(3) identification of performance criteria as measures of effectiveness, i.e., value-parameters defined in terms of goal achievement or error-reduction,

(4) increasing distinction between scientific advisory v. executive staff roles, with insistence on advisory attention to actual exigencies of administrative decision in a specific problem context,

(5) injecti n of scientific methods into practical decision areas that were virgin territory for systematic inquiry,

(6) recognition of the need to identify and incorporate in explicit decision models—so far as practicable—all the significant factors of decision, i.e., the requirement for analysis in a context sufficient in scope to obviate foreclosure by sub-optimization,

(7) explcitation of modern information processing technology in simulation, gaming, and massive computational programs of analysis,

(8) recourse to disciplinary resources of the humanities in addition to the whole of science and engineering, and finally

(9) overt acceptance of professional responsibilities:

(a) to contribute toward improved executive understanding and effective implementation of technical conclusions;

(b) to maintain appropriate ethical standards in every instance of privileged access to information concerning the strategies, policies, plans of a client-organization as disclosed by consultation with responsible officials.

These isolated features fall rather naturally into three groups that yield a more succint specification of what is unique about management science: it is (1) a consortium version of professional practice, (2) prescriptive in mode (because it is a practice), and (3) holistic in scope (because it was the adoption of a holistic perspective that evoked the consortium). These cryptic terms of emphasis doubtless require some amplification of meaning before they can convey the full notion intended here: that management science uniquely constitutes an emergent consortium (i.e., a novel synthesis of preexisting practices) that enables the traditional role of professional practice (i.e., prescription) to be carried on successfully in the new and more demanding problem-context of "total" situations (i.e., holistic scope). Romer's Rule[18] throws some light on the significance of this description; but it can surely have little effect toward justifying our interpretation of what is unique about management science until some clarification is offered in terms of the particular novel features ascribed above.

Consortium: Prescriptive Mode and Holistic Scope. The "science" of management decision[19] is clearly not a science at all in the conventional sense. The classical notion of science connotes investigations oriented by the aim of securing objective judgments, whether formal or factual, invoking systematic rational control of the activities of description, prediction, and explanation—subject to an exclusion of valuative considerations that is little short of a stipulation. We have earlier indicated (cf. p. 1-14) that the decision models and management science embody significant extensions of the characteristic structure of objective theories and the procedures of predictive science by virtue of the necessity to accommodate values as determinants of decisions. To regard management science as a consortium of professional practices is

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[18]Cf. the statement of this anthropological maxim, p. 2-18.

[19]We shall retain this designation, however, for its service as a neologism that continually suggests our preference for an extension of the term "science." Systematic rationally controlled judgment in general conveys the meaning we should wish to assign to "science," and the usage of "management science" would, in that event, acquire a thoroughly legitimate status. The institution of any such linguistic change, however, is an option of the community of discourse rather than our own.

to impute that it differs from classical scientific inquiry in important respects given by items 1-4, 9 above: its pragmatic aim, its mission-oriented advisory concern with practical decisions and organizational performance, its acquiescence in purposive goals, its involvement with clients' values, its ethical strictures. All these characteristics are subsumed under the notion of a prescriptive (or normative) mode of inquiry as contrasted with the descriptive—predictive mode of objective science. It is important to keep in mind that this contrast does not imply a replacement of the objective mode by the normative but, rather, the necessity to embed the objective mode in a more comprehensive rational format that can at least meaningfully essay a systematic treatment of valuative aspects of practical decision.

So far forth an explicit responsibility for prescription (the deliberate recommendation of decisions for action by an autonomous client) does not entail the uniqueness of management science. The prescriptive mode, as described here, is obviously the common characteristic of all the traditional professional practices. But these concern precisely the technical domains in which disciplinary compartmentalization has been developed toward the end of specialized expertise. Management science, on the other hand, is distinguishable by features given in items 5, 7, 8 above: the pursuit of general inquiry as a principal strategy in problem solving v. the application of a technical repertoire; the appropriation of a wide diversity of technologies; the synthesis of research teams that are multidisciplinary in the wider sense of incorporating certain of the humane studies with science and engineering. All of these features are encompassed by the characterization of management science as a consortium. Closely related to this aspect—literally, the innovation that has motivated the development of a professional consortium—is the one remaining novel feature given by item 6 above. It concerns the adoption of the principle that the minimal configuration for an adequate decision model must countenance, in principle, all the significant factors of decision making. From this commitment the tendency toward a holistic scope in management science has emerged, giving rise in the process to the rather overwhelming number of diverse interests and fractional popular labels that have rung the changes on terminology noted in Figure 2.7.

This view of what is unique about management science will, perhaps rightfully, call out a mixed reaction. There seems after all to be nothing here that is astoundingly new, nothing that we have not seen at least suggestively presented either in the conduct of systematic inquiry or of artful practical judgment. Yet we have certainly not seen all these features presented together nor, particularly, have we seen them even tentatively institutionalized. It is therefore reasonable to settle finally on this general conception: the uniqueness of management science essentially consists in its embodiment of a social evolutionary development. Its appearance marks the beginning of yet another concerted attempt to extend the domain of rationally controlled judgment; and its initial practices therefore inevitably raise fundamental questions, as yet unanswerable, concerning just what "rationality" entails in the larger context of inquiry where problems are construed as being sensitive to valuative as well as formal and factual aspects of "optimal" decision.

This conception of the tentative emergence of a more unified, and more comprehensive version of rationality certainly does not admit of any immediate justification. A very long time scale will necessarily be required for the vindication of any such evolutionary interpretation. Nevertheless, it is already apparent that the new "science" of management decision does represent an innovation by which the traditional separation of knowledge, value, and action tends to be closed up. Certainly the earlier cleavage between the detached role of the scientist and the partisan role of the executive is disappearing. Through the practice of management science, the manager is learning something of the application of scientific principles and methods to the process of practical decision making; and the scientist is learning something of the function of managerial control of the theoretical development of his new science. For, as we have suggested under the heading Search For A Solution, the management scientist encounters entrepreneurial problems of his own. In attempting to develop systematic rational control of his prescriptive role in practical decision making, he discovers that he is necessarily involved also in developing improvements at the more abstract level of metadecisions, i.e., decisions involving selection among alternative commitments, strategies, policies, modes, techniques, and operations of inquiry—decisions, in short, that are involved in attempting to improve the process and the results of rational thought per se. Only the most arrant technical provincialism will allow him to avoid the methodological issue raised by the fact that his profession can presently claim, at best, the status of a science-based art. We can pose the issue in this question: What has to be done, if management "science" is to become a legitimate science, i.e., a <u>warrantedly</u> rational, systematic version of inquiry? Or an equivalent: What creative modifications are demanded in "science," if predictive and prescriptive modes of rationality are to be legitimately synthesized under this single rubric?

While the idea of such a synthesis and the difficulty of its attainment are admittedly imposing, it does not seem at all premature to think of this as an explicit long range goal. The symbiotic relationship between practical decision maker (manager) and metadecision maker (scientist), which we attempt to portray in Figure 2.8, has already shown that remarkable results can flow from the interpenetration of theory and practice. It remains for us to exploit to the fullest the novel realizations that have been fortuitously opened by the emergence of management science as a typically "conservative" evolutionary innovation: (1) that systematic inquiry itself is most adequately construed as a <u>decision</u> process, and (2) that every attempt to employ inquiry toward the rationalization of practical-operational decisions forces inquiry toward creative modification of its own theoretical-operational decisions in a self-correcting, self-amplifying cycle.

Theory of Management

PRACTICAL DECISION	METADECISION
☐ action	☐ process
☐ policy	☐ normalization
☐ organization	☐ objectification

Management of Theory

Figure 2.8

Part II. PROSPECTUS

PART II: PROSPECTUS

PROGRAM—

<u>Encounter</u> the central methodological problem that presently obstructs theoretical advance in prescriptive science, i.e., the problem of normative method.

<u>Survey</u> the methodological resources provided by existing paradigms of scientific and axiological inquiry.

<u>Disclose</u> a conceptual-methodological impasse stemming from the historic institution of fact-value dualism.

<u>Demonstrate</u> that an escalade of successively more abstract projects in the development of prescriptive science terminates only with the necessity for reconstitution of primitive concepts and commitments.

<u>Outline</u> the strategy and program of philosophical reconstruction.

Chapter 3

EXTENSION AND UNIFICATION: PRESCRIPTIVE SCIENCE

So far as our rudimentary account has traced the still evolving science of management decision, it is evident that its early methodological development has been directed primarily toward attainment of

(1) quantifiable decision models and theories, e.g., macro-economic models, input-output tables, network flow models, inventory, replacement, queuing, sequencing, routing, allocation, and search theories;

(2) analytic optimization techniques for operations research, e.g., cost-effectiveness analysis, mathematical programming, analysis of stochastic processes, micro-economic marginal analysis; and

(3) computer assisted simulations, games, and evaluation-review techniques of problem-specific character: air and sea lift military logistics, equipment maintenance and replacement scheduling, strategic nuclear exchange, PERT and PARM techniques, sometimes as subsidiary aids to administrative planning but most often as means to improved operational effectiveness.

On the strength of these technical resources, management science presently affords demonstrated capabilities for solution of optimization problems that admit of quantitative criteria for the elemental objectives of maximal effectiveness and optimal allocation—insofar as a suitably restricted subsystem of interest can be "isolated," i.e., characterized independently. Definitive advances have been made regarding problems specifically involving the operational level of decision making, essentially the type of decision problem in which the selection of value criteria, the factorization of significant variables, and the partitioning of a total decision situation are noncontroversial, thus permitting the use of the analytic mode of inquiry traditional to both the formal and empirical divisions of objective science.

A continuing demand is certainly assured for management science within limits necessarily imposed by objective scientific methods and techniques of analysis. It is already clear, however, that the future of management science is being shaped by increasing demands for improved rational control of decision making at higher echelons of organization where the reductionistic assumptions of objective inquiry cannot be acceded to with any sense of meaningfulness or realism.

CURRENT TENDENCIES IN DECISION SCIENCE

Decision problems of the type usually designated "command/management" or "policy-decision" problems constitute the heaviest burden of managerial responsibility. With increasing frequency such problems have gradually been opened to scientific advisory analysis preliminary to executive decision.

Historically, operations analysis began with the problem of maximal effect. The typical "client" was a military operations officer with given mission and resources. His objective was to approach as closely as possible the completely successful accomplishment of that mission under the constraint of his resources. The operations analyst devised a measure of effectiveness, that is, a vector error signal. With this measure, and with access to direct observation of the operation, he detected any disparity between the results and the intentions of the operations officer, who could then attempt to devise corrective actions to reduce error and thereby "optimize" his operation. Operations analysis supplied a feedback loop from effect to control, providing the possibility of reducing an error signal to its minimum with the obvious consequence of overall operational improvement. The practice of many operations research professionals, particularly in industry, is purposefully restricted to just this servo-feedback function.

On moving one stage deeper into organizational decision processes, however, the typical problem of the management scientist becomes the question of optimal resource allocation. The variables of the analysis shift from those of effects to those of costs. For a constant probability of accomplishing a given mission, the analyst seeks to minimize the expenditure of resources. He must face the problem of weighing the relative costs not only of ordinary commodities but of intangibles: human lives, time, and critical resources (say, fissionable material) in such strictly limited supply as to possess some claim to pseudo-intrinsic value. The relevant analytical procedures are those of marginal economic analysis, stationary and dynamic, linear and nonlinear mathematical programming. The policy-type accounting problems of division of common costs, amortization and replacement scheduling, assignment of intrinsic values (slack prices) all enter here for situations susceptible to marginal analysis. For situations which are nonmarginal (e.g., the introduction of nuclear armaments in warfare), the structuring of a decision problem in terms of effects as distinct from costs is itself a policy decision that is not within the province of objective science; and here, of course, the limitations of scientific method in administrative advisory practice begin to be asserted.

From the beginnings of systems analysis, yet a third order of scope in organizational decision problems has more and more frequently confronted the management scientist. The issue is one that we might describe as optimal "realization" of the potential of a given organization. The problem is most succintly stated in the question: What mission shall be elected? In contrast with the operational decision level, where unambiguous goals and noncontroversial criteria of optimality generally permit well formulated decision models, missions-problems are decidedly intractable to formal characterization. The elemental operational criteria of maximal effectiveness and optimal allocation appear here in the guise of undefined, intuitive issues of optimal policy and optimal organization. The context of decision is that of a commander or administrator concerned, not simply with maximally effective operation or minimal-cost programming, but with the viability of a complex organizational unit as a whole in a selective or competitive environment. In such a context of total-system responsibility and control, the critical sensitivity of decision to valuative considerations becomes the paramount consideration. In a strongly polarized hierarchy, e.g., a military command, the choice of mission for an organizational subunit may indeed be dictated from higher echelons, and this process repeated in kind through a chain of command. However, the more difficult value-sensitive version of the missions-problem persists at the locally "terminal" level of every sub-organizational unit where some degree of autonomy and entrepreneurial initiative have been invested, where the specifics of ultimate objectives have been left to the creativity of a responsible agent.

The selection of an ultimate objective or mission consitutes a fundamental value posit that will necessarily serve as a determinant in subsequent decisions at every subordinate level of organization. Wherever such valuative aspects of management decision have been posed as potential areas for systematic analysis, management science has forcefully encountered the limitations of the mode of inquiry that characterized its successful early development.

This standing problem motivates a second phase of conceptual and methodological development that begins just when the science of management decision might otherwise appear to have attained the settled status of a mature discipline of objective scientific inquiry. In this regard management science clearly is involved in the process of modifying the analytic-objective mode that has heretofore been the mark of its aspirations. Its present development contributes strongly to the establishment of two current tendencies that have begun to exert considerable influence throughout behavioral science generally: (1) extension of the scope of decision-oriented inquiry and (2) unification of this broadened sector of interest as a new domain of inquiry characterized by aims, concepts, and methods that are distinct, though not disconnected, from those of the formal and physical sciences. Because these tendencies are not readily distinguishable from those that mark the rise of the broader interdisciplinary complex known as systems science, management science is now generally thought of as having been merged smoothly into this complex, along with systems engineering, cybernetics, general systems research, and general systems theory. In some respects this view is quite acceptable. Extension of the scope of decision-oriented inquiry is as evident in certain of the physical system sciences as it is in management science. In cybernetics, for example, the conceptualization of communication-control devices as adaptive decision systems extends the range of decision science toward the mechanistic, while in management science this range is extended toward the opposite extreme of the humanistic by the incorporation of valuation and social organization under the rubric of cognitive decision processes. In addition, intimations of a unified domain distinct from traditional inquiry would certainly seem to be drawn as cogently from the emphasis of systems research on completely general characterization of behavioral systems as they are from the emphasis of management science on optimal organization and optimal systems control in the specific context of a social behavioral system. As Ackoff [1] has maintained, using inventory theory to exemplify the type of cross-disciplinary synthesis that accrues from the holistic approach of systems research:

> [Inventory theory] is applicable to all open systems in which the exchange of material or energy (and hence information) with the system's environment is at least partially controllable . . . .
>
> This type of theory may be used either (1) to predict future system performance, (2) to explain past performance, (3) to explore the sensitivity of system performance to values of variables defining the system, or (4) to determine those

values of the controlled variables which optimize system performance.

> . . . It is applicable to any type of input-output system to which benefits and losses can accrue. For example, the metabolic processes of a living organism can be studied as an inventory process, the operation of a heating system, a computing center, a documentation center, and the natural water system of a geographic region. The inputs, outputs, and system involved can be of relevance to any and every scientific discipline . . . .
>
> Operations Research [as a sector of systems research] has produced a number of other theories with similar characteristics; for example, allocation, queuing, sequencing, routing, replacement, competitive and search theories. These theories provide new ways of studying phenomena holistically . . . .
>
> Structural isomorphism between several aspects of these [bodies of theory] have already been found; . . . there is no doubt that higher order generalizations than have yet been obtained are forthcoming. Such generalizations will reveal more and more of the fundamental structure of organized systems.

In view of the abstract generality of systems research, it is clear that management science must indeed be construed so far forth as one sector of systems research—namely, the particular version of systems research that addresses the type-problems of systems analysis, systems evaluation, and systems design associated with the treatment of a social organization as an adaptive decision system. But this identification itself indicates that management science is a version of systems research that, by the nature of its special development, tends to reconstitute the very province of systems science to which it belongs. In making explicit an essential prescriptive function of management science, and its attendant methodological problems of valuative judgment, one immediately discloses a trend toward the acquisition of another order of generality quite distinct from the generality of objective systems science. A holistic approach based on abstract concepts possesses generality in the specific sense of a broad range of interpretability. It is this advantage that systems science has previously exploited, there being no objects or events whatever that may not in principle be identified with some abstract definition of "the system of interest" and thereupon investigated with some degree of meaningfulness by objective scientific methods. The question of broadly adequate interpretability, however, is a separable issue. The version of holism that confers this kind of generality, of course, requires the use of characterizations that accommodate the broadest range of distinct aspects of the objects or events of interest. Since it is certainly a truism that not all aspects of our interest can be adequately treated by objective scientific methods, this version of holism also presupposes an order of methodological generality beyond that of the previous analytical orientation of systems science. A crude but effective way of illustrating the intended contrast would be to say: In systems science we can try to devise a way of looking at things such that everything there is can be regarded in that way; we can also try to devise a way of looking at things such that everything that is there (in each instance) can be regarded—and it is to be hoped that we might approach success on both lines of effort.

In concentrating on methodological developments aimed at accommodating the hierarchy of decision processes and the multiple aspects (formal, factual, valuative) of optimal decision in the context of a social organization, management science tends toward the acquisition of a holistic perspective and a generality of this second kind. Its current tendencies therefore contribute uniquely to the evolution of systems science, though here again we are dealing with considerations that were at least conceivable from the beginnings of decision science. The total-system motif has always been an underlying theme—as witness, the early emphasis on the ideal of encompassing <u>all</u> significant factors of decision in analysis. The maturing of the prescriptive-oriented component of systems science, however, has been constrained by difficulties that preclude such rapid advances as have been possible in the core areas of operations research, where reductionist theories proved to be both feasible and immediately fruitful. In the latter sections of Part I, these difficulties will be seen to be inherent in the prescriptive character and holistic scope peculiar to management science <u>as</u> a system science.

MANAGEMENT SCIENCE <u>AS</u> A SYSTEM SCIENCE

With regard to both origin and practice, management science and the more strictly objectivist system sciences have arisen in such close alliance that any definitive clarification of their relationship would require something on the order of a detailed taxonomy. While there is perhaps no undertaking that would prove more helpful for an appreciation of what is happening in this sector of science, such a task falls technically under the competence of cultural studies. We shall depend here on the simplest informal classification that will allow a delineation of developmental problems in systems science that are raised by the unique character and tendency of management science.

Broadly speaking, the following sectors of systems science can be distinguished:

(1) Applied

Systems Engineering: investigation of mathematical models that approximate physical phenomena; design of alternative machine systems to accomplish a predesignated behavior; planning and control of construction for a preferred design.

Human Engineering: specialized systems engineering in which interest is concentrated on scientific adaptation of machine systems to human physiological constraints in order to obtain optimal performance characteristics.

Operations Research: multidisciplinary modeling and simulation of existing organizations (man-machine systems) operating in concert, competition or conflict with others, where the aim is identification and control of operational parameters that optimize organizational performance under given resources.

Management Science: characterized in detail by the whole of Chapter 2; of primary relevance here is the extension of the concern for optimal organizational performance to include the total context of action, policy, and organizational decision making.

(2) Theoretical

Communication-Control Science: embracing cybernetics and information theory, the first comprising investigations of the formal principles of feedback or casual loop control mechanisms in physical and physiological systems characterized by goal-seeking behavior and the mathematical conditions for optimal control, maximal capacity, reliability, and sophistication in machine simulation of intelligent behavior; the second identified with the quantification of the concept "information" by analogy with negative entropy and investigation of the principles of optimal coding, transmission, storage, and retrieval of information.

Systems Research: co-terminal in interest with management science but distinguished, as in Chapter 2, by emphasis on objective-scientific characterization of total-systems in terms of abstract formalizations, for example, input-output models, graphs and networks, game theory, decision and utility theories, inventory and queuing theories.

General System Theory: as in systems research the orientation is toward objective-scientific characterization of total systems by interplay of empirical and formal (axiomatic) theory construction—but with emphasis on concrete, holistic (as against abstract, reductionist) characterization of intuitively significant features of whole-systems (e.g., stability, information transfer, control, adaptation) either in the sense of (a) generalized physical principles of "organization" or (b) theoretical models of perceptual objects of traditional interest in behavioral science (cells, organisms, social organizations, and the like).

It is no simple task to comprehend the inexplicit conceptual basis that permits such diverse activities to be assembled under a single heading. Represented here at once are formal, empirical, and normative cognitive procedures, practical and theoretical aims; specific and general problem orientations; descriptive, predictive, and prescriptive modes of inquiry; and finally, objects of interest occupying a range of complexity from the mechanistic to the humanistic. On the face of the matter, an intuitive notion of a "systems approach" is the only obvious element that these entries share in common. Nothing could be more indicative of the fact that this approach must somehow be connected with a major transition in scientific perspective. A significant conceptual-methodological shift is presupposed by the very suggestion of coherence among these nominally compartmented sectors of inquiry. The special status of management science <u>as</u> a system science cannot be readily appreciated without at least a rudimentary treatment of the innovative character of the systems approach.

<u>Rudiments of the Systems Approach</u>

The essential novel aspect of the contemporary systems approach is not given merely by featuring the bare notion "system," nor by any claim attributing unqualified <u>generality</u> to the modern system point of view, as sometimes implied by intimations that an idealized interdisciplinary synthesis is conceivable on this basis. The bare concept <u>system</u>, as a primitive abstraction, is perhaps as old as systematic inquiry; and the generality of this abstraction—as evidenced by its status as an undefined notion in mathematics and physical science—could not conceivably be increased. The pristine meaning of system, as a set of elements with a set of relations defined on those elements, is already so generalized that any analyzable entity whatever is patently admissible as an interpretation of the term. The innovative aspect of the recent systems orientation stems rather from productive qualifying connotations that have been appended, all too covertly, to the bare notion of system: specifically, connotations that have the effect of assigning to systems the additional properties of irreducibility and idiosyncracy. Briefly stated, the significance of these two system-properties may be given as follows: (1) Irreducibility attributes some holistic specification—a protocol for synthesis of interdependent components—as an intrinsic characteristic of anything termed a "system;" therefore no decomposition in terms of independent elements can be a complete representation of a system. Tautologically, the whole is not equivalent to any sum (concatenation) of parts; a system consists of parts-as-related by a protocol, i.e., a pattern, plan or rule of composition. (2) Idiosyncracy combines the root meanings "proper, peculiar" with "composition, synthesis" to yield a notion best rendered as "peculiar to, or characteristic of, the synthesis." When ascribed to behavior, its central import is the idea of response determined in part by intrinsic organizational characteristics (mutual causal, internal relations) independent of conditions imposed externally on a composition as a whole. This, of course, is literally a specification of the minimally sufficient condition for what we would intuitively mean by "self-determined" response. Only when this bare notion of self-determination is amplified in turn by the attribution of internal adaptive control processes do we further ascribe to systems the goal seeking type of purposive behavior associated with autonomy. But in general, "idiosyncracy" attributes to anything termed a "system" a characteristic response that is consistent with the imputation of at least an elemental version of normative, adaptive self-determination: namely, the extremalization of some holistic criterion (measure) by variation of mutual causal internal relations.

It should be specifically noted that the actual modification of meaning for the term system, occurring through intuitive and informal usage in systems research and system theory, is represented only as "having the effect" of appending these connotations. One does not encounter in the literature of systems research any such explication of normative aspects of the system concept. Both (1) the categorical demand for a protocol-component in the specification of a system and (2) the conception of norm-directed system response as an extremalizing transformation (a directed transformation) are notions that represent what seem to us the minimal implications present in expressions actually in frequent use, e.g., that a system-as-a-whole exhibits equifinality, or acts as if possessing a goal of its own. Our manner of stating these principal connotations is controlled by our need for commitments that will prove defensible and durable in later use when normative considerations are accorded paramount importance for prescriptive science. In contrast, the general emphasis thus far in systems research has been constrained by an understandable preoccupation with conceptual innovations that do not entail any significant departure from the traditional aims of objective science. The intellectual promise of the systems approach is generally assessed merely in terms of the realization that (1) the way in which entities are organized and (2) the characteristics of their behavior as organizations are ideas permitting novel modes of classification and investigation that are cross-disciplinary in scope.

With the acquisition of even this much additional strategic significance, however, the concept "system" assumes a status very different from that which it has traditionally held in mathematics and physical science.[1] In the practice of systems research from its beginnings in

[1] Since this appropriation of a supposedly pre-empted term has never been very openly declared, it is not surprising that the word "system" should have become a current source of considerable confusion of meanings. The additional connotations noted above yield a modification of the traditional notion that might well have been rendered by some such designation as "organismic system" or simply "organization" (since every organismic system—even an organism—is perforce an organization). It is useless to pursue such an issue at this point, however, since much more than a terminological compromise will later become necessary in developing the concept system as a philosophical primitive. Perhaps the sensible course is simply to countenance the appropriation of this term for the moment on the grounds that it receives only trivial usage in mathematics and physical science and can therefore easily be spared for significant use where the need for a potent primitive notion is extreme.

operations research, and in general system theory from its beginnings in mathematical biology, this concept has gradually been informally invested in the role of a paradigm for the representation of unitary wholes. Here "unitary wholes" refers to the complex but nontheless individualized conceptual objects ("things" in general)—evoked by involuntary perceptual synthesis—that constitute intuitively primitive concretions (as against analytically primitive abstractions) with which all cognition, and therefore all inquiry, necessarily begins. This unwieldly idea, in simpler form, is conveyed with helpful directness by Rapoport [2]:

> Biological processes are simply too complex to yield to the analytic method....
>
> Convinced as we may be that the whole situation [the behavior of an organism] is "ultimately" describable in terms of [deterministic trajectories of variables], this outlook is all but useless for analyzing the event into its constituents,... [Rather] we understand the event directly by perceiving wholes....
>
> It follows that understanding cannot be extended beyond the scope of physical science without introducing concepts which embody irreducible wholes in place of physically measurable variables.... Each of these wholes presents itself naturally, because we perceive it as such. We recognize an organism, an individual, a nation; and we assume that under proper circumstances it acts as a whole....
>
> A whole which functions as a whole by virtue of the interdependence of its parts is called a system....

The conceptual groundwork that has gone into the gradual renovation of the meaning of "system" therefore amounts to the reclaiming of a basic intuitive notion from the process of abstraction. An alternative description would be that it amounts to a belated explication of more of the content of the original intuitive notion. In either case the crux of the matter is this: that the interests and needs of part of contemporary science are found to be poorly served by an abstract notion of system that is radically distinct from the ordinary language and analogical models native to intuitive intelligence. If one dispenses initially with too much of the detailed structure of experience in the interest of securing representations that are readily comprehensible, it is to be expected that sufficiently detailed description—much less fruitful investigation—of the more complicated events in experience will become impracticable in terms of such abstract representations. As suggested in the passage quoted above, the complex structure and variable behavior of organic entities makes them quite intractable to a radically reductionistic treatment that depends, as in classical physics, on a completely idealized dichotomy of the structure of experience into two abstract domains: incidental initial conditions as against regularities having the status of physical laws. In these terms mere specifications of whole organisms as objects of interest would run to interminable lengths and the relevant physical laws of "behavior," if indeed they should become accessible, would be multitudinous in number. A solid appreciation of this kind of impracticability is, no doubt, among the reasons that have led experimentalists in the life and social sciences to favor strictly circumscribed investigations of organismic subsystems, where a limited number of variables can be treated under experimental control without reference to the imposing question of how isolated relationships might be composed into characterizations of wholes. Indispensable as this partitioning strategem is for the acquisition of rigorous disciplinary findings, the fractionation of the scientific enterprise that tends to result from dependence on this strategem alone already threatens to subvert the principal aim of science, i.e., the acquisition of a coherent structure of knowledge.

These considerations suggest the possibility of viewing the emergence of the modern systems approach as the swing of a massive process of adjustment within the community of inquiry. The strategic objective of inquiry—that is, the overall objective that would constitute a sufficient condition for the attainment of innumerable specific goals—may be loosely described as the attainment of a way of thinking that would be both comprehensive in scope and rigorous in method. The intuitive conceptualization of "things in general" as holistic systems—the way of thinking apparently native to human perception and intelligence—is the mode in which inquiry begins. It is satisfactorily all-embracing, but it proves to be riddled by uncritical anthropocentric presuppositions and sterile or positively misleading conjectures and extrapolations. With the development of analytic method, first in mathematics and later in physical science, the naive system point of view (with its crude analogies, teleological, vitalist, and even mystical "explanations") declines and a concerted swing toward the mode of objective science carries much of rational inquiry before it. Comprehensiveness of the kind peculiar to characterizations as abstract systems, is maintained and with it notable advances in rigor are gained by way of strict formalization. Yet something very like overshoot is detectable in this swing toward elementalism and radical abstraction. The horns of a dilemma appear with the belated realization that either (1) the impracticability of adequately detailed representations or (2) the fragmentation, and even trivialization, of behavioral inquiry by independent partitioning of organismic phenomena would be equally insupportable costs attached to any rigid insistence on analytic method throughout rational inquiry.

It is against this background that one can see the modern systems approach as a return swing from radical abstraction toward a conceptual basis that may more adequately accommodate the admitted complexity of intuitive experience. Something nearer the kind of comprehensiveness that encompasses multiple aspects of "things," as they are intuitively conceived, must be recovered. The return swing, however, cannot simply reassert the naive holistic approach to knowledge in abandonment of scientific rigor. A middle way is required; and the development of a more highly specified primitive notion of system—obviously a more complicated primitive—appears as the instrumental change that is required. Admittedly a sacrifice of simplicity, in one sense, is the price of accepting this increase in the complexity of a primitive term. It is well established, however, that simplicity is properly relevant only as an overall criterion of scientific investigation. The meaningful test is not whether the elemental ideas selected are more immediately comprehensible, but whether the initial choice of a given conceptual scheme leads toward generally improved comprehension of a domain of inquiry via theoretical constructions that exhibit adequate comprehensiveness and acceptable rigor at minimal cost in terms of cognitive processing.

With the attribution of additional connotations, the resulting system-concept constitutes a conceptual format that is not radically distinct from that of intuitive conceptualization; and yet, unlike an ordinary language term, it is constrained by specifications of meaning that are little short of the explicitness of definition. (The closure of discourse that would result from employing "system" as a defined term rather than a primitive would institute a formal version of system theory that would presumably be simply a special sector of set theory.) On the basis of this more complicated primitive notion, the "middle way" of the modern systems approach constitutes a way of thinking in which it seems possible to go beyond intuitive conjectures and metaphorical analogies, to educe cross-disciplinary homomorphisms and theoretical constructions that sacrifice neither too much of the content of experience nor too much of the rigor demanded of a scientific regimen.

Only insofar as the rise of the systems approach is properly identifiable with the seeking of a balanced tradeoff between comprehensiveness and rigor will its description in terms of a process of "adjustment" be anything more than an insightful figure of speech. But in any event, such a description enables us to identify its essential innovative feature: an adjustment of conceptual "scale" toward an order of resolution that establishes unitary wholes as objects of *a priori* interest for inquiry. The strategic problems associated with changes of conceptual scale, and the misunderstandings and controversies that they inevitably produce among disciplinarians, have been dealt with at some length by Bradley [3]. One finds in his even-handed treatment of successively embedded versions of scientific explanation, from macro to microtheoretic levels, much that suggests a pluralistic view of science, which would assign to the systems approach the status of merely one among many modes of analysis that may "work" for solving some problems but not for others. This is in sharp contrast with the anticipation of a possible unification of science—predicated precisely on the synthetic character of systems-theoretic formulations—that appears consistently among the intimations of those system theorists who have been willing to risk preassessment. The possibility of unification is an issue marked by such ramifications that no informal conjecture—however well grounded in the experience of scientific practice—can have significant force. Short of detailed demonstrations of the equivalence, subordination, complementarity, or incoherence of alternative theoretical structures and modes of inquiry, no resolution of this issue can be envisioned. In this sense, the consideration of possibilities for unification will comprise one of the central themes associated with philosophical reconstruction throughout this work. It is important, however, to insist at once that this theme need not be introduced by invoking any such grandiose idealization as an unqualified unity of science. A drive toward unification is implicit in the scientific prospectus; the embedding of supposedly autonomous disciplines in other more general ones has been the mark of the most readily appreciated advances in the history of science. Stages of improvement in the comprehensiveness, elegance, logical economy, and pragmatic adequacy of theoretical structures are recognizable;[2] and staged improvement indicates that unifying

[2]For example, the reduction of astronomy, acoustics, and thermodynamics to mechanics, optics to electrodynamics, and the impressive unification of mechanics with electrodynamics that was brought about by relativity and quantum theories. Further unifications may well be emerging in such borderline areas as bio-physics, bio-chemistry, and psycho-physics.

innovations can have immediate significance for ongoing strategic selection among alternative cognitive modes in scientific inquiry. If the system point of view does support a claim to provide new impetus toward unification, some understanding of the nature of that claim chould properly be an integral part of even the most preliminary assessment.

While actually cautioning against sanguine expectations for an idealized unity of science, Rapoport presents the clearest case for a realistic contribution based on the systems approach. In a review marked by a rare sense of historical perspective, he shows that the physical sciences, during roughly the past century, have been brought toward unified status essentially on the basis of homomorphic mathematical representations attained via analytic method. The following excerpts summarize his subsequent description of the quite different basis for unification represented by the concept of a system as an organized entity:

> . . . Quasi-purposeful behavior can be manifested by an open physical system that is not necessarily "alive." Since all living systems are open, we have a conceptual link between living and nonliving systems . . . [suggesting] a new concept of the living organism, namely one which, in addition to being an engine (a device for transforming energy from one form to another) and a chemical laboratory (a device for transforming matter from one form to another), is also a decision making system (a device for processing, storing, and retrieving information). The apparent "purposefulness" of living processes, especially of behavior, has always suggested that organisms "make decisions." What was new was a set of concepts susceptible to logical (or mathematical) operations, from which the "purposeful" or "intelligent" aspects of living systems could be derived. Besides suggesting nonvitalistic explanations of these aspects of life, the concept of information processing clarified the role of "organization" in a living organism.
>
> . . . Systems that are "living," in the common sense or biological sense of the word, share many features with systems that are not; and these common features derive from the way

systems are organized. This suggests a generalization of the concept of "organism" to the concept of "organized system." Organized systems include organisms.

. . . Once it is recognized that structure, function, and evolution (or being, acting, and becoming) are fundamental aspects of all organized systems, the concept of organism can be broadened still further to include, for example, whole complexes of living organisms plus the inanimate artifacts functionally related to their structure, behavior, and development. Such are societies, conceived in the broadest sense.

. . . Human social aggregates (families, institutions, communities, nations) exhibit all the features of organized systems.

. . . The analogies established or conjectured in system theory are not "mere" metaphors. They are rooted in actual isomorphisms or homomorphisms between systems or theories of systems.

[Ref. 2, p. xviii ff.]

It is with this much basis in reason that interdisciplinary synthesis in contemporary behavioral science has lately been envisioned by enthusiasts. It is an idea of synthesis presaged by the conceptual range of a notion of system that connotes adaptive organization and suggests the general relevance of decision-control processes throughout the domain of behavioral phenomena. Despite all restraints of realism, some sense of "the almost"—some intimation of a unifiable domain of adaptive systems extending from simplistic mechanical-chemical processes through complex information processing "machines" (some of which are organisms) to psycho-social organization—seems to be an extrapolation that is as seductive to the imagination as it is premature for considered judgment. While we need not subscribe to rough handling of such visions as we ourselves share, our attention must be given to the work of realization that is yet to be accomplished.

First, the problematic character of normative (valuative) aspects implicit in the systems point of view have not received sufficient recognition in approaches to system-theoretic development that so far have taken recourse primarily to abstract characterizations that could not, in principle, constitute sufficiently comprehensive representations of unitary wholes, which the term "system" now denotes linguistically. Systems are spoken of with holistic intensions; with the notable exception[3] of the work of Mesarović, et. al. [4,5], they have generally been explicitly objectified only in reductionistic terms that are patently deficient with regard to any reasonable correspondence with intuitive attribution of (1) values as determinants of behavior, and (2) distinguishable types of norm-oriented processes that appear as potent distinctions in any informal understanding of purposive behavior. An "organismic" system-concept so far permits things of very dissimilar appearance to be thought of consistently as alike in some essential respects; it does not yet provide the

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[3]In addition to the selected references cited, see in general the publications of the Case-Western Reserve Systems Research Center (c. 1962-present). It should be specially noted that these works, while specifically addressing the problem of modelling normative aspects of systemic structure and function, do not introduce an organismic system-concept as a distinct primitive notion. Rather, they accommodate intuitive normative considerations by definition of special-purpose mathematical functions as formal analogs of goal-attainment, satisfaction of norms, adaptation, etc., building up the requisite complexity of the system model from original dependence on the pristine notion of system as a mathematical relation. This alternative to our own option (philosophical reconstruction of primitive concepts and commitments for inquiry in general) is an eminently acceptable alternative—and, in view of its directness, an immediately attractive one. Any possible consideration of long-term preference between the two options would have to await demonstration that disparate capabilities in inquiry result from alternative choices of approach, since they may very well yield equivalent outcomes.

further necessity of essential distinctions that generate definitive new categories for investigation. The differentiae necessary to an unambiguous systems taxonomy have not been forthcoming; consequently, even the elemental classificatory stage of systems-inquiry is marked by a disconcerting slackness. Second, no such unification as has been envisioned can be predicated on a shift in conceptual scale that introduces unitary wholes merely as ad hoc constructs that are interpretable only under some arbitrary order of resolution, say, ordinary perception. Components of "systems" qualify as systems in their own right; to be more explicit, each of the type-systems comprising the loosely construed "spectrum" from elemental to sophisticated organization are related, by common processes if not as literal components, to a next-order type characterized by greater complexity. The inherent "embeddedness" of systems indicates that unification is conceivable only on condition that the systems approach, in terms of contextually defined unitary wholes, is generally interpretable and effectual throughout the entire hierarchy of levels of resolution in scientific explanation. While this condition may not seem too severe at the macroscopic level (e.g., the requirement that individual organisms, as components of a social organization, shall be construed as subsystems), this approach as a basis for unification would also have to provide connectivity throughout any legitimate sequence of successively embedded reductions, such as the one suggested by Bradley's example [Ref. 3, p. 42] of the morphologist's "explanation" of species-specific traits of organisms in terms of heredity; the biologist's explanation of heredity in terms of DNA replication; the biochemist's explanation of replication in terms of complementary nucleotide base pairs; the chemist's explanation of base pairing in terms of hydrogen bonding; and so on—by way of molecular physics, quantum mechanics, and analytical mechanics—to intermolecular potentials, the wave equation, and properties of space-time. The demand that the system-concept be technically interpretable and effectual throughout any such connected sequence of contexts makes it very clear that the actual realization of a definitive and fruitful transition in scientific perspective waits upon the prerequisite of a thoroughgoing metascientific reconstruction. Presumably, this will have to be a conceptual-methodological reconstruction that formally institutes "system" as a basic conceptual paradigm—a way of thinking about things in general—that is demonstrably

(1) indifferent to arbitrary levels of resolution or complexity referenced by a minimal hierarchical configuration (super-system-system-subsystem) and

(2) capable of accommodating—by indefinite extension of this metatheoretical configuration—the particular processes that characterize the conversion of properties of a given level of resolution into those of lower or higher order, i.e., capable of providing the formal structure of a coherent version of multi-level analysis for hierarchical compositions of systems-within-systems as connectable representations of "level-specific" conceptual constructs that already bear established scientific meaning and significance.

The modern systems approach is therefore a study in contrasts. It introduces a profound innovation: a modification in conceptual format that, when used to reconstitute the objects of inquiry, at least intimates that the presently fractured world of scientific discourse might legitimately be invested with more of the coherence that marks intuitive comprehension; but the task of reformalization that it raises now calls for equally profound innovations in the methods of systematic inquiry in order to secure—for the novel type of theories required by norm-directed behavioral systems—the indispensable warrant of rational admissibility. The origins of the systems approach are as old as the Aristotelian analysis of multiple types of causal relation; but its effective implementation is as recent as the rise of the assemblage of new system sciences with which this section opened. Its ramifications are utterly confusing, as the details of an abrupt evolutionary proliferation always are; but its central import seems unmistakable: in cultural development, novel concepts and novel practices rise together in an iterative, mutual causal loop that tends toward successive advances in sophistication. Just as the idea and the use of a novel tool mutually amplify each other in successive stages of development, the new conceptions of system-theoretic inquiry (appearing in cybernetics, systems research, general system theory) and the new practices of optimal systems design and control (appearing in systems engineering, operations research, management science) tend to reinforce each other. And their tendency is apparently toward maximal exploitation of cognitive capabilities in this latest interpretation of the long-standing goals of rational inquiry: (1) description-characterization and (2) prediction-explanation of the structure, function, and evolution of purposive-adaptive systems in general; and (3) prescription-control of decisions aimed at optimizing the designs, programs, and operations of systems (whether physical, social or conceptual) created specifically for their service toward human ends.

It is by virtue of the coherence of this cultural evolutionary problem-context that the loose assemblage of the system sciences "hangs together" despite its present lack of any unified and formally adequate conceptual-methodological basis.

Position of Management Science

Not even an enthusiast could responsibly present the existing assemblage of the system sciences as a stable interdisciplinary synthesis. Clearly it can claim a status only somewhat more institutional than the "invisible colleges" of which one now hears; the notion of a working symposium on the topic of adaptive organization might be a reasonable simile. Yet the categorization of systems science that we have presented does have sufficient structure to add new significance to our view of management science as a consortium. It discloses one continuing theme of development that runs through the applied sector of system science (systems engineering, human engineering, operations research, and management science): namely, the prescriptive role which characterizes all professional practice (i.e., the optimization of organizational performance by improvement of control and/or design) recurs in versions that are increasingly demanding—in the special sense that additional complexities are successively introduced by expansions of the scope of practice (hence, admitting new types of issues as additional factors of significance for practical decision). Appearing as the last entry in this sequence of successively expanded practices, management science occupies an advanced professional position—where "advanced position" is meant in the sense of the "exposed forward position" of an outpost. Except by arbitrary foreclosure, its mandate cannot be restricted to merely technical-objective aspects of client-organizational problems; and in attempting to grapple with total problem situations that may include formal, factual, and valuative issues at once, its practice properly incorporates the aggregated resources of all the system sciences. It suffers, in fact, from need of normative theoretical and methodological capabilities that have not yet been even envisioned as goals of systems-inquiry by theorists who—because of their removal from the stress of immediate problem solving—have had no cause to be diverted from preoccupation with traditional tasks of objective science that are even more interesting for having been recast from the perspective of the systems approach. A forefront position falls to management science by virtue of the special version of holism that marks its concerns. There is no type-problem in analysis, design, evaluation, or control of systems that may not appear as a component of the overall problem of optimizing the performance of a social organization; and there is no version of system science that, when appropriated for application here, does not sometimes encounter more difficulties than can properly be handled.

That management science has served as a compendium of the resource of all the system sciences is patently obvious with respect to the level of applied research and engineering. Many of its major successes, from the very beginnings of operational analysis, have consisted precisely in the adequate marshalling of multidisciplinary techniques of science and engineering. That the theoretical sectors of system science also have been exploited as they developed is borne out by our historical abstract; but, with respect to the communication-control sciences, this is more adequately justified by the account that Page [Ref. 5, p. 25 ff.] gives of the impact of cybernetics and information theory on past studies of military communications, intelligence systems, computerized information processing and command-control systems.

One further implication of the forefront position of management science—and the most important one—is neither quite so obvious nor quite so readily justified. It is this: that the practice of management science, by virtue of its exposure to first confrontation between the demands of systematic inquiry on the one hand, and the demands of the full scope of practical decisions on the other, now faces the need for theoretical and methodological advances that, by their normative character, presuppose a significant expansion of the domain of systems science at large. This is what was meant in earlier statements (1) that management science contributes uniquely to the evolution of systems science and (2) that it tends to reconstitute the very sector of science to which it belongs. This conception is by no means generally held even by practicing professionals in management science, many of whome actively prefer to place the most stringent limitations on the prescriptive role of their profession. But, as we shall show in the following section, the needs for scientific advisory assistance in policy-level decision making are there. They cannot be blinked. They must be handled either with or without the leverage of systematic rational methods. If the choice is to accept responsibility for a professional-advisory response to those needs, this is also to accept, necessarily, the ensuing challenge of trying to develop a rational modality sufficient to meet that responsibility.

The Hierarchy of Practical Decisions. The type of decision making in which the systematic methods and technical expertise of management science have had their most authoritative impact is the sector of operational decisions. Tightly formulated operational problems normally admit of the application of a decision principle as a prescribed sequence of formal operations—the execution of a directive to maximize or to minimize—for example: "Minimize the expected cost of development and production of a weapons system designed to meet the following specifications . . . ." Such directives must, of course, be accompanied by a set of constraints on assignable quantities of material and human resources, ranges of environmental conditions, and relevant policy restraints. For the application of decision algorithms, the objectives of the operational system must be given, the resources and restraints stipulated, the measures of effectiveness known, or at least identifiable as non-controversial commitments. The technical requirements for problem solving arise sheerly from complications introduced by the presence of multiple objectives, numbers and types of resources and restraints, their combinatory or logical relations, and probabilistic or time-dependent aspects of the problem situation. Under such conditions an impressive battery of decision-theoretic techniques can be brought to bear with precise effect.

In order to convert an actual decision problem into a rigorously formalized problem, however, those parameters of decision which are required to be given or known (objectives, utilities, resources, constraints, measures of effectiveness, risk-strategy, tradeoff coefficients, and the like) obviously have to be established by prior decisions. Normally such decisions are worked out by cooperation of the analyst with decision makers at higher echelons of the client-organization. But, as our previous observations on practice have indicated, it is certainly a blazing presumption to suppose that, at echelons of organization above the operational level, all the relevant strategic and valuative issues can be definitively resolved. These issues themselves give rise to classes of decision problems—distinct from the operational—in which the client will further require professional assistance (see Table 3.1), for only the injection of rational control at every level of organization could assure both immediate operational effectiveness and overall viability. This sweeping premise is a truism certainly; but it does at least unmask the disconcerting range of intractable problems (Figure 3.1) that actually constitute the task of improving institutional decisions.

The critical feature of this range of problems is a "chain reaction" increase of decision alternatives that can be set off by the exercise of creative intelligence in organizational problem solving. The kind of freedom that is peculiar to the human cognitive capability opens

COMMAND AND MANAGEMENT PROBLEM AREAS

1. Allocation of resources and budgets; determination of tangible costs (and consideration of intangibles).
2. Management and budgeting of research and development programs.
3. Relation of measures of effectiveness to immediate v. long-range objectives.
4. Projection and evaluation of technological and tactical innovations.
5. Design of experiments and/or simulation for the production of data applicable to future situations.
6. Design of admissible, meaningful, and practicable models leading to decision principles under uncertainty.
7. Extension of practicable models to more complex or more comprehensive problems; in particular, the inclusion of a more complex and realistic set of environmental conditions.
8. Improvement in methods of filtering, processing and retrieval of information.
9. The connection of effectiveness analyses with logistic and economic models.
10. Analysis and diagnosis of deficiencies of management policy.
11. Conceptualization of warrantable management models.

Table 3.1

THE HIERARCHY OF PRACTICAL DECISIONS

ENTREPRENEURIAL	"Ultimate" Values Problematic Situation – Opportunity Conceptual Synthesis: Mission / Capabilities Resources Requisition
ORGANIZATIONAL	Coherent Design (cybernetic) Factorization of Mission / Support Policy: Control Principles Norms: Performance Criteria
PROGRAMMATIC	Immediate Objectives Models / Simulations: Predictive / Prescriptive Contingent Plans operational – allocational strategies activities levels Appraisal and Heuristic Modification Adaptive Control
OPERATIONAL	Expenditure / Account of Resources Action / Report of Effects

Fig. 3.1

alternatives of action (operational alternatives) that normally can be resolved by simulating—if only by mentally "playing out"—their respective consequences and selecting the action that would contribute most toward an ongoing program of activity of the moment. At the same time, cognition opens possibilities for alternative programs that must in turn be resolved on the basis of their comparative contributions to some definite strategic objective or organizational mission. But cognition further opens missions alternatives that can only be resolved by specific principles that serve, however provisionally, as ultimate value-commitments; and, while alternative ultimate values are perhaps only rarely envisionable, there is nothing sacrosanct even here.

The import of this sequence is the realization that cognitive decisions are inherently relativistic. Practical decisions (by which we ordinarily mean operational decisions) can be determined only with respect to higher order decisions—equally "practical"—that necessarily involve the selection of values, missions, objectives, policies, strategies, and programs in addition to, and prior to, the selection of immediate actions. The full range of practical decisions, and the magnitude of the task of improving rational control in practical institutional decision making, must therefore be understood in terms of the hierarchical categories of (1) entrepreneurial, (2) organizational, (3) programmatic, and (4) operational decisions given in minimal detail by Figure 3.1. A logarithmic accumulation of freedom of choice, such as we have just described, is generally unmanageable by a crisis-beyond-crisis style of decision making. An intuitive version of the central strategy of dynamic programming appears natively in the norm-oriented application of human intelligence: namely, a massive combinatorial array of possibilities is considered "backward" from a valued future state to the present requirement for a particular act. Foreclosure of freedom (i.e., decision making), proceeding in echelon from highest to lowest levels of options in a hierarchical array, produces a logarithmic reduction in the number of effectual alternatives (hence practicability) and yet yields a decision sequence that is admissible, or even "optimal," with respect to the particular ultimate value commitment just so far as these criteria have been met in each stage of decision.

This is the basic strategy that is invoked, though often enough unwittingly, in every instance of the entrepreneurial recognition that certain values will best be served by the creation of an organization specifically designed for the prosecution of given missions and objectives. From every such inception of an organization, its executives are confronted by subsequent demands for control of decisions-beyond-decisions in this same pattern, but in their own subordinate spheres of responsibility. Meanwhile, the creative process—which we originally associated with the critical problem of cumulative freedom—may not simply be dispensed with, once it has initiated a new organization. Continuing creative effort, by its inevitable increase of freedom, does continually reinject the problem of practicable control at every level; but it represents the indispensable means of (1) refining the structure and function of an existing organization through adaptive modification, or of (2) ultimately recognizing that, once again, the demands of the total problem situation can only be met by the envisionment of a novel type of organization.

This complex interplay of the counterposed uses of creativity v. rationality (freedom v. rational control) indicates that the needs of executives for professional advisory assistance must be scaled to demands actually placed on them for optimal decisions in echelon throughout the following major sectors of institutional decision making:

(1) Entrepreneurial

Conceptual synthesis of innovative organization: diagnosis of large-scale situation in terms of fundamental values (survival, security, viability, and the like); identification of strategic opportunities to be exploited, possibilities for reduction of threat or stress; initial estimation of desirability of new missions/capabilities v. their demands on limited total resources; initial feasibility estimates for assembly of existing subsystems (individuals, groups, institutions, disciplines) as an emergent system that will prove effective and viable in competitive environment.

(2) Organizational

Coherent organizational design: factorization of missions/objectives for suborganizational units; design of management communication/control system; institution of policy commitments and performance norms.

(3) Programmatic

Structuring of goal-oriented programs: selection of immediate objectives; contingent planning (acquisition, supply, logistics, production, training); institution of predictive procedures providing expectations of future performance and prescriptive procedures relevant to continual evaluation of performance and adaptive modification of organization; institution of decision procedures yielding determination of activities and force levels, program mixes, allocation of resources.

(4) Operational

Implementation and execution of programs: utilization and account of resources; conduct of tactical operations and reporting of results.

When management science is construed as a professional activity that undertakes to provide resources for improved rational control throughout the entire range of a client-organization's decisions, no less imposing array than this can give an adequate impression of the scope of its mission. It is a legitimate simplification to associate the mission of management science with "optimal decision;" but it is a generally misleading one, due to the extreme range of interpretation permitted by that term. Optimal decision obviously may be expanded—by shifting the organizational context of decision—to refer successively to selection among alternatives for optimal response, optimal program, optimal strategy, optimal policy, optimal organization, or even optimal "realization" of an emergent social organization. While there is perhaps no decision level or type-problem of optimal decision that has not commanded attention in the previous conduct of systems analysis and systems research studies in management science, previous treatments of valuational and organizational aspects of decision have necessarily been informal, intuitive, and sometimes even frankly subjective. The technical capabilities of management science for systematic, warrantably rational formulation of decision models and rigorous procedures of optimization have proved adequate for application only to the first rank of decision problems: namely, the problems of allocation of resources and the maximization of effectiveness in operational decision making. The scope and complexity of issues of optimal policy and optimal organization are presently intractable under existing decision-theoretic methods and techniques; and these issues therefore generate a collection of crucial "second-generation problems" in management science.

Second-Generation Problems. Figure 3.2 presents an array of decision problems of the type usually designated "command/management problems." They are categorized by levels of decision making in a typical hierarchy of administrative responsibility; and they are distinguished from operational problems (shaded sector of Fig. 3.2) on the basis of their scope and their intractability to formal characterization. The elemental objectives of maximal effectiveness and optimal allocation—which in well formulated operational problems admit of unambiguous, quantitative measures—appear here in the guise of undefined, intuitive notions of optimal program, optimal policy, and optimal organization. The context of decision is that of a commander or administrator concerned, not simply with the cost-effectiveness of an operation, but with the viability and overall effectiveness of a complex organizational unit in the selective environment of competitive goal-seeking behavior. These problems transparently disclose their requirements for rigorization of the normative (or prescriptive) mode of rational inquiry inasmuch as traditional scientific methods can be shown to be capable, in principle, of providing only a subset of the criteria that would be relevant to "rational" control, i.e., control by warranted procedures of practical judgment, in the following echelon of value problems:

(1) interface (value) problems involving resolution of conflicting program objectives, immediate goals, activities levels, and resource requirements among components of a complex organization;

SECOND-GENERATION PROBLEMS
(Demands of the Future in the Prescriptive Sciences)

Decision Levels	Characteristic Problems
	<u>Holistic</u>
ENTREPRENEURIAL	Terminal values and alternative missions Justification of resource requisition Balanced "portfolio" Combinatorial missions/capabilities
	<u>Instrumental</u>
ORGANIZATIONAL	Optimal Organization structure; communication/control; policy/norms; management models; decision procedures
	<u>Interface</u>
PROGRAMMATIC	Resolution of conflict program objectives; strategies; activities levels; resource requirements
	<u>Suboptimal</u>
OPERATIONAL	Allocation of resources Effectiveness measures and maximization

Fig. 3.2

(2) instrumental (value) problems associated with the optimal design of organizational structure and communication-control functions, evaluation of policies and performance norms, assessment of alternative management models and decision procedures;

(3) holistic (value) problems concerning identification of ultimate values, selection among combinatorial missions/capabilities, justification of requisitions on limited total resources, assembly of a total "portfolio" of balanced activities for attainment of immediate effectiveness v. long range viability.

When problems of valuation and organization are posed as potential areas for the application of systematic analysis, decision science is immediately confronted with limitations, both conceptual and methodological, that are inherent in the radical reductionism of objective science. The characteristics of traditional scientific method listed in Table 3.2 may not be lightly spoken of as "limitations." They comprise the basic epistemological commitments of the doctrine of scientific objectivity; and the productiveness of science under this doctrine has been unquestionable. It is only under a reassignment of first priority to comprehensiveness, and thus only with a different aim in view for inquiry, that the following characteristics of traditional method have been criticized:

(1) Analytical perspective represents a point of view sometimes termed "objectivation" which uncritically assumes the a priori existence of a "real world" of perceptual objects standing completely independent of the cognitive agent in a subject-object dichotomy that Schrodinger [6] has castigated as the "peculiarity" of the scientific world view:

> It is not trivial that we are dealing here, as I maintain, with an at first unconscious and incomplete simplification of the problem of nature by preliminary exclusion of the

LIMITATIONS of "SCIENTIFIC" METHOD

ANALYTICAL PERSPECTIVE	Schrödinger
PRIMITIVE CONCEPTS	Mead
CHARACTERISTIC SYNTHESIS	Smith, C. S.
CRITERION of ADMISSIBILITY	RAC Studies

↓

RADICAL REDUCTIONISM

Table 3.2

cognizing subject from the complex of what is to be understood . . . . It is this . . . from which the main antinomies arise, the amazement that the objective world-picture is 'colorless, cold, and silent,' the vain search for the [interactions of mind and matter].

(2) Primitive concepts of objective science are purposefully denuded under the doctrine of wertfreiheit, which holds that the conduct of inquiry must be neutral in regard to values and that consideration of valuative content must be anathema on pain of a consequent failure of objectivity and observability. Insisting that the ultimate office of inquiry is to represent an unfractured universe in terms of meaningful qualities as well as quantities, Mead [7] has objected:

> . . . The method of exact measurement of the physical sciences has made use of approximations to situations of ideal simplicity in order to discover the laws of change in nature. There arose out of this method of materialism, a view . . . [in which] the whole qualitative aspect of nature, together with the meanings of things other than the scientific objects, was dumped into consciousness.

(3) Characteristic synthesis of compartmented scientific domains proceeds laterally by theory-reduction, i.e., by the process of demonstrating that a generalized structural isomorphism permits the incorporation of formally analogous theories. There is only a remote likelihood that properties of scientific objects at one level of explanation can be formally converted in those of subordinate or superordinate levels, unless methods for handling substructured wholes as such can be developed. As Smith [Ref. 2, p. 916] has observed, this is a task that objective science has in the past neglected; and he therefore urges this need:

> . . . to develop principles, not of simple particles and their interactions, but of extremely complex structures with parts interacting with other parts, on all levels,

> and with a hierarchy of interpenetrating substructures combining to form many levels of interpenetrating superstructure[4]. . . . It would be a marvelous thing if science could put things together, if it could understand more of the transactions between units, small groups, and still larger aggregates. The innumerable combinations that could exist obviously cannot all be computed, and the analysis must, at least partly, be related to the particular structures that have come into existence as a result of the individual evolutionary history which is behind any complexity.
>
> An intellectual approach tempered in this way would be good for human affairs in general, and those who used it would be less isolated than are today's scientists from the ordinary man who sees wholes and learns to enjoy and exploit sensed relationships which defy detailed analysis.

(4) Criteria of admissibility have been instituted in scientific inquiry with the aim of selecting, from a plethora of proposed theories, those that are best warranted for use specifically as cognitive models in description, prediction, or explanation. The essential test for admissibility—after logical relations have been validated—has been the confrontation of theoretical implications by relevant observations. That a theory shall be at least not disconfirmed by experience is the *sine qua non* condition for admissibility; further, the measure of its "confirmation" is a measure of the warrantability that may be assigned to it for use in rational control of factual judgment.

It is immediately apparent that the test criteria and procedures of objective scientific method are insufficient to establish the warrantability of a cognitive model (theory) for use in practical decision

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[4] See also Smith, C.S., *Rev. Mod. Phys.*, 36, 524 (1964).

making. Decision is a normative (value-sensitive) process and rational control of this process can be instituted only by way of prescriptive theories that incorporate valuative as well as factual and formal considerations. Clearly, one cannot "test" one's values and policies by comparison of predicted decisions with actions actually taken; agreement in this case would merely indicate consistent behavior—which might well be leading consistently toward disastrous consequences. Nor can test situations, in the sense of crucial experiments, be conceived in terms of any isolated state of affairs that would disconfirm given value-commitments. Values, policies, strategies, programs are inherently trend-oriented; they are expressly designed for overall benefits accruing from trajectories of events that will necessarily encompass incidental failures and losses as well as successes and gains. Any attempt to improve decisions therefore begins with the questions: How can values and policies be warranted for use in practical decision? What criteria of admissibility would be sufficient to establish the warrantability of prescriptive models and theories for use in rational control of valuative judgment?

The prescriptive mode of inquiry emphasizes a realization that tends to remain hidden in objective inquiry: that all cognitive models are to some degree ad hoc, that is, they are warrantable only with respect to some specific context that is necessarily constrained by commitments of the investigator. The establishment of criteria and the selection of strategy for the formulation and improvement of a theoretical model appropriate to the selected context directly involve the creative capacities of the theorizer as a decision maker. From the objective-theoretic viewpoint, this involvement is handled covertly; the strategy for obtaining an acceptable model has no formal status. Under a prescriptive-theoretic orientation, the involvement of the observer-theorizer in a subject-object dyad must be openly recognized and controlled by cognitive principles as a necessary condition for any claim to warrantability whatever. Further, the strategy for converging on an adequate model must be made an explicit part of the investigation.

Pursuit of these issues of sufficient criteria of admissibility and adequate procedural control for the formulation of prescriptive theories ultimately leads into the recesses of logical and philosophical reconstruction. For the moment we are concerned only to put forward our conception that, in the face of the limitations of traditional scientific method, the second-generation problems of management science raise metascientific issues that call for (1) the coalescence of normative aspects of all the behavioral sciences—as witness, the collections of relevant disciplines associated with the development of theories of decision, valuation, and organization (Table 3.3) and (2) the extension of rational inquiry into a distinctive new domain of prescriptive science that is more comprehensive in context than any that science has previously essayed.

COALESCENCE OF PRESCRIPTIVE SCIENCE

Research Areas	Relevant Disciplines
VALUE-DECISION THEORY	Variational Mathematics calculus of variations first-order perturbation theory
	Theory of Selective Systems
	Adaptive Control Processes
	Phychology (behavioral-social) cognitive theory
	Ethics / Aesthetics
ORGANIZATION THEORY	Mathematics of General Systems
	Partition-Programming
	Communication-Control Theory
	General Systems Research
	Psychology (physiological/developmental)
	Biophysics-Biology (mathematical)
	Sociology
	Cultural Anthropology

Table 3.3

Chapter 4

SURVEY OF METHODOLOGICAL RESOURCES

The identification of valuative issues as the central concern of prescriptive science dictates a consideration of method in the wider sense that we refer to by "methodology."[1] Analytical techniques and algorithms applicable to value analysis assuredly must be generated ultimately; but the selection of an acceptable prototype of rational inquiry emerges as the initial problem. Of all intellectual enterprises, the attempt to provide a rational basis for value judgment has perennially proved to be the most refractory for human intelligence. If we are to place decision systems—with their concomitant value concerns—at the center of interest in a new domain of research, what mode of inquiry is to be taken as appropriate and adequate for a rational treatment of the intractable phenomena that characterize the behavior of such systems? It is this question which inevitably forces a rudimentary science of management into an unfamiliar region of *meta*scientific issues and problems. One intimation is immediately clear: some modification of the presently

[1] It is apparent that this term, as presently used in many areas of technical-professional discourse, is gradually being degraded to the status of merely an elegant synonym for method. Against this trend, we use it in the original sense of *principles* for the control or selection of method.

accepted pattern of inquiry will presumably be a prerequisite to success in the larger mission which has been outlined and claimed for management science.

PROTOTYPES OF RATIONAL INQUIRY

In this situation it is a natural reaction to undertake an examination of successive modifications of scientific thought which already have supported a remarkable history of continued success. There is apparently no such thing as the scientific method, no sudden discovery or unique invention during the Renaissance or any other age. As Schmidt [1] has shown, the evidence points rather to a continuing process of modification which runs across the entire history of Western thought. This, of course, does not preclude the fact that, in a given era, certain patterns of inquiry have become stabilized—even to the point of dogma. It was just the service of Schmidt's phrase "models of scientific thought" to refer to those stable patterns which have occurred in history and which were supposed in their time, and for long periods of time, to provide the prototype for adequate explanation and control of any area of experience. It seems only reasonable to anticipate that an appreciation of this historic process of modification will contribute significantly to present attempts to attain a more comprehensive mode of inquiry specifically relevant to problems of valuation and decision.

Scientific Prototypes

Traces of continuous development in the procedures of inquiry are detectable throughout the history of science. Yet it appears that relatively abrupt innovations during certain particularly fertile periods effectively introduce the salient features with which we are concerned. Essentially, three basic models—each one a modification of its predecessor—have guided the progress of scientific inquiry: we term them the (1) axiomatic, (2) empirical, and (3) conceptual prototype models[2] of scientific thought.

Axiomatic Model. Upon the confused welter of uncontrolled prescientific speculation, the Oreganon of Aristotle (384-322 B.C.)—implemented by Euclid's Elements of Geometry (c. 270 B.C.)—imposed an elegant and orderly classical model of scientific thought. At the foundation of this "axiomatic" model of inquiry (Figure 4.1) lay a complex collection of epistemological assumptions. Aristotle's purely deductive version of science, which was to hold preeminence for more than a millenium, was based upon these presuppositions:

(1) that serious and persistent reflection must ultimately result in the intuitive apprehension of certain "most general" propositions (archi, or axioms) undeniable in character and therefore acceptable to all rational investigators;

(2) that unique definitions (organizing concepts) and self-evident premises (basic propositions relating these concepts) were attainable by agreement of all persons trained in a given subject,

(3) that valid procedures of syllogistic (deductive) reasoning operating on such definitions, postulates, and axioms would produce necessary conclusions, i.e., theorems which were true independent of experience yet universally applicable to the physical world; and

[2]Cf. P. F. Schmidt, "Models of Scientific Thought," American Scientist, 45, 2, March 1957, pp. 137-150. Despite the injection of terminology, interpretation, and illustrative figures reflecting our own interests—for which Schmidt must not be held accountable—the analysis of scientific prototypes presented here should be regarded as essentially a synopsis of his earlier treatment of "geometrical, physical, and logical" modes of scientific thought.

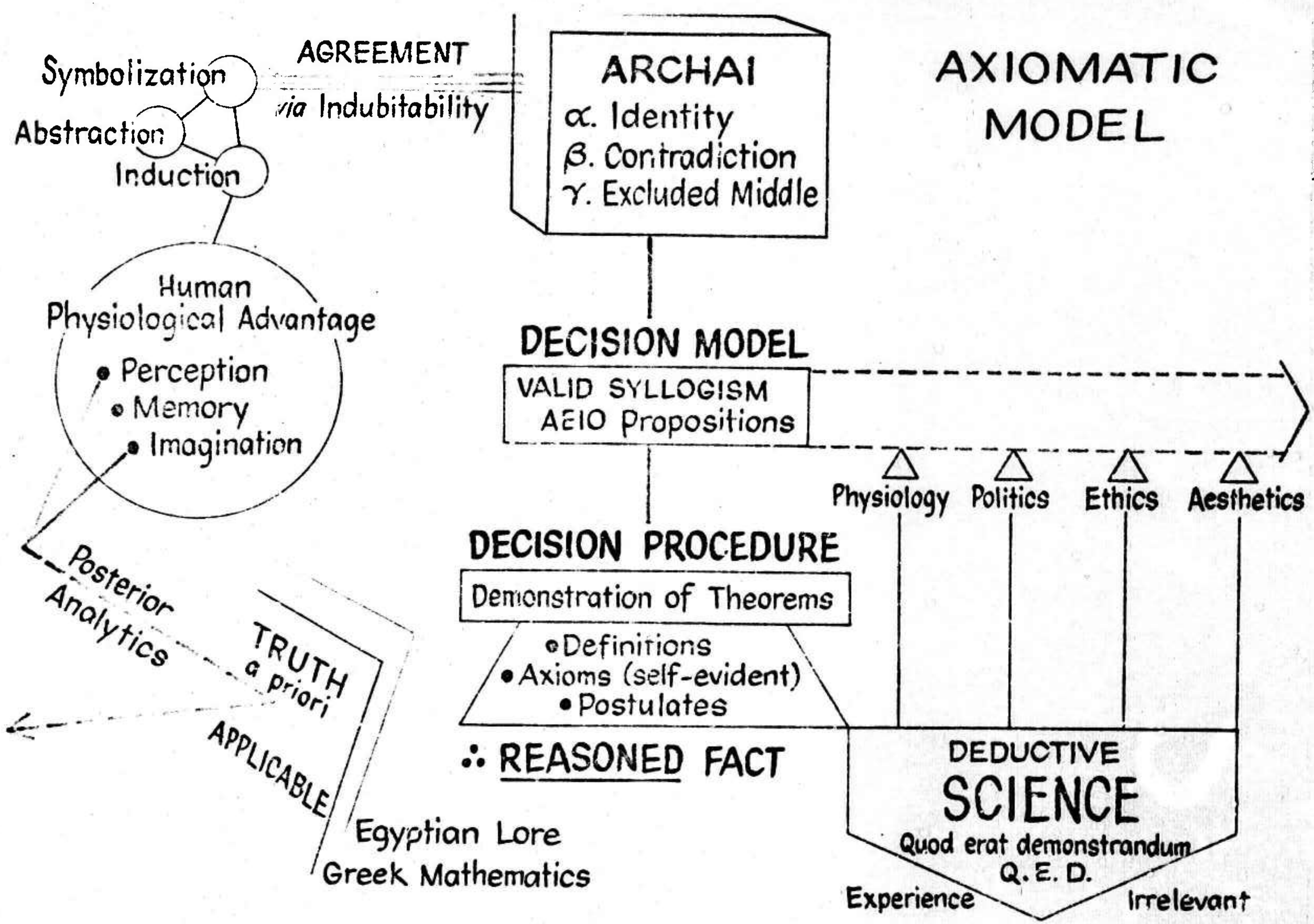
AXIOMATIC
MODEL
Symbolization
Abstraction
Induction
AGREEMENT
via Indubitability
ARCHAI
α. Identity
β. Contradiction
γ. Excluded Middle
Human
Physiological Advantage
• Perception
• Memory
• Imagination
DECISION MODEL
VALID SYLLOGISM
AEIO Propositions
Physiology
Politics
Ethics
Aesthetics
DECISION PROCEDURE
Demonstration of Theorems
• Definitions
• Axioms (self-evident)
• Postulates
∴ REASONED FACT
Posterior
Analytics
TRUTH
a priori
APPLICABLE
Egyptian Lore
Greek Mathematics
DEDUCTIVE
SCIENCE
Quod erat demonstrandum
Q. E. D.
Experience
Irrelevant

Figure 4.1

(4) that the systematic development of the entire complex of theorems possible on this basis would comprise a body of universal knowledge—the product of "scientific" inquiry.

The major obstruction for the prospectus offered by Aristotle was anticipated even before his own time. Socrates had earlier demonstrated (in the hard experience of argument with the Sophists) that, with respect to certain subject matters, it was simply impossible to attain agreement on the selection of basic assumptions. The key to a partial solution lay in the prior invention of Socratic dialectic—the admission of hypotheses into the method of inquiry. Euclid, in fact, had already exploited this method of hypothesis in the form of indirect proof in geometry. But in the main, the Platonic emphasis upon intuitive certainty effectively overwhelmed any general tendency to develop the Socratic dialectic. Considering the whole range of inquiry, the early Greek axiomatic model simply could not consistently resolve disagreements on incompatible basic assumptions, and this embarassment of intuitional riches was the mark of its ultimate breakdown. Dogmatism and tenacity, supported by authority, revelation, and mystical insight, became the inadequate barriers used historically to hide an intolerable deficiency: the lack of an adequate decision procedure whereby purported knowledge could be tested and conflicting claims resolved.

In the long delayed development of the rudimentary natural sciences instituted by Aristotle, there gradually emerged a decided intolerance of any deductive conclusion which constituted a denial of observed facts in experience. By the time of Copernicus (1473-1543), a restricted but influential community existed for which the conception of science involved a thoroughgoing incorporation of a "lost" maxim of Aristotle: that scientific knowledge must comport with *observations* in a given science. Yet it is clear that the addition of Socratic hypotheses and Aristotelian empiricism represented an insufficient modification of scientific method. In the grand debate which arose concerning the acceptability of the Copernican v. the Ptolemaic astronomical theory, a disconcerting realization appeared. Science encountered a prime example of the fact that two different hyctheses, logically quite incompatible, may be equally confirmed by experience. True enough, there existed certain extralogical considerations which afforded criteria for a choice between the alternatives. By virtue of its superior simplicity and elegance (since the Ptolemaic theory required *ad hoc* adjustment), the Copernican theory seemed preferable; but the demand at the time was for an intellectual basis for a decision as to which was the true hypothesis and which was the truly applicable theory. The identical requirement upon which the purely axiomatic model had foundered now confronted the new "empirical" science, viz., the necessity of achieving some incorrigible test for conflicting claims purporting to represent knowledge. Confusion had merely been compounded by the additional weight of experimental verification which seemed to justify each of two incompatible hypotheses. It was, nevertheless, a sharpened version of empiricism which was to lead out to a successful modification of scientific method in the second great model of scientific thought.

__Empirical Model.__ Systematizing ideas and procedures suggested by Kepler, Galileo, and Bacon during a century of precursory work, Newton's __Principia Mathematica__ (1687) struck a new balance between the roles of inductive and deductive procedures of inference. On the one hand sensory experience—under rigorous controls of precise measurement and careful generalization—was interpreted as a directive for the formulation of postulates; the working hypotheses of science need no longer be limited to principles derived by purely reflective reasoning (intuition). On the other hand, mathematical-deductive systems and procedures (carried over from the prior axiomatic model) were to be employed to derive theoretical consequences perhaps unforeseen; and in this promising event, experiments were to be designed specifically to test a given theory for correspondence of its consequences (predictions) with facts obtained by experimentation. The principal assumptions involved in this version of scientific method (Figure 4.2) therefore were:

(1) that basic postulates were in some manner extractable from observations of phenomena (presumably via inductive insight though Newton himself used the obvious misnomer "deduction" to describe this process);

(2) that the postulates specified factual relations among primitive (undefined) quantitative concepts as abstract descriptions of the real character of the natural world;

(3) that axiomatic systems of contemporary mathematics—considered as universally valid and applicable to the physical world—were adequate for derivation of predicted observations and that binary logic provided rational control of the test of predictions; and

(4) that the confirmation[3] of a theory should result from its correspondence with relevant experimental evidence.

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[3]Christian Huyghens, in his preface to __A Treatise on Light__ (1690), had clearly foreseen that the testing of theories by their consequences could only achieve probability, not certainty, as a measure of verification. This logical point was lost, however, as we shall note in the following section.

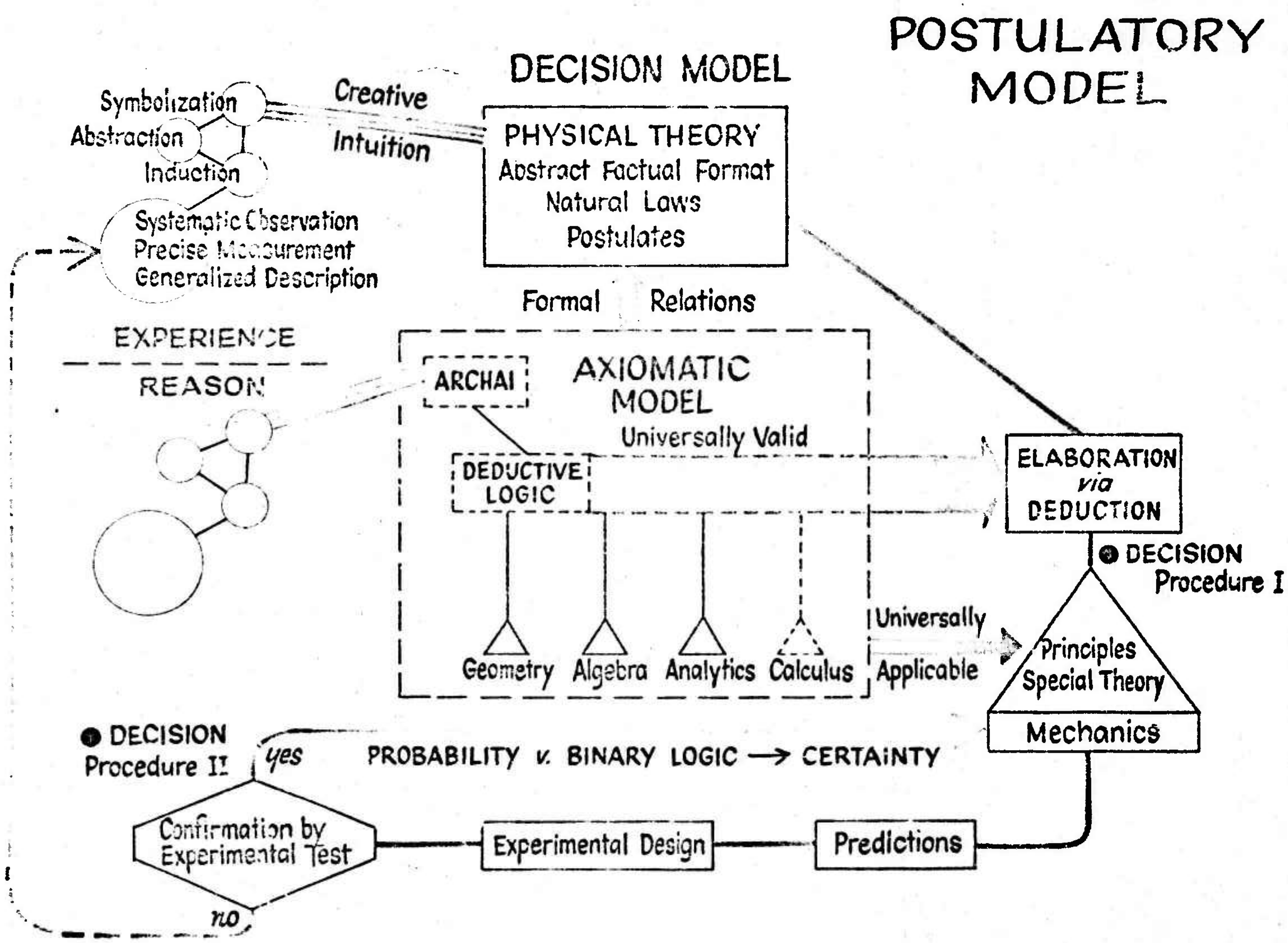
POSTULATORY MODEL
DECISION MODEL
Creative
Intuition
Symbolization
Abstraction
Induction
Systematic Observation
Precise Measurement
Generalized Description
PHYSICAL THEORY
Abstract Factual Format
Natural Laws
Postulates
Formal Relations
EXPERIENCE
REASON
ARCHAI
AXIOMATIC MODEL
Universally Valid
DEDUCTIVE LOGIC
Geometry
Algebra
Analytics
Calculus
Universally Applicable
ELABORATION via DEDUCTION
DECISION Procedure I
Principles
Special Theory
Mechanics
DECISION Procedure II
yes
no
PROBABILITY v. BINARY LOGIC → CERTAINTY
Confirmation by Experimental Test
Experimental Design
Predictions

Figure 4.2

It was just the consistency of its correspondence with experimental evidence that ultimately gave Newtonian science its potent claim to represent a unique schema of explanation directly corresponding to the structure of physical reality. The classical sciences which were subsequently build up by means of Newtonian method exhibited, even through the 19th century, such consistent verification that a crucial logical point was lost. Knowledge attained under the postulatory model had to be attributed such high probability that few, if any, actually doubted its certainty. While the comprehensiveness of this model was not thought to be unlimited (there were, after all, certain areas of human concerns in ethics, politics, aesthetics, and the like which were simply regarded as "off-limits" for scientific inquiry), it was believed that Newtonian method was the method of inquiry relevant to any mechanistic system.

It was the fate of adherents of this powerful system of explanation, however, to find that not only its mistaken claim to certainty was ultimately to be questioned, but even its general applicability. Its weakness was rooted in the failure, prevailing from earliest scientific thought, to appreciate fully the status of its deductive instruments (logic and mathematics) and especially their epistemological relation with empirical observation, inductive inference, and creative (aesthetic) cognitive processes in any concerted attack on the problem of explanation.

Euclidean geometry had furnished the conceptual frame upon which Newton cast his postulatory model. The concepts and axioms of this discipline, along with other "absolute" concepts, had been uncritically accepted at the metascientific level. Thus, the great expectation of rationalism—that unique, incorrigible axioms necessarily applicable and true of nature had once and for all been attained—still persisted at the very foundation of empirical science. Under the pressure of continuing investigation, this unnoticed imperfection opened to reveal a deep flaw in the postulatory model of inquiry; and the process of modification took on renewed impetus.

Conceptual Model. A century of progress in logic, mathematic and physics, beginning with Lobachewski's Theory of Parallels (1840), led to yet a third revolution in the conception of scientific thought which has come to fruition only in our own times. The origination of a collection of consistent non-Euclidean geometries (after Riemann, c. 1850) proved more than a little disconcerting to the view that Euclid's axioms and postulates were self-evident, necessary truths applicable to nature. The characteristic conclusion of the 19th century was, however, that this proliferation of alternative geometries constituted purely abstract creations of interest only to formal science, while Newtonian physics indicated that physical space was in fact Euclidean. In this clear distinction between formal and empirical sciences, the contemporary view of the relation of mathematics and logic to the experimental sciences was suggested. Hilbert's work in metamathematics at the turn of the century, with that of Whitehead-Russell (1910-13), and subsequent developments in symbolic logic attributed to Frege, de Morgan, and Carnap, have served to advance this conception: that it is the task of contemporary formal science to promote the creation of alternative formal systems in which symbols and formal statements (axioms) are to be regarded as open to any consistent semantic interpretation, as required by the needs of experimental scientists for relational structures to organize their empirical data.

But for all this, the Newtonian model still held the field as the effective prototype of empirical inquiry even through the first decade of the 20th century. For ardent empiricists, who awaited the verdict of experience as the test of adequacy of physical theory, a demolition of the Newtonian philosophical conception of unique mathematical disciplines necessarily applicable to nature was soon forthcoming.

Under two great heads, mechanics and electrodynamics, classical physics claimed comprehension of a tremendous scope of physical phenomena— a picture complete but for details, so it might have been regarded. But there were troublesome aspects in the apparent incoherence of the two divisions. Newton's laws of motion and gravitation seemed irreconcilable with Maxwell's equations for the propagation of electromagnetic energy. It was the contribution of Einstein, in his General Theory of Relativity (1916), to discover a basis for merging these apparently disparate fields. Appropriating one of the non-Euclidean geometries that had seemed so difficult for intuition, he succeeded in formulating the fundamental equations of an analytical version of mechanics in which the previously intractable distinction between gravitational v. electromagnetic forces no longer figured. In this novel format, previous concepts of space, time, and matter (or energy) became interpretable as components of a single formal entity: a unified field characterized by a metrical geometry of the Riemannian type. This new four-dimensional theoretical model adequately accounted for the traditionally significant phenomena in both classical mechanics and electrodynamics. It therefore satisfied an important extra-logical (aesthetic) criterion that Einstein personally advocated—i.e., systemic coherence among previously specialized theories—as well as his more technical primitive commitments: (1) formal invariance of basic equations under any continuous transformation of reference systems and (2) quantitative invariance of the velocity of light as measured with respect to any member of the equivalence-class of reference systems.

Due, no doubt, to the strangeness of certain of its implications (e.g., the variation of mass with velocity, the equivalence of mass and energy), Einstein's conceptual modification seemed at first confounding to traditional naive realism. Nevertheless, the confirmation of conclusions from his relativistic postulates resulting from a succession of painstaking experiments, beginning with the South African observations of the 1919 solar eclipse, led within a few years to wide acceptance—at least for the "special" theory of relativity. In subsequent extensions of this acceptance, physical geometry—the geometry of cosmic space—came to be generally identified with one of the supposedly fictional systems of pure mathematics. In satisfaction of the demand for correspondence, relativistic mechanics was shown to reduce to Newtonian mechanics when applied to massive bodies at low velocities; and Newtonian mechanics, unless modified by relativistic corrections, thus came to be regarded as an approximation warrantable only within a limited context. The supreme status of the empirical model of inquiry was therefore diminished as a result of the continuing drive toward comprehensiveness that has always characterized rational inquiry. And the third great modification of scientific thought—the conceptual model—began to emerge as a conception of inquiry (Figure 4.3) in which alternative formal schema were to be utilized under creative, insightful interpretation for the organization and explanation of the widest possible domains of experience.

In the form of this conception of inquiry, subsequent decades in the 20th century (c. 1920-1950) received from history a legacy of such proportions that tremendous effort had to be expended merely in comprehending and exploiting its immediate potential. A notable revolution of modern physics, beginning in the 1920's, featured such an exploitation; and the project of general assessment still absorbs rather completely the interests and efforts of contemporary philosophy of science. Summarizing with respect to the conceptual model of inquiry as it stood at roughly mid-century:

(1) Factual knowledge was to be attained by the combined employment of two <u>independent</u> divisions of inquiry:

(a) <u>formal</u> science—the domain of axiomatic systems—in which arbitrary logical schema (not self-evident propositions) were to be devised and manipulated under the control of deductive logic, and

(b) <u>empirical</u> science—the domain of explanatory objective theories—in which alternative formal schema, in terms of primary inductions (hypothetical constructs), were to be manipulated in order

1. to elucidate purported consequences (predictions) of a theoretical model via deduction, and

2. to test the correspondence of predictions with experimental evidence under the control of verification procedures, sometimes necessarily statistical in character.

(2) Formal (logico-mathematical) schema disclosed nothing about the character of nature; they merely presented conventional, internally consistent, <u>a priori</u> rational forms devoid of content until interpreted in some specific postulate via creative insight and inductive generalization of experience. Formal

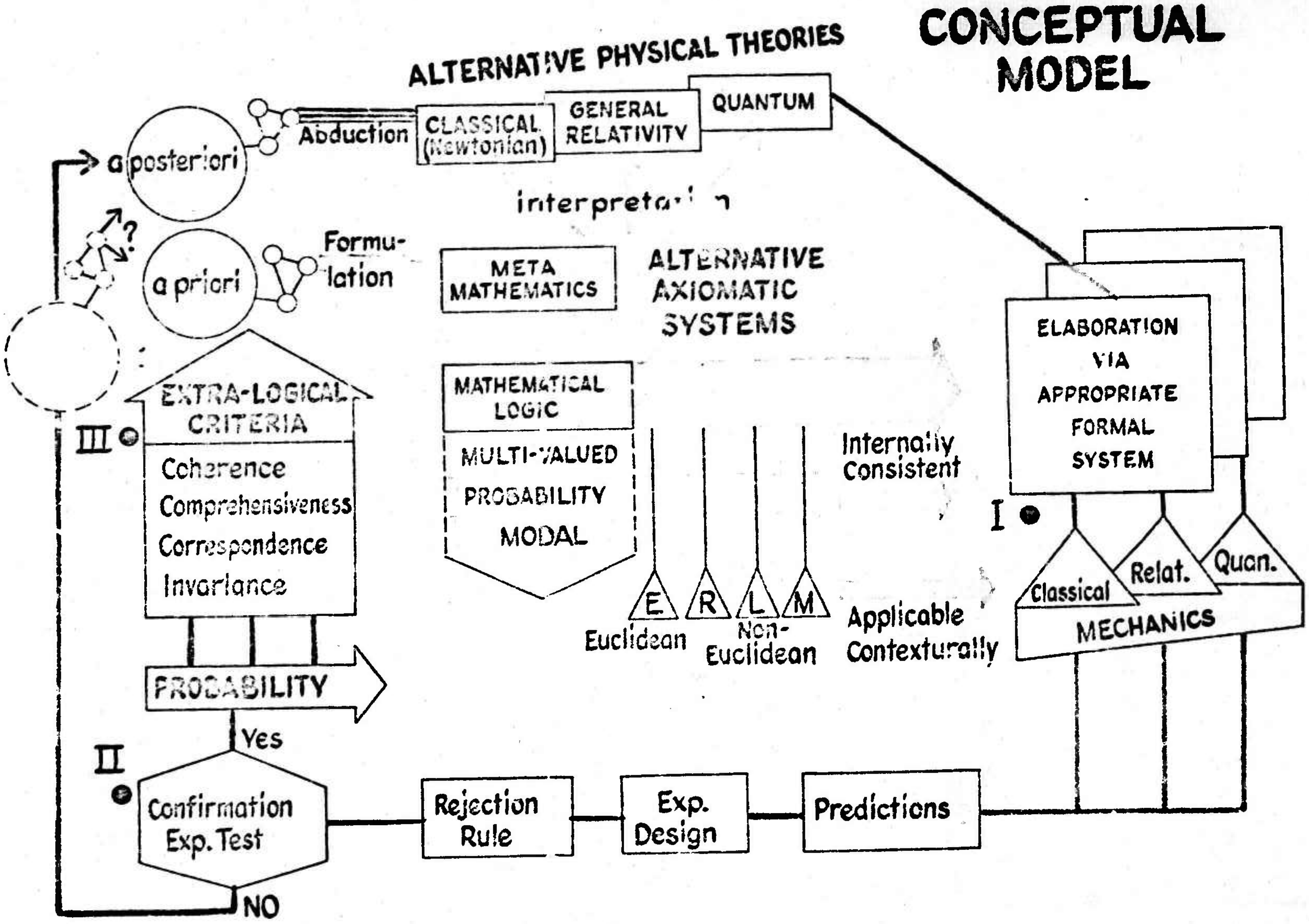
CONCEPTUAL MODEL
ALTERNATIVE PHYSICAL THEORIES
CLASSICAL (Newtonian)
GENERAL RELATIVITY
QUANTUM
Abduction
a posteriori
a priori
Formu-lation
interpreta
META MATHEMATICS
ALTERNATIVE AXIOMATIC SYSTEMS
MATHEMATICAL LOGIC
MULTI-VALUED
PROBABILITY
MODAL
EXTRA-LOGICAL CRITERIA
Coherence
Comprehensiveness
Correspondence
Invariance
PROBABILITY
Yes
NO
Confirmation Exp. Test
Rejection Rule
Exp. Design
Predictions
E
R
L
M
Euclidean
Non-Euclidean
Internally Consistent
Applicable Contexturally
ELABORATION VIA APPROPRIATE FORMAL SYSTEM
Classical
Relat.
Quan.
MECHANICS
I
II
III

Figure 4.3

conclusions (theorems) were considered neither true nor false but valid with respect to a particular axiomatic system. Neither the consistency nor the completeness of a nontrival formal system as a whole was believed capable of demonstration within the system (after the work of Gödel and Church), and therefore no such system could be absolute or universal, i.e., unconditional.

(3) Empirical scientific theories, exploiting an arbitrary structuring of experience, provided some recourse to prediction and explanation. Acceptable theories were sufficient for this purpose, but they did not necessarily correspond to any real structure in nature. Questions as to the character of "reality" were therefore considered irrelevant for science, since neither formal nor empirical science could in principle render a decision on this point.

(4) The elemental procedure of inquiry consisted in

(a) construction of a theoretical model relevant to some specific domain or context of experience;

(b) testing by experimentation designed to exhibit possible inadequacies of the theory; and

(c) modification or reformulation of the theoretical model which had been, to the extent of its inadequacies, disconfirmed.[4]

(5) The quest for certainty was relinquished; scientific knowledge was a posterior (dependent upon the outcome of experience) and probabilistic, though the desire for deterministic theories and perfect prediction seems to have been retained sub rosa.

(6) Such knowledge was subject to pragmatic, systematic, and aesthetic controls; i.e., it must be effective for immediate purposes of prediction and control, it must ultimately comprise a coherent philosophy of nature, and it must prove "satisfactory" for explanation under extralogical demands of simplicity, elegance, and comprehensiveness.

(7) Finally, it was considered to be objective by virtue of public scrutiny, though it was admittedly relative to some frame of reference selected by perhaps a very small coterie of experts.

[4]It was generally supposed that exceptional events could "disprove" a theory; though in fields where only statistical inference was possible, the disposal of a theory rested upon some arbitrary rejection principle.

This conceptual model of inquiry obviously represents a subtle and complex format. It is hardly surprising that, with regard to the rudiments of a new science of management decision, disparate views as to the application of contemporary scientific method should have arisen. At the first level of controversy, it is apparent that the features of this method are not thoroughly assimilated—uncritical employment of the empirical and axiomatic models are common. On a second level, it is at least understandable that a questionable assumption should have been widely accepted even by those who adequately appreciate the subtleties of the conceptual model: the assumption that a straightforward exploitation of this model can be expected to resolve the problem of achieving a theoretical basis for prescriptive science. It was, in fact, this mode of inquiry which directed our own earliest efforts.[5] Yet the expectation that contemporary scientific method can adequately treat valuation-decision phenomena—however strongly it may have been held—must now be abandoned.

Attention to the history of scientific thought forces one to a clear recognition that the progressive development of scientific method has never been accompanied by successful application to value inquiry, or "axiology" as it is termed in philosophy. And this is true despite serious and persistent efforts in every historical era. There is no

[5] Studies in mathematical value theory were initiated informally at Operations Research Office (c. 1953) to provide a methodological basis for a comprehensive decision model which would take into account the military expenditure of certain intrinsically valuable entities (human lives and irreplaceable strategic commodities) as well as ordinary resources. Reference [2] presents a summary of this development.

reason to believe that we can anticipate better results from a straightforward attempt to exploit an unadapted version of the recent conceptual model of inquiry. In order to justify this conclusion, and its implications for contemporary value-decision theory, we undertake a brief examination of historic models of axiological inquiry.

Axiological Prototypes

The history of axiological inquiry in Western philosophy, while it is in one sense obscured by even more complex issues than its scientific counterpart, may be encompassed initially by a relatively simple treatment that takes advantage of an obvious parallelism. The trends exhibited in Figure 4.4 indicate that each of the epistemological innovations that initiated successive models of scientific thought also led out to subsequent attempts to apply the new mode of inquiry to axiological issues. The difficulties involved in these attempts, however, have apparently introduced very great time-lags into this process.

That models of scientific thought, as paradigms of rational inquiry, should have exerted this influence is quite understandable. It was seen with considerable clarity, from the earliest encounters (Socrates v. the Sophists, c. 440 B.C.) with questions of value and decision, that the attainment of knowledge with respect to values and the institution of rational control of value judgments represented directives much needed throughout the conduct of human affairs. It was natural, therefore, that each prevailing scientific prototype—presumably specifying the most recent method of attaining reliable knowledge—should have strongly influenced parallel attempts to formulate a comparable axiology.

PROTOTYPES OF RATIONAL INQUIRY

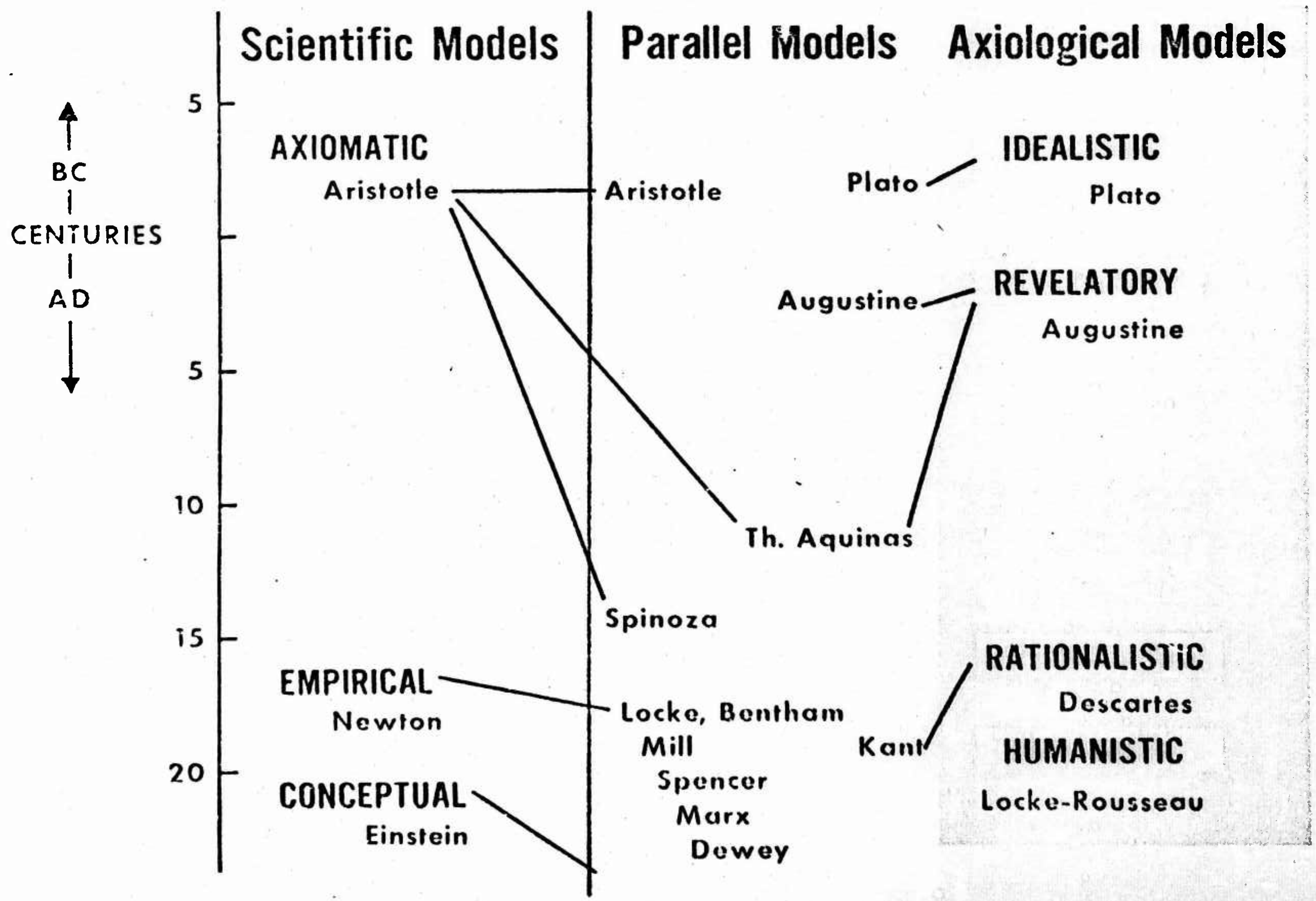

Figure 4.4

Parallel Models. As a first approximation, then, one can characterize the history of axiological inquiry by means of the same prototypes that were identified in the history of scientific inquiry. It is important to note, however, that only the axiomatic model instituted by Aristotle (Nichomachean Ethics, c. 335 B.C.) was destined to achieve an effective and durable application of scientific method to the field of axiology. The influence of his method reappears to affect scholastic thought (Thomas Aquinas, Summa Theologica, c. 1265) and to direct the culmination of axiomatic ethics (Spinoza, Ethics, 1677, which is essentially couched in the format of Euclidean geometry). Beyond this, the effect of the axiomatic ethical model persists even in modern social systems, e.g., the familiar phrase "We hold these truths to be self-evident . . ." plays an important role in our own Declaration of Independence.

The empirical model of inquiry similarly engendered subsequent attempts to apply a scientific innovation to value theory. Impressed by the apparent power of empiricism as an originative source of knowledge, the English hedonistic school (Locke, Hutcheson, and Bentham, 1748-1832) initiated attempts to found a system of ethics in which the fundamental principles were to be supplied by the various sciences. Extending this ambition, Mill (Utilitarianism, 1861) and Spencer (Principles of Ethics, 1879) sought to bring to a study of man the empirical methods derived from Newtonian science. Their effort presaged by Comte's positivism—especially his feature of a descriptive stage of inquiry—and Marx-Engels (The Communist Manifesto, 1847), was ultimately overrun by Marxian social theory, which has been received as a "universal description" of historical process. Sometimes it is the well established conclusion of contemporary philosophical criticism, however, that a fictitious impression of accuracy and precision has been generated. It is not surprising that, whatever the scientific intentions of its founder, Marxism has developed into a new religion—which Comte foresaw and tried to establish. Authoritative dogmas, new revelations, a cult of saints, and all the apparatus of worship have clearly ensued.

The adoption of a more legitimate version of the empirical model issues from contemporary pragmatism (Dewey, Theory of Valuation, 1939) and positivism, e.g., Rapoport's Operational Philosophy (1954); here the attempt has been to construct value-postulates in terms of a number of "invariant human needs." However, the extreme variations of human motivation and behavior in both individual and social contexts, the problems involved in measurement of values (as emphasized by Churchman (Prediction and Optimal Decision, 1961)), and the difficulties of statistical procedures for confirmation of theories in the so-called "value-sciences" all combine to form obstructions—even in the present day—to the successful application of empirical method in value inquiry. As we shall maintain in a later section, even the most gratifying progress in inquiry under this method would doubtless fail to provide an adequate rationale for valuation and decision. In an earlier publication [3], we have pointed out the inadequacy of a postulatory science of value which structures its domain of inquiry in terms of the thesis that decisions imply values, ignoring the prescriptive aspect in which values imply decisions.

The adoption of the conceptual model for an axiology has apparently not presented any great appeal for value theorists. It is characteristic of this model that its use requires an unusual level of synthesis. Since the analytic philosophy of the 20th century has not, in general, continued the earlier interest in systematic theories, the vast challenge of attempting a comprehensive theory of value (in which the conceptual model would provide the most promising format) has seldom been taken up. There are historic attempts which provide very strong support for such a project, e.g., Hegel's Philosophy of Right (1832) and Whitehead's Process and Reality (1929). Rigorous attempts to apply the conceptual model, however, have consisted of reductionistic theories which treat some single aspect of valuation within the strict context of one of the value-sciences, e.g., Debreu (Theory of Value, 1959), a formalistic theory of economic equilibrium in which the form of the analysis is logically independent of its interpretation in terms of a price system or, more generally, a value function defined on a commodity-space. This constitutes the nearest approach we have yet seen to the use of the conceptual model in value inquiry and this, by the admission of its author, concerns but one fragment of the field of value theory.

From the perspective of the primitive view that scientific prototypes have provided putative models for value theories, such is the history of the development of axiological models; and it is a history generally marked by abject failure to accommodate the dual demands of comprehensiveness and rigor. It will be an unusual reader, however, who has not detected—before this point was reached—that this simplistic perspective does not do justice to the history of value inquiry. There exists, of course, a second historic train of development which is relatively independent of that evoked by scientific models of thought. Stemming from rational prototypes which had no fruition in scientific inquiry after the advent of empiricism, this line of development in axiology provides the theoretical basis for those value structures which have actually been effectual in controlling the greater part of social practice throughout history. The general failure of scientific models to generate comparable axiological models does not indicate that no theoretical control of values has ever been exerted. It indicates rather that <u>alternative</u> axiological models have been utilized.

It appears, indeed, that one seminal prototype recurs in many guises. This model of inquiry—which we term the "idealistic model" in its original form—apparently subdivides historically in (1) a nonrationalistic,[6] theistic version (a "revelatory" model) and (2) a humanistic version (a "prescriptive" model). It is possible to acquire, from even the most cursory investigation of these axiological structures, a realization that has important bearing on the construction of a rationale for valuation and decision. To this end, we present an elementary account of successive modifications of the idealistic model of axiological thought.

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[6]We need to emphasize here a distinction between nonrational and irrational, turning upon the difference between anti-intellectualism v. the malfunction of intelligence.

Idealistic Model. Knowledge concerning values and "appropriate" decisions, as we have suggested, constituted a primal objective of systematic inquiry from its earliest inception in Greek philosophy. On this point there was general agreement, but agreement was prone to begin and end just there. For in Socratic times a naive confidence in the human ability to attain knowledge had been shattered. Stemming from a widespread cultural malaise produced by Athenian losses in the long-drawn, bitter struggles of the Peloponnesian War (431-404 B.C.), the radical skepticism of the Sophists marked a failure of nerve that amounted to a catastrophis "crash" of the aristocratic value system of early Greece. Social, political, and moral standards, previously based upon traditional virtues of arrete (personal excellence) and sophrosyne (balanced interests and self-discipline), dissolved under successive attacks of relativism, conventionalism, and opportunism.

Epistemology—the problem of knowledge—was the source out of which the radical Sophistic criticisms arose. An earlier society had known—without any particularly hard thought on the matter—what constituted the good life and what courses of action prudence and honor dictated to reasonable men. But the hard fact was that the decisions of such honorable and reasonable men had led the Attic world to disaster.

The Sophists, as men of admittedly high intelligence and considerable critical faculty examining the basis of this prior "knowledge," concluded that there existed no principles, either of knowledge or morality, that were independent of the natural impulses and dispositions present in particular men, nations, and times. By equating knowledge with perception, and thereby assigning equivalent potential for individual variability, illusion, and error, they were ultimately led to the premise that no such thing as authoritative knowledge was possible. On the strength of their skeptical maxim (that nothing could be known), force became the sole authority; conventionalism (one man's belief is as good as any other's), cynicism, and radical individualism became the general directives of decision and action.

From the social melee that soon ensued in Greek society, Plato emerged as the architect of a reconstruction of order and ethics—much as Aristotle served in the cause of science. With his theory of forms (the later Dialogues, c. 360 B.C.), Plato instituted the idealistic model of axiological thought which, in several variants, has influenced practically every subsequent value system in Western history. In its original rationalistic version, the idealistic model (Figure 4.5) systematics the following commitments of a philosophical dualism—a dichotomy of form (concept) v. matter (content), or conceptual v. perceptual "objects."

(1) Epistemology. The indeterminism or relativity of knowledge (Cf. Protagoras) attained through sensory experience was accepted. Physical science was therefore impossible, since there could be no permanent object of physical knowledge independent of opinions and perceptions of particular observers. But since virtue was to be identified with knowledgeable action (Cf. Socrates), there must exist a wholly different source of this form of knowledge.

IDEALISTIC MODEL

(Theory of Forms)

In preparation.

Figure 4.5

(2) Ontology. Reality as the object of knowledge must, therefore, be immaterial—of the nature of ideas. Thus, class-concepts (forms or ideas) comprised ultimate reality. Immateriality was not equated with spiritist or psychic phenomena; the emphasis was placed on the logical, conceptual character of forms as imparted by reason to the human mind. Ideas constituted a second (or actual) domain of reality related to physical appearances in the same manner as that which is permanent and universal in the world (Cf. Parmenides) is related to that which is changing or becoming (Cf. Heraclitus).

(3) Methodology. Attainment of the forms was to be accounted for by a rationalistic principle: that knowledge of reality is innate to the human mind. In contrast with the creativity presupposed in Socrates' induction of universal concepts from the "common element" of diverse opinions, the rationalistic method featured a process of "recollection" of what was inherently present in the mind. Logical relations between the forms were to be delineated by the division of class-concepts into species under the control of possible v. impossible unions of particular concepts (a precursory version of syllogistic reasoning).

(4) Metatheory. Three relations of forms to phenomena were identified:

(a) Imitation: the class-concept as a logical ideal is approximated in material entities; between a world which permanently exists and a world which is in process of becoming, there exists a relation of archetype to copy.

(b) Participation: the individual thing partakes of the universal essence represented by the form for its class.

(c) Presence: in the process of change, a form is present in any "thing" possessing the properties of class membership.

(5) Theory. In a hierarchy of forms, "the good" was established as supreme, directing all action in nature and bringing about the realization of all other forms. This concept was not defined except insofar as it was posited in relation to all of reality as an absolute goal. The subordination of all other concepts to that of the good was teleological—in terms of means to one ultimate end—rather than logical. All action and change in nature and in men took place for the sake of realizing the good, as was indicated by the fact that preparatory activities, such as joy in the beautiful, development of knowledge and artistic skill, understanding of mathematical relations, and appropriate ordering of practical life, typically culminated in the apprehension of the good.

(6) Ideological Applications. With regard to the fundamental destiny of men, the good represented the end (telos) which the phenomenon of life in society was to fulfill. The practical objective of human life, therefore, was moral education—the entire organization of community life was to be directed toward achieving this end (Cf. The Republic). Following Anaxagoras, Plato identified the good with "world-reason" (nous)—a nonpersonal, nonspiritual diety empowered to attract the efforts of men and to direct their actions and decisions toward its own realization as an ultimate end.

Appropriating much from his predecessors and synthesizing their contributions in a unitary theory, Plato thus instituted with his theory of forms an axiological model of thought which stood quite counter to the rudimentary scientific thought of the time. Summarizing the disparate features which are central to our interest: (a) knowledge of the permanent, universal character of reality—directed toward attainment of virtue and right action—displaced material knowledge as an objective; (b) the source of this knowledge was supposed to lie inside the human mind (innate ideas) rather than outside in the world of sensation and physical change; (c) the unquestionable certainty of such knowledge did not derive from any conceivable test but rather from a straightforward procedure of apprehension—a "looking inside" oneself amounting to recollection; and (c) as a directive to action and decision, this knowledge provided not mere expectations of particular future events but, rather, a fundamental alignment of men with the rationale and power of the Deity—an alignment that assured the attainment of all that was most valuable in the ultimate destiny of man.

This conception that "truly rational" inquiry must be concerned with that which is immutable and ultimately valuable—and this idealistic model of inquiry—has proved an unbelievably durable format for human thought. On the side of rationalism it set the trend of Hellenistic-Roman philosophy in both its Stoic and Epicurean components. But the religious trend in Plato's thought—the elements of otherworldliness, immortality, priestly tone, and the intermingling of intellect with mysticism—made the idealistic model as well a natural receptacle for the religious motif that ultimately saturated the Roman world with the emergence of Christianity.

Idealistic Variants: Revelatory, Rationalistic, Humanistic. Arising from an Oriental foundation quite independent of Greek philosophy, primitive Christianity very quickly came under the influence of the Platonic axiological model with the attempt of the Church Fathers (the Apologists, Gnostics, Dogmatists, and Neo-Platonists) to secularize and thus protect Christianity in the cultivated view. It was in this era of early Christianity that a process of partition began which led, on the one hand, to modification of the idealistic model in an anti-intellectual revelatory model and, on the other, to a version in which rational inquiry—though retained—became subservient to the ends of religious faith.

An anti-intellectual revelatory axiology, in which the logical aspect of Platonic philosophy is replaced by revelation of ultimate truth and value, serves as an admittedly influential mode of thought even into contemporary times. "Revealed" religious tenets, surviving centuries of criticism and even suppression, rise to prominence during the Reformation (with decided impact on secular democratic value systems) and culminate in contemporary Christian ethics with works of philosophical theologians that shape, in no small measure, the present value systems of millions. It is an inescapable conclusion, however, that this revelatory model—whatever its emotive and practical effect—does not constitute a definitive form of inquiry. Our ambition reaches very far in attempting to derive some basis for synthesis of historic versions of rational inquiry. Without any trace of prejudgment as to the ultimately appropriate objective for value inquiry, we may excuse ourselves from any present attempt to incorporate anti-intellectual, revelatory aspects of valuation and decision appearing in religion. This would constitute an anthropological project lying totally beyond our competence.

Returning to a line of development of revelatory type, but featuring a rational axiological format (see Figure 4.6), one finds the total conviction of the Christian church worked out as a Platonic-scientific system by Augustine (Confessions and City of God, c. 388-396 A.D.) in the beginning of the Middle Ages. Under the influence of ethical and religious interests, psychical conceptions gradually replaced the logical ones central to Plato's philosophy. This shift, suggested by Origen and Plotinus, was fully and consciously developed finally by Augustine—a master of self-observation, self-analysis, and the portrayal of psychic states. Beginning with introspective investigation of inner states of the human mind, Augustine developed (from data which he interpreted as primal certainties) via intuition and subsequent deductive inference, conclusions which seemed to him to justify and establish Christian values and beliefs on a basis of rationality.

Thus, the Middle Ages began with a vision of the task of inquiry as that of rationalizing and clarifying the assured content of feeling and intuition with regard to the relation of man to God and of ultimate value to action. But in this project, the aesthetic attraction of knowledge for its own sake returned, at first uncertainly, then with increasing momentum—unfolding at first scholastically (Thomas Acquinas and the Schoolmen), then finally unrestrainedly when the Renaissance scientists began to define limits for knowledge v. faith, philosophy v. theology.

In early modern philosophy—the great age of rationalism—a bid was made to extend the idealistic model to cover not only the ethical interests that were central to its origin but the whole domain of metaphysics as a

IDEALISTIC VARIANTS

Introspective Model

Rationalistic Model

Prescriptive Model

In preparation.

Figure 4.6

"science of being." Under the premise that the ultimately real character of the world was discernable in some rationale that was attainable by human reason, linked to but not dependent upon sensory experience, Descartes (Discourse on Method, 1637), Leibnitz (Monadology, 1714), and Kant (the Critiques, 1781-90) devised staggering constructions of idealistic philosophy which invoked relational complexity of an order that was utterly defeating to any conceivable notion of criteria applicable to the testing of the knowledge claimed. Subsequent versions of metaphysics—in this sense of ultimate knowledge of the character of reality—have worked a remarkable array of changes on the central theme of idealism: the duality of mind v. matter with the supremacy of reason and its formal knowledge over mere factual or scientific theories. Idealisms—subjective, objective, panpsychic, voluntaristic, absolute, pluralistic, and with yet other qualifying adjectives—constituted the core of systematic philosophies to the 20th century, when the hopeless task of interpreting and vindicating any one of these bewildering philosophical systems apparently helped to force philosophy toward analytic, pragmatic, and positivistic pursuits designed merely to clarify the task of philosophy and its connection with practical action.

In each of the philosophical systems mentioned, a component was devoted to the earlier task for which the idealistic model was invented: the structuring of value-experiences and the rational control of human decision in terms of values. The actually effective treatment of values throughout the modern period, however, has apparently stemmed from a combination of the revelatory axiological model and a "humanistic" model which emerged from the main stream of idealism during the Enlightenment.

The humanistic model arose on the tide of social criticism which swept the Western world out from under the dual controls of the religious establishment and the secular claims of feudal lords. With the vision of equality, liberty, and fraternity that moved a succession of humanists to proclaim the natural rights of man (Erasmus, Voltaire, Locke, Rousseau), an emotive version of idealism was introduced that, without recourse to metaphysical principle, has successfully reworked the frame of political and social values. Voluntaristic human prescriptives, asserted without any great dependence on rational justification and conjoined with the directives of Christian ethics, have constituted the axiological mode of the Western democracies as opposed to the ideological scientism of modern totalitarian states.

Twentieth-Century Theories. The various value theories prominent in the twentieth century comprise the spectrum of approaches that we presented in the Preface, and which we repeat here for convenience:

(1) Radically reductionistic theories in which the very relevance of value-inquiry is disallowed due to such conceptions as

  (a) lack of literal meaningfulness of value concepts

  (b) voluntaristic, individualistic nature of values; or

  (c) revelatory, transcendental, authoritarian sources of value.

(2) Linguistic-analytic theories (non-radical reductionism) in which the only legitimate content of traditional problems in value analysis is attributed to the confused and ambiguous interpretation of value terminology in linguistic behavior.

(3) Formal theories of utility and decision in which observable relative preferences disclosed by an individual's acts of decision are treated as interpretations of an axiomatic system.

(4) Naturalistic theories in which value-phenomena are construed as amenable to treatment in the predictive-experimental context of scientific inquiry.

(5) Non-naturalistic (Intuitionistic) theories in which values are associated with a non-empirical yet objective domain of entities sui generis, assessible by introspection and susceptible to logical relation, yet unconditional (or absolute) with respect to human desires, decisions, or actions.

In considering this general field of theories, we are confronted with a difficult problem of classification. What are the primary distinctions that will exhibit such systemic connections as may exist among this array of theories? The most promising possibility is the use of ontological and epistemological issues; in other words, the distinction between various responses to the two fundamental type questions: (1) What is the nature of value? and (2) How can values be known?. As indicated by Figure 4.7, with details in Figure 4.8, these theories fall into two principal groups representing a major dichotomy between naturalist v. non-naturalist (or idealist) ontological commitments. Reflecting a considerable amount of controversy within these divisions, distinguishable groups further derive from alternative positions regarding the relation of science to axiology—since this is the form in which the epistemological question has often been taken up in value theory.

Such a classification yields the immediate observation that no innovation of the order of a novel paradigm for axiological inquiry has emerged in contemporary value theory. The primary dichotomy of Figure 4.7 obviously repeats the basic separation of naturalist v. idealist lines of historical development; most of the positions with respect to the relation of science to axiology are essentially continuations of historic

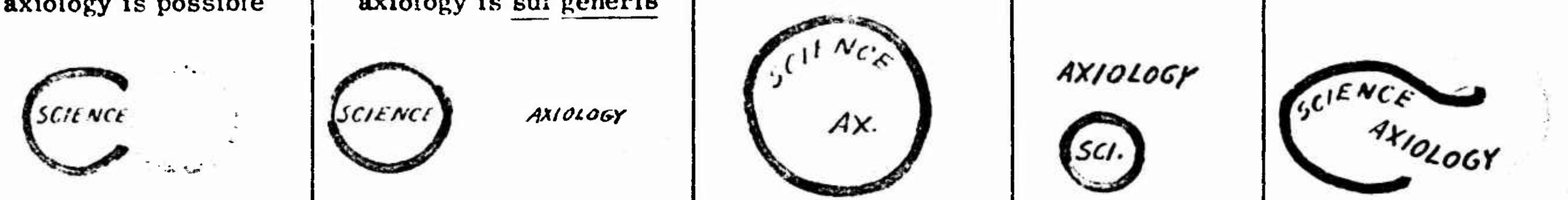
CONTEMPORARY VALUE THEORIES

PROPOSED RELATION	NATURALISTS		NON-NATURALISTS (IDEALISTS)	
No Axiology Possible	**Emotivists** C.L. STEVENSON **Logical Positivists** A.J. AYER	No Referent for value	E. W. HALL R.M. HARE K.R. POPPER	No Logical Applicable Individual Principles
Axiology a Subset of Science	P. EDWARDS A. EDEL **Operationalists** A. RAPAPORT C.W. CHURCHMAN **Motor-Affectivists** P.B. RICE R. PERRY C.I. LEWIS S. PEPPER	COMPLEX OBJECTIVE PROPERTY OF THINGS HUMAN NEEDS, WANTS VALUATION PROCESS IDENTIFIED AS: FEELING (AFFECTIVE) DESIRING (CONATIVE) THINKING (COGNITIVE) SELECTIVE		
Science a Subset of Axiology	**Pragmatists** J. DEWEY G. GEIGER	JUDGEMENT AND VALUATION UNITARY IN CHARACTER		
Science and Axiology Independent	H. MARGENAU	CONFORMAL METHOD	G. E. MOORE A.C. EWING R.S. HARTMAN E.T. MITCHELL	SIMPLE OBJECTIVE PROPERTY; SCIENTIFIC LOGIC UNIQUE LOGIC APPLICABLE TO UNIQUE FORMAL REALM
Science and Axiology Interdependent	**Critical Naturalists** P. ROMANELL C. MORRIS	CONTINUITY IN METHOD AND SUBJECT; NOT IDENTICAL IN SUBJECT OR METHOD		

Figure 4.7

VARIOUS POSITIONS CONCERNING THE RELATION OF SCIENCE AND AXIOLOGY

I.	II.	III.	IV.	V.
No relation ... because no axiology is possible	No relation ... because axiology is <u>sui generis</u>	Axiology is part of science	Science is part of axiology	Science and axiology interdependent



I.	II.	III.	IV.	V.
Emotivists A. J. Ayer C. L. Stevenson **Logical positivists** R. Carnap H. Feigl **Decisionists** R. M. Hare K. Popper	**Intuitionists** G. E. Moore H. D. Ross A. C. Ewing **Other non-naturalists** R. S. Hartman E. T. Mitchell	**Most naturalists** A. Edel P. B. Rice H. D. Aiken R. B. Perry C. I. Lewis **Operationalists** A. Rapaport C. W. Churchman	**Pragmatists** John Dewey G. Geiger	**Critical naturalists** P. Romanell C. W. Morris

Figure 4.8

attempts (1) to develop parallels of existing prototypes (axiology a subset of science or science a subset of axiology), or (2) to dismiss the possibility of unified rational control (no axiology possible or axiology independent of science). The one remaining conception—that scientific and axiological inquiry must be considered as interdependent—might, indeed, appear to claim the status of a significant innovation. Such a view does project precisely the line of development that would seem to promise most for the attainment of a more comprehensive rational format. This view, however, has been introduced only in the status of a prospectus, literally no more than a visionary concept of the kind of response called for by diagnosis of the present obstructions to concerted advance in value-inquiry. No systematic rational prototype featuring the interdependence of objective and normative aspects of decision has been forthcoming.

THE IMPASSE OF DUALISTIC COMMITMENT

A survey of historic models of inquiry fails to disclose, either in the domain of scientific models or in that of axiological models, a prototype which could be interpreted as providing a self-sufficient theoretical basis for value-inquiry. When we cast up the evidence, the record appears to force us to a choice between two almost equally unsatisfactory positions: reductionism or dualism.

By "reductionism" we refer to the following complex of views, each of which arbitrarily minimizes either the domain or the problems of value-inquiry. First, there is the radicalist conclusion that with regard to values there is, in the proper sense, nothing to inquire about and therefore no problem of method. Two versions of this type of reductionism—by no means equal in importance—are the treatment of values in (1) the early form of logical empiricism (value judgments are mere emotive ejaculations, not factually meaningful statements) and (2) traditional theistic ethics (ultimate values are revealed in man-God encounter or by authoritarian exegesis of sacred texts). One who finds himself coordinating his actions in community with others by the use of "meaningless" propositions will normally see a contradiction in the first of these views; and, in fact, it has had only a very brief vogue. Further, one who is not sensible of any special religious dispensation must forego the certainties of the second and will perforce continue to inquire as to the nature and source of values and the methods of value-inquiry. In another type of reductionism, inquiry is held to be appropriate; but the domain of values is arbitrarily restricted. For example, the contemporary school of linguistic analysts propose only a careful investigation of <u>the use of value terminology</u>. While such an approach can doubtless contribute much toward the technical development of pragmatics, it could not conceivably establish any normative principles of rational control in decision and valuation. The most important version of reductionism of this type, of course, is just the <u>ivertfreiheit</u> (value-free) conception of objective scientific inquiry at large. The limitations of traditional scientific method that were enumerated in the previous chapter have their obvious consequences in the severely restricted scope of interpretation and application that marks the contemporary value-sciences, i.e., formal decision and utility theories.

By "dualism," in regard to value inquiry, we refer to the existence of two unalterably opposed methods—apparently logically incompatible—each claiming to represent the legitimate approach to rational control of decision and action. In contrasting alternative attempts to utilize traditional prototypes, scientific and axiological, we come at last to a realization that dualism of this sort is the story of history in one word. We have carried the analysis of models of inquiry forward in two separate lines; but in their actual context, where both methods intermingled and competed for the adherence of particular men, these separate lines represented wavefronts that alternately forced men to oscillate between two polarized conceptions. Constrained by this polarization, their beliefs, decisions, and actions—directed either by (a) reductive scientific knowledge gained through controlled investigations or (b) holistic axiological commitment subject to relatively uncontrolled intuition—had to be rigidly compartmented by schism and treated in one of two mutually incompatible ways. The general solution has been to choose one stance or the other as directed by individual disposition and situation.

In appreciation of the engrained character of naturalist v. idealist tendencies, William James proposed that there are actually two fundamentally opposed attitudes or temperaments present in human beings and that these lead to alternative choices of metaphysical commitment. Feigl [4] has offered the following comment on this point:

> The "tough-minded" and the "tender-minded," as William James so brilliantly described them, are perennial types, perennially antagonistic. There will always be those who find this world

> of ours, as cruel and deplorable as it may be in some respects, an exciting, fascinating place to live in, to explore, to adjust to, and to improve. And there will always be those who look upon the universe of experience and nature as an unimportant or secondary thing in comparison with something more fundamental [i.e., the significance of man, his ultimate values and his destiny].
>
> . . . Profound differences in personality and temperament express themselves in the ever changing forms these two kinds of outlook assume. Very likely there is here an irreconcilable divergence. It goes deeper than disagreement in doctrine; at bottom it is a difference in basic aim and interest. Countless frustrated discussions and controversies since antiquity testify that logical argument and empirical evidence are unable to resolve the conflict. In the last analysis this is so because the very issue of the jurisdictive power of the appeal to logic and experience is at stake.

While we intend ultimately to show that the dualism represented by scientific naturalism v. axiological idealism need not be considered ineradicable, the foregoing view at least serves to indicate how sharp the divergence has been. In order to show the thoroughgoing separation between the two, as perspectives for value inquiry, we summarize the elements of this dualism in the array of Table 4.1.

Under every category which we have considered, these two perspectives of inquiry seem to be solidly counterposed, incompatible. Certainly a protagonist of either division will stoutly maintain that this incompatibility is not only apparent—it is logically ordained and it is factual. If a naturalist, our protagonist will very likely express contempt for the "empty verbiage" of idealism, shoring his criticism with the most fundamental tenet he holds: that conclusions which are <u>untestable in principle</u> can never be admitted as knowledge. If an idealist, he will perhaps counter with a sharp retort of his own: that anyone who proposes

dualism in value inquiry

NATURALISM (scientific)	HISTORICAL ISSUES	IDEALISM (axiological)
	Ontological	
objective realism	OBJECTS	subjective realism
decisions of other systems	PROCESSES	decisions of a self-system
	Epistemological	
empiricism	PROCEDURE	intuitionism
confirmation via experience	VERIFICATION CRITERION	indubitability of introspection
	Modal	
axiomatic, empirical	METHODOLOGY	revelatory, rationalistic, humanistic
prediction of decisions of object systems	OBJECTIVE OF INQUIRY	relation of present values to supreme values for self-control of decision
ADEQUATE WARRANT, REDUCTIONISTIC SCOPE		**ADEQUATE SCOPE, QUESTIONABLE WARRANT**

Table 4.1

to determine values by empirical observation simply does not understand the meaning of certain crucial terms in the language. What is never implies what should be; and therefore whatever a naturalist may discover by empirical observation, it will certainly not concern the "real" nature of value.

The deep-lying character of this problematic situation is due, so we believe, merely to the long-continued toleration of a fundamental incoherence between objective (factual) and normative (valuative) versions of rational analysis. The dichotomy of factual v. valuative judgment and, consequently, the formal separation of scientific reasoning from axiological (appraisive) reasoning is almost as old as systematic inquiry itself. This early commitment to dualism has been massively reinforced by historic successes in the "value-free" scientific inquiry that it permitted. The original status of this dualistic commitment as a strategic policy for the control of systematic cognition has therefore been effectively obliterated by the very successes that have seemed to vindicate the policy so far. Thus, the value-fact dichotomy has gradually assumed almost the status of a sacrosanct principle. It is now thoroughly engrained, traditionally instituted—a thematic feature of thought so pervasive as to be easily mistaken for a necessary condition of rationality. However prejudgmental this "over-commitment" to dualism may be with regard to the possibility of creative modification at the foundations of inquiry, it is the result of a powerful and generally fruitful tendency toward institutionalization.

In this light it is readily understandable that when difficulties began to be encountered with the <u>sub rosa</u> injection of value-considerations in behavioral science, the general tenor of methodological research should have been solidly constrained by an almost unnoticed dualistic assumption, just as previous value inquiry in the humanities had long been constrained.

The single characteristic that is common to the really incredible number of disparate value-decision theories extant, across both the divisions of scientific and philosophical investigation, is their general acquiescence in the adoption of dualism as a point of departure. From this origin the two major lines of proliferation have issued—scientific naturalism v. axiological idealism—each phylum of theories subsequently admitting of the specification that we are witness to in contemporary value theory.

On either side of the deep fissure produced by objective v. normative dualism, theoretical alternatives have been worked out rather exhaustively. The resulting chaotic assemblage of theories—some of them comprehensive but not rigorously warranted, others rigorous but drastically reductionistic—admits only of this conclusion: that we are presently confronted with supposedly incompatible basic perspectives of inquiry, each of which faces its own kind of impasse for want of those very features which the other has specially developed. Certainly it must be admitted

(1) that there exists no domain of phenomena that is commonly shared by scientific (objective) and axiological (normative) interests in value-inquiry; and

(2) that their respective approaches to disparate domains constitute quite distinct components of inquiry, with necessarily different

techniques of observation and analysis, methodologies, and objectives.[7]

If anything at all has been made clear in the arduous development of contemporary value theory, it is the fact that scientists v. axiologists have not been talking about the same things, have not been directed toward common objectives, have never supposed that their respective modes of inquiry could be resolved one into the other. An attitude of antagonism has generally prevented even the minimal concession that their disparate approaches to value-inquiry individually comprise meaningful projects, that each approach does in fact concern itself with relevant types of data and procedure. Consequently, there is little realization that a comprehensive rationale for valuation and decision would be required, first of all, to achieve a coherent synthesis of two equally legitimate theoretical enterprises: (1) objective-scientific inquiry regarding values (as hypothetical constructs) interpretable in the context of a decision system as an object, where the aim of inquiry is prediction-explanation of the observable behavior of an external somatic system; and (2) normative-axiological inquiry regarding values (as norms to be instituted) for adaptive control by some decision system as a subject (a "self" or an organization), where the aim of inquiry is a prescription

[7] This assertion must, indeed, be qualified by anticipation of the necessity of interlocking controls for warrantability of theories generated under either mode of inquiry. The statement, however, is technically correct; these approaches share in common the foundations of rational methods in general but they do not share any element of their respective domains of phenomena.

determining a behavioral trend (a program, strategy, or policy) contributing toward the viability of that subject of self-system in a selective environment.

In the face of a complete schism between the concerns of science and axiology, there is no conceivable treatment of valuation and decision that could adequately satisfy our aesthetic, intellectual, and practical demands collectively. The extralogical criterion of elegance does not admit of compartmenting experience in any manner that smacks of ad hoc theorizing. Coherence and correspondence, as well, are sacrificed if nontranslatable versions of value theory are accepted. More critical yet, the warrantability that is required as the literal sine qua non of rational decision is unattainable. This is to say that neither values as norms for decision nor factual knowledge for predictive purposes can be unambiguously warranted when science and axiology are rigorously construed as mutually independent. The "objectivity" that is claimed for tested predictive knowledge and the "indubitability" that is claimed for values vindicated in experience can be shown to be equally subject to criteria of admissibility that involve an irretrievable interlocking of the basic procedures of acting-valuing-knowing.

But above all, decidability is jeopardized by a scientific-axiological schism. This essential criterion is associated with the general capability of adaptive systems to select responses that maintain their viability by resolving problematic situations, i.e., conditions of physical stress of failures to attain intended goals. Any theory that involves a thoroughgoing separation of objective v. normative aspects of decision must eventually encounter one of two versions of an impasse that may be termed "nondecidability." (1) If the theory is used predictively, it must fail to provide accurate expectations concerning the forthcoming behavior of any selective system that is engaged in problem solving, since the theory cannot, in principle, accommodate <u>normative</u> modifications of response. (2) If the theory is used prescriptively (as a directive for the selection of practical action by some cognitive agent), it must lead to a catastrophic loss of the capability to act or decide just whenever an imposed problem turns out to be amenable only to modification of strategies, goals, values, and/or reobjectification of the external "factual" situation.

Instances of these two versions of impasse are all too familiar. The first characterizes the general failure of deterministic theory in molar-behavioral inquiry; the second typifies the paralysis of decision that marks "trapped-state" conditions as exhibited by an individual personality, a corporate organization, a social institution, or a para-institution (e.g., a community of scientific inquirers faced with an inability to select among alternative cognitive models).

This array of practical, intellectual, aesthetic, and evolutionary limitations imposed by dualism evokes one very secure conviction: that the appropriate recourse for contemporary inquiry lies in a concerted attempt to resolve the difficulties inherent in dualism by an alternative commitment that construes the objective and normative concerns of science and axiology as interdependent in principle.

Chapter 5

METASCIENTIFIC PROBLEM AND PROSPECTUS

The service of the preceding chapter has been the crucial one of diagnosis at the deepest layer of problems that we shall have to encounter. With the identification of a long-established fact-value dualism as the ultimate obstruction to advance in prescriptive science, we have completed the course of motivational development that was outlined in the Preface. Beginning with the confident initial employment of scientific inquiry in practical decision making, we have shown that an eminently practical aim—to extend the technical capabilities of decision science—forces us inevitably toward confrontation with obstructions at a level of generality beyond the immediate concern of any scientific discipline and hence with problems that are metascientific in scope. Significant extension of presently limited capabilities for systems analysis, systems evaluation, and systems design in the context of the "second-generation" problems of management science has been our objective. But it is now apparent that such practical ends can be attained only on the strength of success in problems that are logically superordinate. In the endeavor to secure for management science the broader capabilities of a prescriptive science, we have been forced back upon the troublesome presence of a dualistic impasse; and the central metascientific problem addressed by this volume must therefore be identified with the pervasive need for a unified rational paradigm for the construction of theories admitting of significant interpretation in terms of formal, factual, and valuative aspects of decision, valuation, organization, and cognition.

This problem arises from the fact that obstructions to methodological advance form an escalade in which the problem at each level can be seen as a direct consequence of a next higher-order problem. Our research program may therefore be characterized by a sequence of successively more abstract problems, beginning with practical concerns and terminating only with the patently metatheoretical task of attempting to extend the present scope of rational inquiry per se. As indicated in Table 5.1, we have encountered, in ascending order of generality,

(1) intractability of practical decision problems of the command/management type,

(2) inapplicability of existing limitation of analytical techniques of management science,

(3) incoherence of objective v. normative theories of decision and valuation, and

(4) incompatibility of dualistic primitive commitments and reductionistic criteria of rationality.

RANGE OF THE PRESCRIPTIVE SCIENCES

The "domino-effect" in this problem formulation is unmistakable:

CONCEPTUAL — METHODOLOGICAL DEVELOPMENT

(Situation: An Escalade of Obstructions)

SECTOR	STATUS	PRINCIPAL OBSTRUCTION
METATHEORETIC Primitive Concepts/Commitments	not sufficiently comprehensive	Reductionist Abstractions re: criteria of admissibility
THEORETICAL Schematic Formal Structure	non-conformal non-correspondent	Dichotomy of Prototypes re: value-decision theories (objective v. normative)
APPLIED OR/MS Analytical Techniques	not directly applicable	Limitations of Scientific Method re: prescriptive rational control
PRACTICAL Second-Generation OR/MS Problems	intractable	Non-complete Characterization re: hierarchical systems (a[illegible]ptive-normative)

Table 5.1

each obstruction will yield only to higher-order innovations and only the cascading results of modifications of primitive concepts and commitments could be envisioned as a sufficiently fundamental response to the overall problem. The potent line of attack is from the general to the specific, from the metatheoretical task to the practical. It is by way of philosophical reconstruction, and its improved control of the theorizing process, that coherent theories of decision and valuation, relevant techniques of systems analysis and design, and ultimately more adequate resolution of complex practical decision problems may hopefully be sought. As a directive to methodological research for management science, we have emphasized the realization that the attainment of systematic rational control in valuative decision problems ultimately involves a totally new order of theoretical difficulty. In close association with work on general theories of valuation and organization, we therefore append projects of metatheoretical reconstruction, indicated in Table 5.2, as a proper sector of the range of the prescriptive sciences. The requirement is that we design and execute a program of methodological research that adequately supports the total mission of prescriptive science: i.e., the conceptual modeling of complex decision processes that determine the characteristic response of a social organization as a whole:

(1) descriptive analysis of characteristic structure, function, and present state of the organization-in-environment (essentially intelligence acquisition via mapping, modelling, and simulation);

THE RANGE OF THE PRESCRIPTIVE SCIENCES

(From Practice to Theoretical Foundations)

MANAGEMENT		PRESCRIPTIVE SCIENCE	
Practical Decision Making	Applied	Theoretical	Metatheoretical
ENTREPRENEURIAL	Intuitive Factorizations	Normative Theories decision valuation organization	PHILOSOPHICAL RECONSTRUCTION
ORGANIZATIONAL	Decision Models	Management Models	RATIONAL PARADIGM
PROGRAMMATIC	Simulations	Analytical Procedures	UNIFIED METHODOLOGY
OPERATIONAL	Sub-Optimizations	Optimal-Decision Processes	COMPLEMENTARY MODES

Table 5.2

(2) predictive evaluation of the impact of current operations and programs in correlation with environmental and organizational trends (essentially measurement of effectiveness and viability, diagnosis of present needs, anticipation of stress);

(3) prescriptive design of putative improvements in operational, programmatic, structural aspects for consideration by responsible administrators (essentially the role of change-agent in the interest of adaptive organization);

(4) methodological research aimed at extension of presently limited technical capabilities in analysis, evaluation, and design (essentially cognizance and exploitation of current advances in the prescriptive sciences with a view to attainment of theoretical models applicable to decision problems of increasing scope and complexity);

(5) metatheoretic inquiry as an attempt to extend the conceptual foundations necessary for the formulation of sufficiently general theories of decision, value, and organization.

In disciplinary terms these component missions are the enterprises of (1) applied systems science, (2) theoretical systems science, and (3) general (philosophical) systems research respectively. In entrepreneurial terms they comprise just the combined sectors of objective and normative scientific inquiry most relevant for the implementation of a reflexive mode of institutional adaptation that would roughly approximate the self-organizing capability of the individual cognitive agent. This significance of this consideration is this: that the second-generation practical problems of management science, by their demand for creative innovations of the order of general theories of value and organization, ultimately create problems for the theorist regarding rational control of the cognitive process per se in theory-construction for the distinctive new domain of prescriptive science.

Thus, the entrepreneurial problem of the theorizer becomes the creation of a conceptual-methodological paradigm for warrantable decision making that will encompass (reflexively) his own cognitive decisions in the very process of theorizing. As a necessary adjunct of the theoretical development of prescriptive science (Cf. Table 3.3, p. 3-46), the ultimate range of the prescriptive sciences therefore encompasses the research areas and the coalescence of sciences and humanities presented in Table 5.3. From the vantage point of a number of years of involvement with the interdependent complex of problems associated with this area of research, we can set forth—in a deceptively neat array—general objectives, problem areas, and relevant disciplines, comprising the rather painfully wrought prospectus of research that has guided the investigations reported in this volume.

General Objectives:

(1) To attain an explicit formulation of a "systems-philosophy" that effectively assimilates and exploits the potent complex of new intimations currently issuing from specialized investigations in cybernetics, general systems research, analysis of creative-logical-aesthetic components of the cognitive process, methodological study of historic prototypes of scientific and axiological inquiry, mathematics of optimal control, and behavioral inquiry (psycho-social-biological);

(2) On the basis of a metatheoretic reconstruction of primitive concepts and commitments, to generate a unified prototype of rational inquiry that admits of (a) the coherence of scientific (factual) and ethical (valuative) aspects of deliberativ decision, (b) the attainment of theoretical models applicable to classes of practical decision problems that are presently amenable only to subjective-intuitive solution, and (c) an improved understanding of the process of theory-construction itself as a creative activity.

UNIFIED STUDIES
in the Sciences and Humanities

Research Areas	MODES \ SYSTEMS	SOMATIC (Substantive)	SEMIOTIC (Symbolic)	NOETIC (Conceptual)
SYSTEMS-THEORETIC SCHEMA	ANALYTIC (formal)		logic	mathematical analysis
UNIFIED RATIONAL PARADIGM	OBJECTIVE (predictive)	experimental physical sciences	linguistics	mathematical physical sciences
	NORMATIVE (prescriptive)	management sciences	aesthetics	mathematics of optimization
PHILOSOPHICAL RECONSTRUCTION	SYNOPTIC (holistic)	historical anthropological evolutionary disciplines	thematics	systematic philosophy

Column heading over SOMATIC, SEMIOTIC and NOETIC: Relevant Disciplines *

* Generalized entries only; See p. 5-10 for detailed listings

Table 5.3

Problem Areas

(1) systems-theoretic schema: a conceptual format applicable to phenomena associated with organization and transformations of organization in general;

(2) canons of rationality: a systemic collection of formal, empirical, intuitive-aesthetic, and evolutionary criteria as controls affecting the admissibility of alternative cognitive models, i.e., formal, predictive, and prescriptive theories in general;

(3) unified methodology: operational integration of the supposedly disparate methodologies of formal science (logic-mathematics), experimental science, and axiology;

(4) unitary paradigm of rational analysis: a schematic rational format possessing the formal property of duality and admitting of alternative interpretations identifiable respectively as objective and normative prototypes of analysis that are mutually complementary; and

(5) normative prototype of inquiry: formalization of detailed procedures for warranting prescriptive (as against predictive or formal) cognitive models and for applying the legitimate variant forms of analysis that ensue from alternative primal-dual rational modalities.

The assemblage of relevant disciplines from the sciences and humanities may best be represented by the matrix of Table 5.4, in which the disciplines are arrayed in terms of their respective modes of inquiry and categories of interest.

FOUNDATIONAL RECOURSE

A comprehensive rationale for valuation and decision, then, requires a synthesis of the dualistic, specially constituted paradigms of factual v. valuative judgment—a possibility that we now seriously propose. That

RELEVANT DISCIPLINES, SCIENCES AND HUMANITIES

Categories of systems / Modes of inquiry	Somatic Systems	Semiotic Systems (symbolic)	Abstract Systems
Analytic		formal linguistics syntactics	advanced algebra mathematical analysis general analysis measure) relation) theories modeling)
Predictive	physics chemistry biology psychology physical anthropology sociology economics	linguistic analysis semantics	mathematical physics and biology
Prescriptive	cybernetics medicine-psychiatry management science ethics jurisprudence	logic aesthetics	variational mathematics mathematics of optimal control perturbation theory statistical decision theory dimensional analysis
Synoptic	history (social-political) history of science and philosophy cultural anthropology evolutionary biology general systems theory	thematic analysis pragmatics	systematic philosophy

Table 5.4

we do so is, in itself, a signal that we anticipate the introduction of a new rational prototype under which scientific and axiological models can be legitimately assimilated. This is not to say, of course, that they can be assimilated while the basic regimen of rational decision remains unchanged. The realization that only fundamental modifications can lead away from or around an impasse in rational inquiry has already been historically grounded: (1) The introduction of an extralogical criterion of simplicity was required in order to resolve the grand confrontation of Copernican v. Ptolemaic cosmologies. (2) Conflict as to the admissibility of relativistic v. classical mechanics gave rise to a principle of correspondence which allowed their coexistence under a new categorical criterion. (3) Recognition of the operational equivalence of wave v. particle conceptions (within the intersection of their respective ranges of interpretation) led in physics to the assertion of a principle of complementarity that simultaneously accommodated alternative theories for the propagation of radiant energy which—though independently confirmed—had previously seemed to be logically incompatible.

These examples serve a double purpose in that they clearly emphasize the essential character of inquiry *per se* as that of a decision process. Under a decision-oriented approach to a theory of value dictated by our initial strategic premise—that values constitute appropriate determinants to decision*—it is clear that a comprehensive theory must provide for two quite different aspects of valuation and decision: (1) inquiry regarding values presumably operative in any given decision system as an object, where the aim of inquiry is the attainment of knowledge for the purpose of prediction-explanation and (2) inquiry regarding values-to-be-instituted as norms for some decision system as a subject (one's self or an organization in which he is privy to internal information), where the aim of inquiry is prescription-control.

In predictive inquiry—characterized by the value-sciences (economics, sociology, cultural anthropology, behavioral psychology, and the like)—the observable data consist of overt decisions, acts in which selections are made among alternative courses of action purportedly open to the decision system under observation. The source of data lies external to the observer, and we therefore describe the procedure of predictive inquiry as being "extrospective." In prescriptive inquiry—characterized by the arts of psychoanalysis, management science, personal and systematic ethics, and the like, the "observable" data consist of sometimes quite tenuous information as to the internal states

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* This placing of the central interest upon decision making and the decision process is, of course, quite in line with the traditional conception of value theory as concerned with choice or preference. This minor shift in emphasis renders explicit the crucial significance of the relation of reflective thought to preferential behavior. The entire range of types of decision clearly would include not only selective behavior in which choice is aesthetically determined, but it would encompass as well behavior in which deliberate decision is directed by rational inquiry and the cognitive processes in general.

of a decision system. Since these data may well be internal even to the observer (e.g., in the case of the self system), we describe the procedure of prescriptive inquiry as being "introspective." In the light of this analysis, one realizes that the primitive statement used to structure value inquiry (values constitute determinants to decision) may now be reformulated as: Decisions imply values; values imply decisions.* The first element of the statement refers to extensional inquiry (value-science), the second to intensional inquiry (axiology).

Thus far our conception of value inquiry achieves no more than to render explicit our contention that (1) the traditionally disparate approaches to value-inquiry individually comprise meaningful but separate projects, (2) each approach does in fact concern itself with relevant though different procedures and types of data, (3) putative knowledge of the operative values of an external system is the product of value-inquiry from the objective scientific perspective; putative norms for decision by a self-system are the product of inquiry from the normative scientific perspective.

At the core of our expectations for a more comprehensive rational prototype is the conception that neither knowledge for predictive

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* The term "imply" is not to be interpreted in its strict logical sense, but rather as referring to the notion that some prescriptive transformation, under a specific axiological model, may convert a set of values into a set of decisions, and that another prescriptive transformation, under a specific behavioral-scientific model, may convert a set of decisions into a set of values. In this context we may have occasion to use the following terms synonymously: imply, determine, transform into, lead to.

purposes nor valuation for prescriptive purposes can be adequately warranted so long as science and axiology are conceived as independent; or, equivalently, that the "rationality" of neither factual nor valuative judgment can be vindicated without reference to cognitive control principles that render science and axiology inescapably interdependent. The development of the formal character of this interdependence will ultimately depend on (1) utilization of the schema of formal duality and (2) extension of the metatheoretical basis of the conceptual mode of inquiry. An intuitive basis for synthesis of dualistic aspects of value-science and axiology is already conceivable: a relationship of complementarity which seems to presage (1) a much needed extension of scope for the value-sciences, and (2) a means of bringing axiology, for the first time, within the reach of systematic warrantability.

(continued on next page)

Levels of Abstraction

It would be regrettable if, in the process of setting forth our prospectus for metatheoretical reconstruction, the realistic and practical orientation with which we began should be lost sight of. We are not engaged here in esoteric philosophical investigation for its own sake. The issues are those which have been forced upon us by the character of prescriptive science and the domain of its problems. We have had to reassign priority repeatedly—from (1) the practical objective of attaining methods of analysis applicable to command/management problems to (2) value-theoretic foundations for more adequate formulation of management models to (3) philosophical reconstruction in the interest of a more comprehensive prototype of rational inquiry. We found it necessary to encompass an obvious coalescence of normative concerns throughout the behavioral (system) sciences. We found it inadmissible in principle to isolate the hierarchical levels of operational, programmatic, organizational, and entrepreneurial decisions. We found it impossible to accommodate the relevant formal, factual, and valuative aspects of optimal decision under the traditional dualistic commitment.

It is thus by force that we are presently far removed from practicality; our aim is to return just there—but better armed against the complexity of those kinds of practical problems that are now quite intractable to systematic rational control as we have known it. Relying on the pith of an ancient saying—that there is nothing in the world so practical as a sound philosophy—we shall step off, shortly, into a rarefied domain of problems associated with the admissibility of cognitive models in general. This is the context with which we shall be occupied throughout the remainder of Volume I without further deference to specific practical problems (though practicality and practicability as criteria will still figure prominently). The sequence of Tables 5.5-7 serves to lay out the field of effort for philosophical reconstruction in terms of successive levels of abstraction. Tables 5.5 and 5.6 are to be understood as providing, respectively, horizontal and vertical factorizations that are combined in Table 5.7.

The greater part of the history and philosophy of science has been taken up with a slow and arduous development of the realization that formal-empirical-intuitive resources of human intelligence must be simultaneously accorded their rightful roles in the conduct of rational inquiry. By representing the three great methodological divisions of axiomatics, experimental scientific method, and axiological method as a "spectrum of inquiry," we mean to indicate our intention of construing them as assimilable by embedding, in the sense that only the incorporation of additional criteria of admissibility and objectives would distinguish goal or norm-oriented prescriptive inquiry from process-oriented predictive inquiry from structure-oriented descriptive inquiry.

BASIC PARADIGM I

THE SPECTRUM OF INQUIRY

Domains	FORMAL SCIENCE	EXPERIMENTAL SCIENCE	AXIOLOGY
Processes	demonstration	prediction	prescription
Principal Criteria	logical	perceptual	pragmatic
Objects	formal abstractions	substantive entities	values

Table 5.5

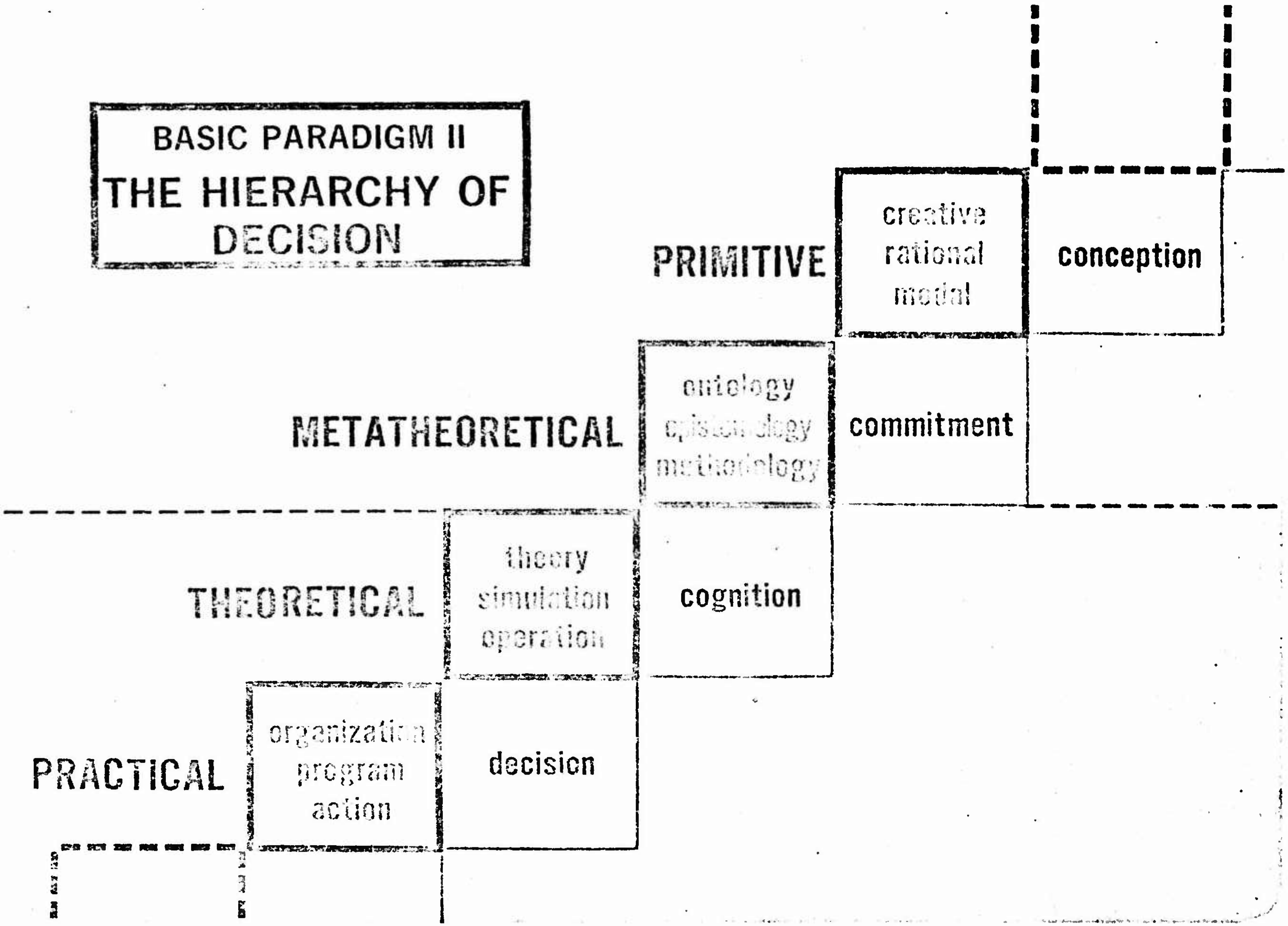
BASIC PARADIGM II
THE HIERARCHY OF DECISION
PRIMITIVE
creative
rational
modal
conception
METATHEORETICAL
ontology
epistemology
methodology
commitment
THEORETICAL
theory
simulation
operation
cognition
PRACTICAL
organization
program
action
decision

Table 5.6

Levels of Abstraction

rational primitives			
metatheory	COGNITION	control process creative process aesthetic process	
	unified metasystem		
	matics	method	axiological method
object theory			axiologies ics rals value–theory decision theory
objects			values
object process			retrodiction **practical decision**

Table 5.7

With the concept of a hierarchy of practical decisions, we have emphasized that action-decisions presuppose higher-order decisions; with the hierarchy of cognitive decisions (Table 5.6) we introduce the notion that the basic action-program-organization triad of decision levels recurs in a larger pattern of practical-theoretical-metatheoretical-primitive decisions faced by an inquirer as a cognitive entrepreneur. Each successive stage serves to provide the conceptual-methodological grounds for cognitive modeling and rational control of selection among alternatives in the preceding stage. Thus, the central feature of the field for philosophical reconstruction—when inquiry in general is conceived in terms of creative-rational-aesthetic decision processes—is the necessity to provide for "management" of the process of theory-construction; in other words, the necessity to mount a self-correcting, self-amplifying process of innovation and selection that can produce cognitive models and methods at each successive level (from practical action to primitive commitment) that are admissible and systemically coherent.

By the shading of Table 5.7, we indicate that with regard to axiological inquiry almost all of this task of systemic construction remains to be done—as against the relatively sophisticated structure already extant in formal and experimental science. Yet it is already apparent that metatheoretical reconstruction, undertaken from the innovative view of a unified field of inquiry, will have significant possibilities for modifying even the more established versions of rational method. The cascading production of unexpected consequences from even slight modifications of primitive concepts and commitments is the one expectation we have learned to associate with philosophical reconstruction.

It will perhaps be useful to attempt a dual purpose summary at this divide between problem and response in philosophical reconstruction. The following section will therefore present briefly (1) a recapitulation of motivating issues from Parts I-II and (2) a preview of the approach that will be taken in Parts III-IV. Illustrative figures will generally be treated only as suggestive clues since their elaboration will be forthcoming in later sections.

INTERDISCIPLINARY SYNTHESIS--A SUMMARY AND A PREVIEW

Without serious risk of overdramatizing, one might describe contemporary science as being locked in by its own abstractions, the very abstractions that constitute supreme intellectual achievements of more than three centuries. Reductionistic abstraction is at once the strength and the weakness of objective inquiry. This conceptual mode has addmittedly sustained the most remarkable succession of accomplishment- in both the formal and the physical sciences; yet it appears to be obstructive to any comparable advance in behavioral science, where the principal challenge is given by tne heed to accommodate the full organizational complexity of adaptive systems--biological, social, and psychological.

Reductionism, essentially, exploits just the philosophical foundations of early modern science that A. N. Whitehead [1] so brilliantly analyzed in Science and the Modern World (Lowell Lectures, 1925). It would be difficult to find anywhere a more ample historical appreciation of the genius expressed in the Cartesian scientific abstractions concerning matter, its simple location and motion in space and time, and the ensuing triumphs for the notion of mechanical explanation appearing in a succession of great analytical treatises: Newton's Principia Mathematica (1687), the Méchanique Analytique of Lagrange (1787), and Maxwell's Electricity and Magnetism (1873). Yet the final outcome of Whitehead's analysis was his anticipation of the general dissolution of the reductionistic scheme of scientific materialism that dominated the period from the 17th to the 20th century. His principal thesis—answering to developments in recent mathematical physics as well as in biological and psychological investigations—maintained the necessity of an alternative system of thought, basing our understanding of nature (that is, all nonformal disciplines) upon holistic concepts of organismic structure and process. The ultimate import of his critique was given in this pronouncement: "A civilization which cannot burst through its current abstractions is doomed to sterility after a very limited period of progress." [Ref. 1, p. 86]

Only by an overreaching use of hindsight could one conclude that

Whitehead's "philosophy of organism" has directly motivated the current emphasis on systems-oriented inquiry. Yet the impression is inescapable that his originative conception has somehow worked its way toward consensus. His commitments to holism and unification obviously anticipate the two principal features of the contemporary systems approach:

> First, a realistic reaction against the incoherence that threatens to develop between disciplinary compartments of life and social sciences when inquiry is limited to sets of elemental variables treated without reference to the question of how isolated relationships might be composed into characterizations of organic wholes.
>
> Second, an idealistic drive for breakthrough to a unified rational paradigm that would permit an extension of inquiry encompassing purposive behavior and normative theories of optimal control and optimal organization in man, machine, and society.

Attracted by intimations of an overarching unitary domain of adaptive systems, and the completely general relevance of adaptive control processes, the new system sciences introduce notable modifications of the basic conceptual format that historically supported the objective physical sciences. Our understanding of organizational complexes in general can apparently not be advanced without the use of concepts that lie beyond the scope of reductionistic abstraction: <u>structural</u> concepts (organism, individual, institution, social class, nation, society, ecology, culture); <u>functional</u> concepts (life, growth, adaptation, mutation, selection, evolution); and <u>modal</u> concepts (motivation, aversion, need, norm, utility, expected value, subjective probability, preferability, optimality).

It seems clear that there is no longer any question as to the need for interdisciplinary principles predicating fundamental relations among holistic concepts of this type. It will, no doubt, be generally conceded that such a development would contribute to one of the most productive tendencies in the history of science, i.e., the gradual concrescence of previously distinct theories, methods, and cognitive modes. Proponents of systems research no doubt rightly emphasize, as a newly explicit goal, the deliberate acceleration of the slow historical progress toward holism and unification. Yet this enterprise continues to be seriously obstructed by failure to realize that the introduction of interdisciplinary principles adequate to generate a legitimate general systems theory would almost certainly amount to an epochal modification of the perspective of rational inquiry *per se*.

Under the assumption that the magnitude of this task will not yet dissuade us from the policy of seeking interdisciplinary principles, this paper concentrates on a factorization of the specific metatheoretic projects that are thought to be entailed. More simply, the attempt will be to show in some detail what it is we go to do in undertaking the attainment of interdisciplinary synthesis.

Interdisciplinary Principles--Selection of Domain

By the term "principle" we normally refer to a fundamental premise having the status either of an inductive generalization (a universal "law" of nature) or a doctrinal commitment. In either case, principles are instituted by deliberate decision and it is the service of Fig. 5.1 to display the several levels of cognitive decision that might be associated with the search for interdisciplinary principles. A cascade-type connectivity quite evidently holds throughout this hierarchy: Strategic directives for the control of practical decision are supplied from the theoretical level of formalized cognition; the theorizing process is in turn controlled from the level of metatheoretical commitment—which comprises roughly the domain of philosophical positions extant—and, finally, our philosphical constructions are given their fundamental mode and tone by the nature of the primitive processes of conceptualization. A less technical way of generating this hierarchy of decision types might be simply to maintain, as the pragmatists would have it, that "thinking is for the sake of acting." Then with the realization that thinking itself is only a special version of acting, we see that a number of higher-order modes of thinking, providing control of more elemental thinking, must necessarily arise in an echelon that terminates only in some psychologically primitive (as against logically primitive) version of mental process.

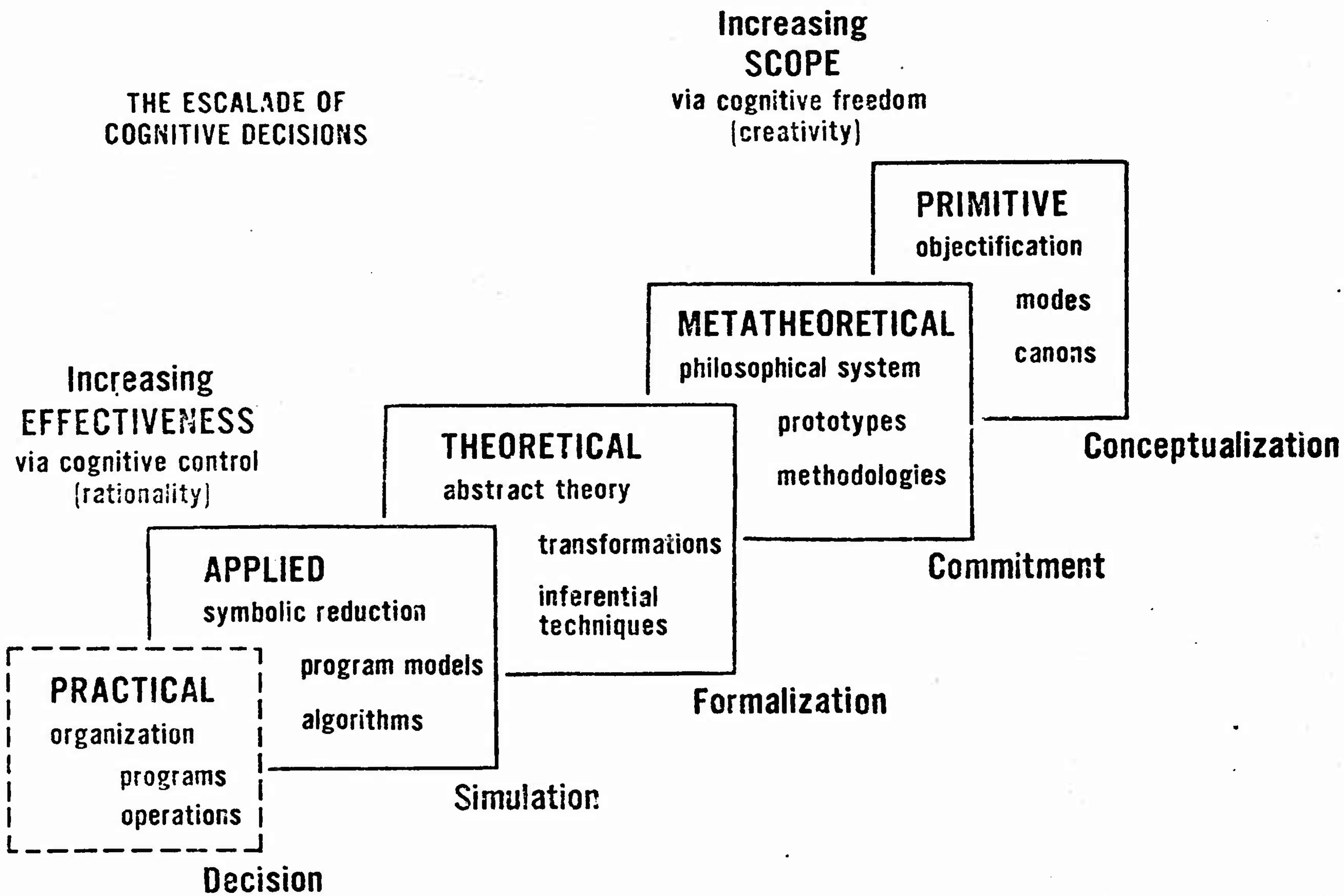
THE ESCALADE OF
COGNITIVE DECISIONS
Increasing
SCOPE
via cognitive freedom
(creativity)
Increasing
EFFECTIVENESS
via cognitive control
(rationality)
PRIMITIVE
objectification
modes
canons
METATHEORETICAL
philosophical system
prototypes
methodologies
THEORETICAL
abstract theory
transformations
inferential
techniques
APPLIED
symbolic reduction
program models
algorithms
PRACTICAL
organization
programs
operations
Conceptualization
Commitment
Formalization
Simulation
Decision

Figure 5.1

Presumably there are possibilities for synthesizing interdisciplinary principles that would be characteristic of each of these levels of decision making. As an example at the level of practical action: actual military operations, military gaming or simulation, and professional military training admit of codifiable principles of organization and strategy that represent helpful generalizations regarding the artful exercise of command responsibility. Similarly, principles of interprofessional practice are to be found throughout the range of medical-psychiatric therapy, legal-ethical counsel, engineering and general scientific-advisory services. No one, however, can fail to be aware of the very serious limitations of such practical generalizations. They hold force, like all casuistic principles, only so far as elemental aspects of intrinsically different "situations" (in our example, combat v. gaming v. training) are correctly identified as <u>invariants.</u> We should therefore not be disposed to expect any profound synthesis of principles at the immediately practical level. Perhaps the most we can say is that there is,indeed, some touch of legitimacy in such claims as that engagements of British arms are won on the playing fields of Eton.

At the theoretical level a somewhat more promising type of interdisciplinary synthesis is open to development. It is an activity currently receiving concerted attention under the term "theory-reduction," which may be interpreted roughly as referring to intertheoretic explanation, i.e., one scientific theory "explained" in terms of another initially formulated for a different domain. An example of intense current interest would be the attempt, in molecular biology, to characterize the gene in chemical terms and to account for Mendelian inheritance in terms of enzyme action and DNA structure. Investigation of the logic and methodology of theory reduction is principally the interest of logistic-oriented philosophers of science, notably Ernest Nagel [2], J. H. Woodger [3], W. V. Quine [4], J. G. Kemeny and P. Oppenheim [5], K. R. Popper [6], P. K. Feyerabend [7], P. Suppes [8], and K. F. Schaffner [9].

From the point of view of systems-theoretic ambitions, however, theory reduction is subject to imposing restrictions from logical, conceptual, and methodological considerations. On the side of logical structure there is the prerequisite that both reduced and reducing theories must be adequately axiomatized—only thus can whole theories be treated economically in terms of primitive predicates, axioms, and transformations ("reduction functions") defined on their logical objects.[1]

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[1] The skeletal notion of theory reduction can be given by paraphrase of W. R. Ashby's [10] importation of the concept "homomorphism" from mathematics: "If two.. [theories] are so related that a many-one transformation can be found that applied to one of the ... [theories] gives a ... [theory] that is isomorphic with the other (the simpler of the two), then the other is a homomorphism of the first."

The system theorist—if we take, say, the organismic biologist as a prototype—proposes to describe the interdependent parts of a complex organic whole by reference to molar characteristics that have no conceptual counterparts in an analytic-objective theoretic mode. It is precisely by dealing with organizational rather than elemental properties that he hopes to derive an important methodological advantage. Even if axiomatization in terms of holistic primitive notions should ultimately become feasible, the project of theory reduction would still face the intractable problem of establishing connectivity throughout hierarchical sequences of successively embedded reductions, such as the one suggested by D. F. Bradley [11]: the morphologist's explanation of species-specific traits in terms of heredity; the biologist's explanation of heredity in terms of DNA replication; the biochemist's explanation of replication in terms of complementary nucleotide base pairs; the chemist's explanation of base pairing in terms of hydrogen bonding; and so on—by way of molecular physics, quantum mechanics, and analytical mechanics—to intermolecular potentials, the wave equation, and properties of space-time.

Early proponents of general systems research (cf. L. von Bertalanffy [12] and Anatol Rapaport [13]) have understandably tended to avoid prouncement on the ultimate relation of reductionist v. holistic theoretic modes. Will systems theory indefinitely constitute a version of inquiry _sui generis_, as certainly it does at present? Alternatively, will the project of theory reduction ultimately succeed in providing connectivity throughout the hierarchy of successively embedded frames of explanation from the elemental to the organizational? Neither expectation can be embraced with unqualified enthusiasm. A residual incoherence between fundamental intellectual modes would be attached to the first. A defeating sense of impracticability (though note, not _impossibility_) would accompany the second, inasmuch as the near-incredible complexity of unification by theory reduction would make this project not the work of men but of an age of man.

A third alternative is conceivable as a way of avoiding the slow development of the dilemma projected above. We can attempt to accede to the demand that the system concept be technically interpretable and effectual at every level of any connected sequence of phenomenal contexts. That is, we can attempt the actual realization of a definitive and fruitful transition in scientific perspective, the establishment of the systems approach by _thematic_ change as a natively accepted way of thinking in which the objects of our interest, in general, are conceived as

(1) organized systems, presupposing change—in structure or behavior at every level of analysis—to be associated with normative, selective responses of subsystems

(2) coordinated by a protocol or regimen of synthesis (an intrinsic design-characteristic of the system as a whole)

(3) tending toward extremalization[1] of a value-measure that is "holistic"

(4) in the sense of encompassing all of the normative criteria that are specific to a given existant-in-milieu (a given individual selective system [2] embedded in the universal evolutionary context of a selective ecosystem).

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1. Depending on the complexity of the system in question, "extremalization of a holistic value-measure" might be interpreted: minimization of action; minimization of stress; maximization of effectiveness in purposive goal-seeking; optimal allocation of resources over alternative goals; optimization of strategy, policy, and organization; stabilization of a trend-measure of viability; maximal realization of the potential of a given system design. There is little doubt that further investigation will yield additional interpretations that must be accommodated by an adequate theory of organization for normative-selective systems.

2. Any individual existant—whether man, machine, society, or electron—admits of theoretic representation in terms of this conceptual format (1-4 above). This generality is due to the fact that the a priori commitment here is far less presumptive than the attribution of anthropocentric value concerns. When purpose, goal, and value—in unqualified senses that properly presuppose cognitive freedom—are incautiously attributed to systems in general, the result is inevitably the kind of incoherence that vitiated early teleological and vitalist versions of inquiry. In contrast, normative theory couched in the format of extermalization of minimally sufficient value-functions (via the mathematics of optimization) yields characterizations that are (1) precisely equivalent to those attained by deterministic models of elementary mechanistic systems, yet (2) require only the introduction of hierarchical complexity in order to accommodate the creative, rational, and aesthetic dimensions of value specific to cognitive and cultural selective systems. It is perhaps unnecessary even to mention that, despite the impressive range of coherent interpretation attainable by means of a normative conceptual format, we are very far indeed from attainment of the methodological capability to handle the grades of systemic complexity present in hierarchical (multilevel, multi-goal) systems involving cognitive-cultural decision, valuation, organization—and particularly the creative, self-transforming capabilities of such systems.

Any such thematic change in the perspective of rational inquiry clearly presupposes a fundamental reconstruction of primitive concepts and metatheoretic commitments—a philosophical reconstruction that formally institutes "system" as a basic cognitive paradigm

(1) demonstrably indifferent to arbitrary levels of resolution referenced by a minimal hierarchical configuration (an "embedded" complex of supersystem-system-subsystem) and

(2) capable of accommodating—by indefinite extension of this configuration—the conversion of phenomenal properties at a given level of resolution into those of lower or higher order, i.e., capable of providing for coherent multilevel analysis of hierarchical compositions (systems-within-systems) <u>connecting</u> level-specific concepts that already bear established scientific meaning and significance.

To put it more directly, we can attempt a metatheoretic reconstruction under which objects, organisms, organizations of organisms (societies), and even organizations of abstract concepts, <u>all</u> are characterized in terms of value-sensitive structure and norm-directed adaptive processes of extremalization—not as contradicting or even as standing separate from objective scientific inquiry couched in the paradigms of deterministic or stochastic processes—but as complementing these abstract-reductionist modes with a more comprehensive normative-theoretic mode.

Under the terms of this high-risk, high-payoff strategy, we have chosen to concentrate on still a third sector of the cognitive decision hierarchy, denoted in Fig. 5.1 by the term "Metatheoretical Commitment." This is normally understood to be the domain of philosophical construction; but our emphasis of this sector is in itself the signal of a presupposition: that the advances in systematic philosophy which will be required for synthesis here cannot conceivably come from academic philosophy as it is now constituted. Analysis, rather than system building, is too clearly in the ascendant. The kind of philosophizing that will have to be done—the speculative kind now rather generally abandoned by professionals—must apparently be undertaken by investigators who have been trained in specialized scientific disciplines, but whose problems now seem amenable to solution by no other route than a difficult detour by way of metascientific construction.

Prospectus

Fig.5.2 presents an assemblage of components for a philosophical reconstruction that might now be envisioned. One will recognize, under the heading "Problem Areas" on the left of this figure, four sectors that are traditionally associated with philosophical commitment. Notice that term "commitment." The kind of principles that will be of first concern to us do not belong to the class of invariance (or conservation) principles which are generally construed as having been instituted on the basis of empirical generalization. Of course, all principles at the metatheoretic level appear in the guise of commitment; but the interest here is confined to the kind of premises to which we must commit ourselves a priori by policy in order that intellectural "discoveries" of any order whatever may be possible. Taken in order, these sectors might well be correlated with the traditional divisions of metaphysics: ontology, axiology,

INTERDISCIPLINARY SYNTHESIS: PROSPECTUS

Problem Areas	Developments Predicated
CONCEPTUAL SCHEMA	• Interpretable organismic system-concept
RELEVANT TAXONOMY	• Comprehensive systems taxonomy
SYNOPTIC PARADIGM	• Evolution (Legitimate extrabiological extension)
EXTREMAL PRINCIPLES	• Categorical hierarchy of norms
THEORETIC PARADIGM	• Formal dual prototype: objective-normative
RATIONAL CANONS	• Formal, empirical, pragmatic, evolutionary criteria
METHODOLOGICAL SYSTEMATICS	• Integrated analytical, experimental, dialectical methods
MODAL DIRECTIVES	• Strategy of reduction • Procedures for warranting prescriptive v. predictive models

Figure 5.2

epistemology, and methodology. Because we are not proposing anything so rarefied as the traditional task of metaphysics, this classification has no special relevance here other than to indicate the origins of the domain of synthesis that we have chosen to emphasize.

On the shaded side of Fig. 5.2, we have tried to indicate the kind of developments that are predicated by the contemporary drive toward interdisciplinary synthesis. At the least, they are predicated in the course of our own recent work; but, more important, we believe that they must generally be accorded the status of prerequisites to ultimate success in the general systems enterprise. Let us attempt to summarize very briefly the nature of these developments. The primary intention will be simply to show the enormous range of tasks involved in interdisciplinary synthesis.

Conceptual Schema

First, an organismic version of the system concept must be established as formally interpretable over the range required of a basic conceptual paradigm. So far only partial success can be claimed in this task. It is true that, from the side of mathematical system theory, [1] concerted attempts are being made to develop the term "system" formally on set-theoretic foundations. Without any intention of depreciating this important attempt to inject precision and rigor into the use of the

1. In addition to Mesarović [14,15], see publications of the Case-Western Reserve Systems Research Center (1962-present). While specifically addressing the problem of modelling normative aspects of systemic structure and function, these works do not introduce an organismic system concept as a distinct primitive notion. Rather, they accommodate normative aspects of an intuitive system concept by definition of special-purpose mathematical functions which depend explicitly only on the abstract notion of system qua mathematical relation.

system concept, it should be noted that an imposing obstruction would remain even after the successful advent of generalized set-theoretic foundations for systems research. The objects of central interest in biological and psychological behavioral inquiry are characterized by such orders of complexity that adequate descriptions in set-theoretic terms would almost certainly prove to be unwieldly. In such terms, mere specifications of whole organisms (organizations) would tend to run to interminable lengths and relevant characterizations of behavior, if indeed they should become accessible, would presumably involve multitudinous collections of statements. Alternatively, a great deal of conceptual groundwork has been done in attempts to reclaim the meaning of "system" from the process of abstraction. The concept "system" in its natively intuitive sense has come into very widespread use. But this intuitive usage, and particularly the intuitive attribution of unqualified generality to this concept, admits of troublesome ambiguity. The bare concept of system, as a primitive abstraction, is perhaps as old as systematic inquiry; and the generality of this abstraction—evidenced by its status as an undefined notion in mathematics and physical science—could not conceivably be increased. The pristine meaning of system, as a set of elements with a relation defined on those elements, is already so generalized that any analyzable entity whatever is patently admissible as an interpretation of the term. The innovative aspect of the recent systems orientation depends rather on productive <u>qualifying</u>

connations that, all too covertly, have added highly significant structure to the bare notion of system: specifically, connotations that have the effect of assigning to systems the additional properties of irreducibility and idiosyncracy.

Briefly stated, the significance of these two system-properties may be given as follows: (1) Irreducibility attributes some holistic specification—a "protocol" for synthesis of interdependent components—as an intrinsic characteristic of anything termed a "system;" therefore no decomposition in terms of independent elements can be a complete representation of a system. Tautologically, the whole is not equivalent to any sum (concatenation) of parts; a system consists of parts-as-related by a protocol, i.e., a plan or rule of composition. (2) Idiosyncracy combines the root meanings "proper, peculiar" with "composition, synthesis" to yield a notion best rendered as "peculiar to, or characteristic of, the synthesis." When ascribed to behavior, its central import is the idea of response determined in part by intrinsic organizational characteristics (mutual causal, internal relations) independent of conditions imposed externally on a composition as a whole. This, of course, is literally a specification of the minimally sufficient condition for what we would intuitively mean by "self-determined" response. Only when this bare notion of self-determination is amplified by the attribution of internal adaptive control processes do we further ascribe to systems the goal seeking type of purposive behavior associated with autonomy. But in general, "idiosyncracy" attributes to anything termed a "system" a characteristic response that is consistent with the imputation of at least an elemental version of organismic self-determination: namely, the extremalization of some holistic criterion (measure) by variation of mutual causal internal relations.

In a recent review Anatol Rapoport shows that the gradual realization of technical connotations hidden in the notion "organized system" leads toward unification of supposedly disparate domains of inquiry. This composite range of interpretation, which is roughly as broad as the universe of discourse for behavioral science, obviously marks the system concept as a singularly promising conceptual paradigm.

> ...Quasi-purposeful behavior can be manifested by an open physical system that is not necessarily "alive." Since all living systems are open, we have a conceptual link between living and nonliving systems...[suggesting] a new concept of the living organism, namely one which, in addition to being an engine (a device for transforming energy from one form to another) and a chemical laboratory (a device for transforming matter from one form to another), is also a decision making system(a device for processing, storing, and retrieving information). The apparent "purposefulness" of living processes, especially of behavior, has always suggested that organisms "make decisions." What was new was a set of concepts susceptible to logical (or mathematical) operations, from which the "purposeful" or "intelligent" aspects of living systems could be derived.
>
> ...Systems that are "living," in the common sense or biological sense of the word, share many features with systems that are not; and these common features derive from the way systems are organized. This suggests a generalization of the concept of "organism" to the concept of "organized system." Organized systems include organisms.
>
> ...Once it is recognized that structure, function, and evolution (or being, acting, and becoming) are fundamental aspects of all organized systems, the concept of organism can be broadened still further to include, for example, whole complexes of living organisms plus the inanimate artifacts functionally related to their structure, behavior, and development. Such are societies, conceived in the broadest sense. [Ref. 13, p. xviii ff.]

However, one does not yet encounter in the literature of systems research any formal explication of distinctively normative aspects of the system concept. Both (1) the categorical demand for a protocol-component in the specification of a system and (2) the interpretation of characteristic system response as an extremalizing transformation (a <u>norm-directed</u> transformation) seem to represent minimal connotations that are seriously glossed by intuitive descriptions actually in frequent use, e.g., that a system-as-a-whole acts <u>as if</u> possessing a goal of its own. Systems are spoken of with holistic intentions; with the notable exception of the work of Mesarović et. al. (Refs. 14, 15), they have generally been explicitly objectified only in reductionistic terms that are patently deficient with regard to (1) norms, values, or constraints as determinants of behavior and (2) distinguishable types of normative processes that are potent distinctions in our intuitive understanding of purposive behavior (e.g., minimization, maximization, optimization, stabilization processes attendant on optimal response, optimal strategy, and optimal organization). An "organismic" system concept so far permits things of very dissimilar appearance to be thought of consistently as alike in some essential respects, namely, in certain features of the way in which they are organized. It does not yet provide the further necessity of formally definitive new categories of classification and related modes of investigation that are legitimately cross-disciplinary in scope.

This, of course, is to say no more than that when we attempt to employ "system" as a holistic primitive (undefined) term—as a fruitful complement to the radically abstract notion of mathematical relation—we find ourselves involved in the complicated task of explicating all the entangled connotations that attach to what is perhaps the fundamental intuitive construct native to human intelligence. The role of the organismic system concept is, after all, that of a paradigm for the representation of unitary wholes. (Here, "unitary wholes" refers to the complex but nonetheless individualized conceptual objects—"things" in general—that are apparently evoked by involuntary perceptual synthesis and hence constitute intuitively primitive concretions, as against analytically primitive abstractions, with which all cognition and therefore all inquiry necessarily begins.) The formal ground-clearing for this intellectual route to a new (i.e., newly codified) way of thinking may finally entail all the excruciating difficulties that are to be encountered in Process and Reality, Whitehead's metaphysical *magnum opus*.

Perhaps it will be sufficient to the day merely to note cryptically that such a fundamentally new (by renovation of the oldest) way of thinking about "the nature of things" presupposes that the conceptual schema, system, can explicitly incorporate (1) multiform structure, (2) polytypic content, (3) polymodal process, (4) multiplex criteria, and (5) multiple constraints; and that it can then prove to be interpretable at every level of the hierarchy of cognitive objectification (creative conceptualization) and cognitive control (rational selection) suggested by Fig. 5.3. After this, the qualification is hardly needed: that we are very far from mastering the use of a conceptual format that must successfully

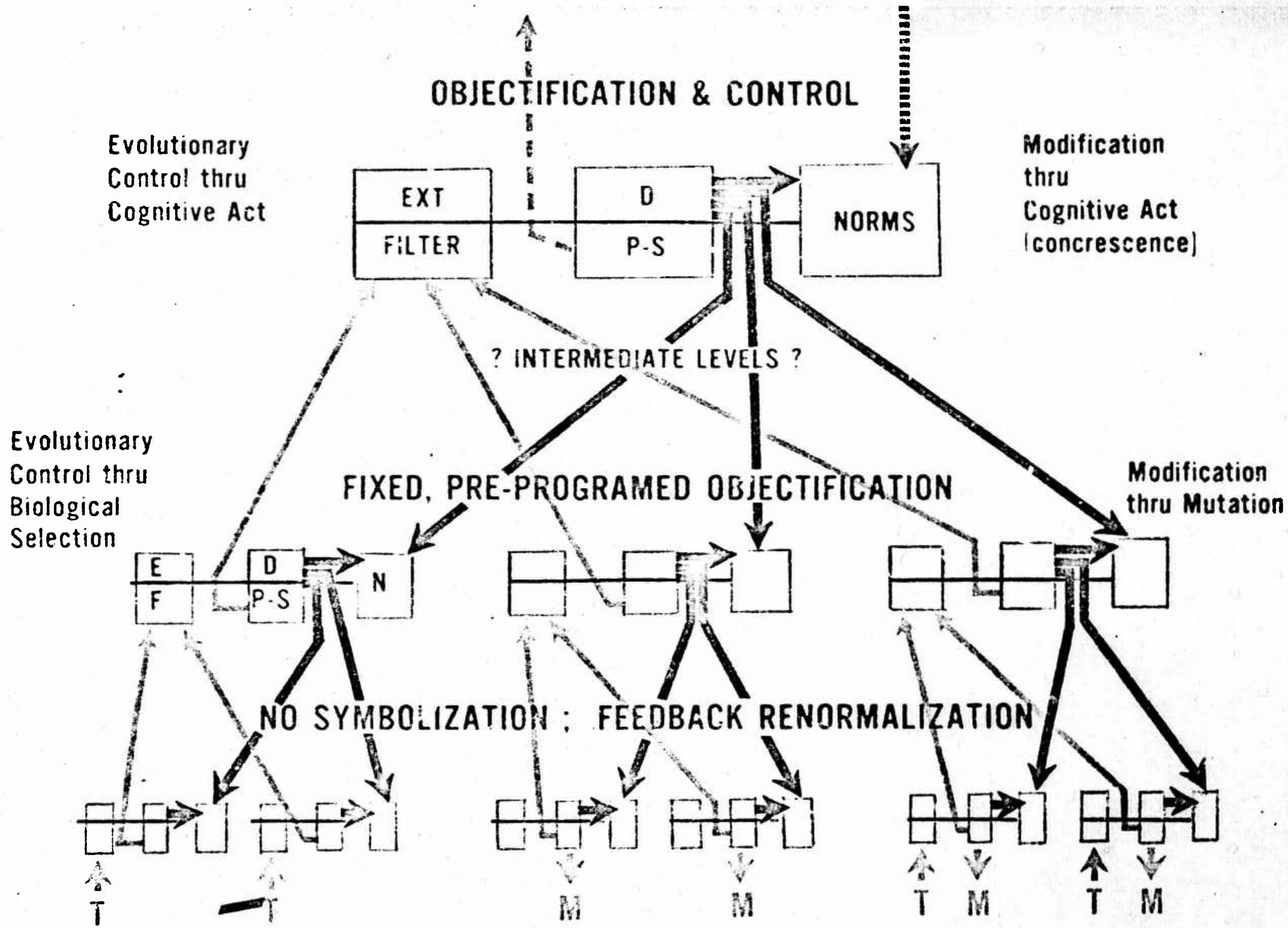

Figure 5.3

EXT, Extrospective Situation
N, Norms

D, Decision Output
P-S, Problematic Situation (disparity, EXT v. N)

I, Transducer (info)
T, Transducer (motor)

encompass somatic, semiotic, and noetic entities involved in extremal processes of emergence, homeostasis, and degradation—subject to simultaneous selection-criteria of optimal control, maximal freedom, and maximal scope (cf. Fig. 5.4).

Relevant Taxonomy

Preliminary to the very hope of systems theoretic construction stands the elemental task of devising an ordering relation that permits unambiguous classification of systems in general. To attempt to establish a taxonomy for a complex domain is to return to long-foresaken territory. The procedure of taxonomizing is, first of all, a complicated version of concept attainment. It therefore involves the employment of skills that tend to lapse into disuse with the inevitable development of the familiar and habitual structuring of experience derived from cultural conditioning. If we are to succeed in viewing the world from a systems perspective, we must succeed in categorizing the kinds of things we posit , namely systems, in terms of more complicated taxonomic characteristics than any yet employed in traditional systematics. Our "taxa" must typify the basic organization of distinguishable systems, where "organization" is attributed to every entity belonging to our cosmographic domain, i.e., our local universe of experience and discourse.

Fig. 5.5 suggests an initial partition that distinguishes four major categories of natural systems and appends to these a "technosphere" of synthetic systems, i.e., the domain of relational structures and artifacts conceived, fabricated, or assembled by the agency of natural systems. Leaving the open rectangles (representing natural systems) to be filled by obvious entries, we have detailed only enough of the content of the

PROPOSED PRIMITIVES: GENERAL SYSTEMS

Philosophical Categories (traditional)	Primitive Concepts (systems-theoretic)	Connotations (analytic)
entity	SYSTEM	somatic semiotic noetic
process	TRANSFORMATION (directed)	emergence homeostasis degradation
value (process-criterion)	OPTIMALITY	freedom decidability (control) extensionality

Figure 5.4

GENERAL SYSTEMS - GROSS CATEGORIZATION

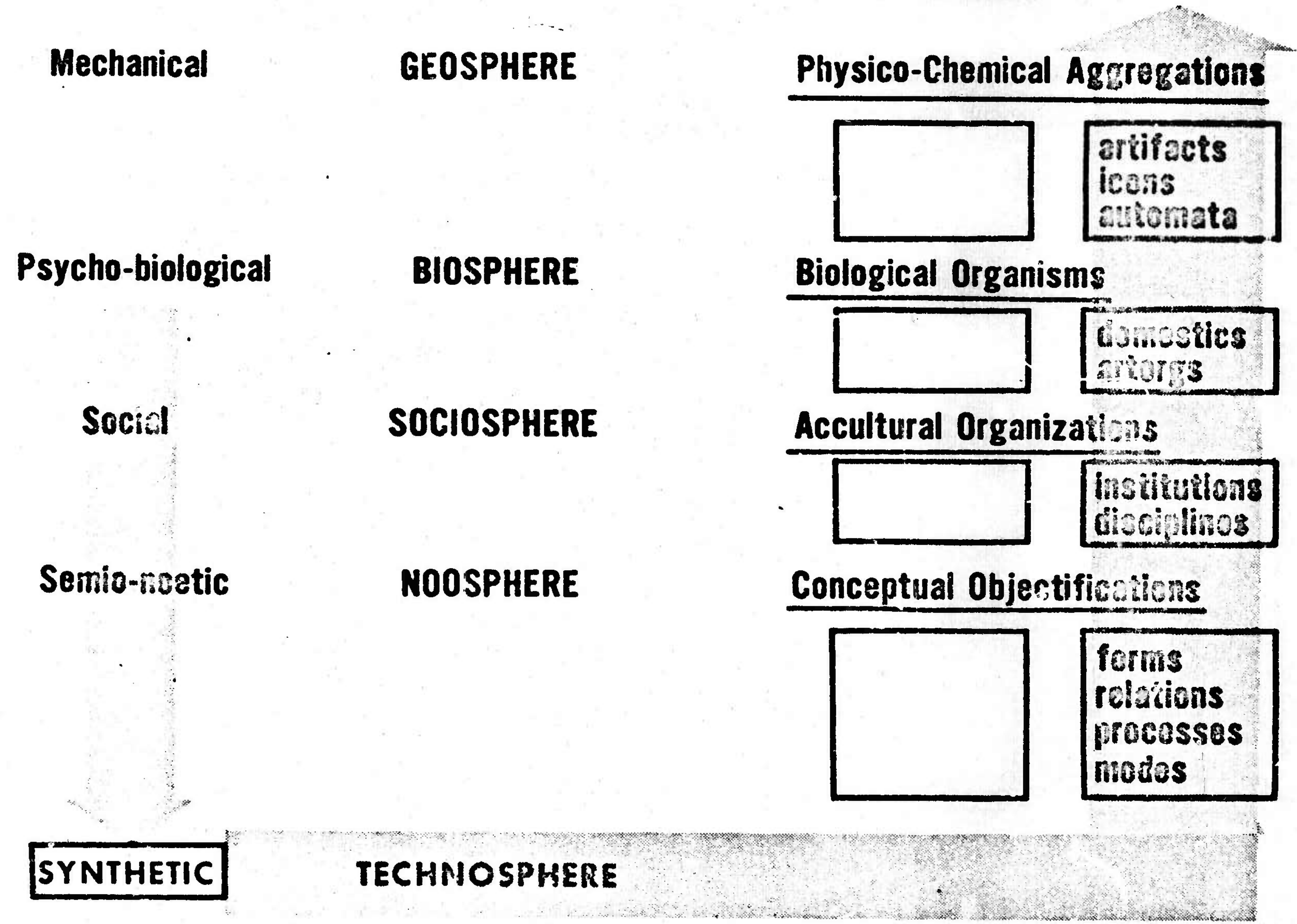

Figure 5.5

technosphere to indicate that the creative cognitive agent and all his works are to be added to the already staggering demand for a categorization relevant to our interests. Even when we dispense with all technical problems of taxonometrics, the figurative lineages of Fig. 5.6 will convince us that the establishment of connectivity between such apparently disparate types of entities as (1) conceptual objectifications, (2) linguistic systems, (3) institutional control systems, and (4) the physical complexes necessarily associated with cultural organization must certainly belong to a futuristic systematics.

Synoptic Paradigm

Any attempt to establish connectivity within such a cosmographic domain of systems will presumably depend upon the attainment of a legitimate extrabiological extension of evolutionary process as a synoptic paradign. That this format constitutes an appropriate structure for our purpose is strongly supported by A. Roe and G. G. Simpson [16], who report the adoption of this basis for a recent symposium concerned with theories of behavior.

> ... It is so universally accepted as not to need explicit statement that ... there is, indeed, a general theory of behavior and that the theory is evolution, to just the same extent and in almost exactly the same way in which evolution is the general theory of morphology. To make the relationship more obvious and to demonstrate that morphology, physiology, and behavior are aspects of organisms all inseparably involved in and explained by the universal fact of evolution became a principal object of this symposium.

At this point is is our responsibility to make it perfectly clear that Roe and Simpson, in the citation just given, are referring to the

EMERGENT SYSTEMS, NOOSPHERE

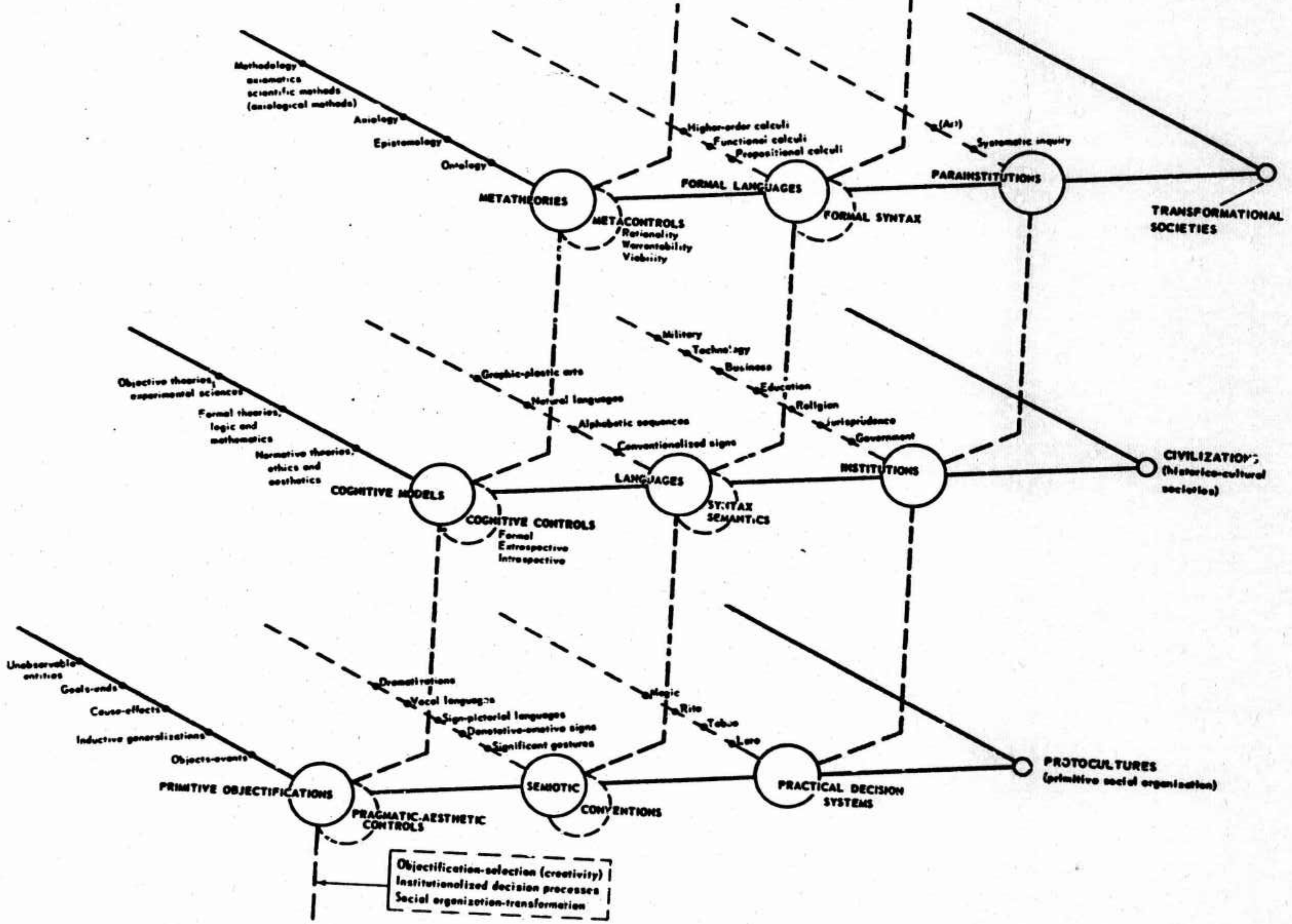

Figure 5.6

syncretic theory of biological evolution now available to specialists in that field. The prospect put forward here has decidedly more of the nature of conjecture: that a rigorous and technically meaningful account of extrabiological evolutionary process can be attained. Let us state this conjecture with a bit more formality. What is being presupposed is this: (1) that the continuous development of the cognitive modality is marked by one general feature, the successive displacement of models of rational thought by novel formats of cognitive organization that are capable of resolving previously obstructive ambiguities; (2) that the succession of these emergent prototypes admits of connectivity that can be legitimately exhibited in extra-biological "phyletic" lineages; and (3) that cultural evolution—the emergence of viable social institutions as an extension of biological evolution—is interdependent with noetic evolution, i.e., with the emergence of increasingly stable and durable organizations of ideas and modes of abstract thought. The conviction is that generalization of concepts and postulates central to evolutionary biology can contribute to the initial enterprise of contemporary systems theory, namely, the attainment of a synoptic paradigm applicable to description, explanation, prediction, and control of phenomena associated with organization and the transformation of organization in general.

This conjecture has been explored elsewhere [1] in our analysis of principal features of scientific advance that are discernable when

1. "Major Features of Scientific Advance," commissioned essay presented to Wake Forest College, November 1966, in commemoration of the distinguished career of Albert Clayton Reid, for many years Chairman, Department of Philosophy, Wake Forest College.

"science" is construed—in an evolutionary context—as a lineage of successively dominant rational prototypes. The lineage of scientific prototypes encompassing the continuing modification of (1) the axiomatic model of scientific thought (Greek mathematics and philosophy), (2) the empirical model (early modern physical science), and (3) the "conceptual" model (contemporary coalition of the formal and experimental sciences) seems to disclose a coherent trend toward optimal organization of the cognitive-semiotic modality. Any such conclusion must be qualified by the consideration that "optimality" is inherently a relativistic criterion, but if emergent features of scientific advance may legitmately be identified with

(1) the gradual relinquishment of absolutism (maximization of cognitive freedom),

(2) the accretion of more nearly holistic criteria of admissibility (optimization of cognitive control), and

(3) the concresence of previously distinct theoretic structures (maximization of cognitive scope),

it appears that this is all one needs in order to make the transition from biological to cultural and noetic evolutionary posits. If one sees in the institution of successive rational prototypes evidence of gestalt novely, systemic sophistication, and negentropic gain in freedom, it becomes difficult to deny that the sociosphere and nosphere, as well as the biosphere, feature directed transformations that are interpretable as evolutionary processes of selection affecting the durability and effectiveness (i.e., viability) of successive dominant forms of cognitive organization.

In summary on this point, the purely figurative tree-graph motif of Fig. 5.7 is to be interpreted as the token of a synoptic hypothesis concerning our local "universe" of discourse and experience: that in terms of either a structure-oriented conceptual framework or a process-oriented equivalent, biological organisms, social organizations, and conceptual objectifications are all susceptible to interpretation and theoretical treatment by way of an adequately generalized evolutionary paradigm.

Extremal Principles

Immediately following this display of conjectural bravura, if indeed one can still be heard over the screams of anguish from any evolutionary biologists present, we promptly admit that a considerable price must be paid for the success of any such synoptic paradigm. Only so long as we remain within the confines of biological science, can we even simulate in evolutionary theory the general tone and character of traditional scientific inquiry. For a brief description of that tone and character, we refer to E. P. Wigner's [17] recent Symmetries and Reflections:

> The world is very complicated and it is clearly impossible for the human mind to understand it completely. Man has therefore devised an artifice which permits the complicated nature of the world to be blamed on something which is called accidental and thus permits him to abstract the domain in which simple laws can be found. The complications are called initial conditions; the domain of regularities, laws of nature. Unnatural as such a division of the world structure may appear from a very detailed point of view, and probable though it is that the possibility of such a

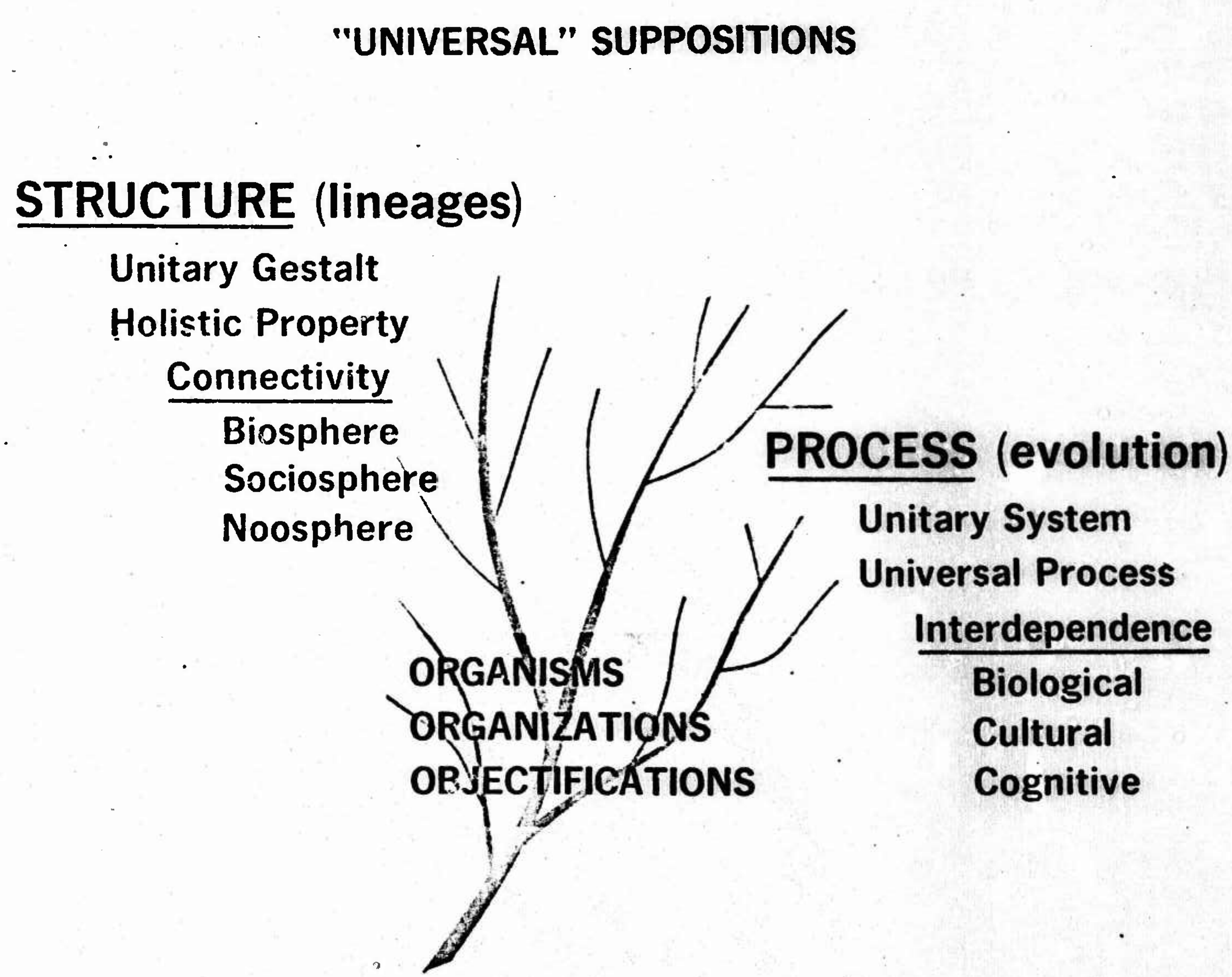
"UNIVERSAL" SUPPOSITIONS
STRUCTURE (lineages)
Unitary Gestalt
Holistic Property
Connectivity
Biosphere
Sociosphere
Noosphere
PROCESS (evolution)
Unitary System
Universal Process
Interdependence
Biological
Cultural
Cognitive
ORGANISMS
ORGANIZATIONS
OBJECTIFICATIONS

Figure 5.7

division has its own limits, the underlying abstraction is probably one of the most fruitful ones the human mind has made. It has made the natural sciences possible.

The world of objective science is therefore just that part of the experiential world than can be successfully characterized by relations describing the course of events following analytically from a given initial state of a system. As to which initial conditions may be realized in nature, no assertion can legitimately be made. The reductionistic peculiarity of this objectivist world-view, as noted earlier by Erwin Schrödinger [18], affords no means of characterizing a synoptic trajectory of events in the evolutionary history of a system, in particular, the succession of novel transitions associated with a connected sequence of modifications in the characteristic response of an adaptive system. Properties acquired by organizational concrescence, origins and processes of development for individuals, species, or phyla identifiable as synthetic "wholes" enduring through trajectories of structural-behavioral transformation do not lend themselves to a theoretic paradigm based on the fundamental abstraction of objective inquiry: the partition of arbitrary initial conditions v. law-like uniformities of deterministic systems response.

When we essay an extrabiological interpretation of evolutionary process designed to accommodate social-cultural and individual cognitive phenomena, we therefore take ourselves quite literally out of the game of traditional objective scientific inquiry. This is the heavy price of success that was foreseen. In more specific terms, this means that we most pose a radically innovative phenomenal rationale—an alternative nomothetic (law-like) regimen to be imputed to the world of nature in view of the admitted purposive, motivational character of sufficient cause in the context of creative human behavior.

Since it would be difficult to imagine a more audacious intellectual move, there is much more to be done at this juncture than we can properly discuss here and now. One can only state, quite baldly, that the hope we have for carrying out such a maneuver rests with the possibility of complementing traditional regimens which predicate deterministic necessity or chance—the "laws of motion" format of Newtonian type or the stochastic-definite format of probabilistic characterizations—with a correspondent but more comprehensive normative explanatory schema emphasizing sufficient conditions for adaptive response. This means that the natural world would be construed as comprising the interaction of selective systems, the behavior of any system being characterized by a tendency toward extremalization of some holistic measure as a "desideratum."

A grand strategy of this type is not, in itself, a new conception. Hamilton's Principle of Least Action (cf. C. Lanczos [19]) constitutes, in effect, a generalized imputation that natural processes always minimize the quantity of action, where "aotion" is defined as the time integral of the difference between kinetic and potential energy. More precisely, Hamilton's Principle states that the trajectory of states actually followed by a mechanical process, as represented in a phase space, is such that the trajectory has a smaller action integral than that of any neighboring trajectory. The motion of a particle moving in a gravitational field, e.g., may be regarded as an extremalization (minimization) problem; and the physicist may alternatively model this phenomenon by means of the deterministic equation of motion or, in differential form, the "laws" of motion, or by inference from the normative principle of minimal action.

That objective v. normative explanatory schemata are correspondent and complementary is evidenced—in this restricted instance—by the fact that the fundamental invariance principles of classical mechanics (e.g., conservation of energy) can be derived from Hamilton's Principle, using the calculus of variations. R. Bellman [20] has recently shown that normative theory, couched in the format of the mathematics of optimization, can be utilized quite generally for explanation of the "behavior" of elementary mechanical systems in terms of extremalization of appropriately formalized objective functions and constraints, with results that are precisely equivalent to those obtained by the objective (deterministic) approach.

The radically novel aspect of this explanatory strategy is the notion of a completely general normative-theoretic format capable of doing justice to the complexity of organismic adaptive systems. The premises that are central to this conception are: (1) that adaptive systems can be characterized in terms of norm beyond norm, setting up a hierarchical control structure in which response at each level is the result of successively more abstract selection-criteria; (2) that there is a degree of freedom at each level which is "consumed" (i.e., selection made among alternatives permitted by the range and degree of freedom in force) by an extremal principle acting as a decision operator at the next higher level of the total-organizational echelon.

The technical accomplishment that is prerequisite to the success of this normative schema is the formulation of a categorical hierarchy of organizational norms. By "categorical" hierarchy, one refers to a cascade-type collection of variational measures, each of which would constitute sufficient conditions for the maintenance of successively more elementary norms.[1] As presently envisaged, such a categorical hierarchy would presumably constitute some such sequence of norms as might be associated with (1) optimal organization, (2) optimal strategy, (3) optimal program, and (4) optimal response.

The literature of systems research, of course, currently abounds with proposals of extremal principles that might be taken as candidates for inclusion in an explicit categorical hierarchy. We are witnessing what appears to be a recurrence, in biological and social fields, of emphasis on minimal principles that marked classical mechanics and thermodynamics. Some modern alternatives that may be mentioned as examples are: (1) minimization of energy costs, (2) minimization of power consumption, (3) minimization of physiological stress, (4) minimially sufficient design. R. Rosen's [21] recent <u>Optimality Principles in Biology</u> is indicative of the fact that only an extensive compendium could do justice to the number and variety of principles of this type enunciated in physics and the life and social sciences. Conceptual elements relevant to the formulation of a normative explanatory schema appear to lie in profusion all over the intellectual landscape. Their systematic assemblage into a definitive theoretical mode constitutes one of the most difficult and crucial phases of development in general systems theory.

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1. It may be helpful to emphasize that the term "norm" is to be understood as referring to "a standard value of an essential system measure" where <u>essential</u> measures are those to which the viability and/or the quiescence of the system are sensitive.

Theoretic Paradigm

With regard to the conceptual reconstruction that is entailed by attempts to establish an organismic systems approach as a normative mode of inquiry, the problematic situation is best characterized by paraphrase of Ludwig Wittgenstein's notion of the type-problem for philosphy: One does not know his intellectual way about. In contrast, the task of securing a basic theoretical format that admits of normative (value-sensitive) interpretation benefits from well developed technical precedents. Mathematical structures that are interpretable in normative terms already exist: first-order perturbation theory, theory of stochastic-indefinite processes, contemporary mathematics of optimization and its parent discipline, the calculus of variations, offer resources for formalization of the verbal-intuitive constructs that necessarily issue first from involvement with specific problems of optimal systems organization.

It will perhaps be immediately evident (from earlier insistence on the correspondence and complementarity of objective v. normative theories) that formal duality—an invention of mathematical analysis for the calculus of variations—must appear in a strategic role. The formal dual acquired through generalization of the Legendre transformation is always interpretable as a value system and its canonically conjugate variables as value-measures. Note for instance, that the formal dual devised by E. P. Wigner as the adjoint function for nuclear reactor theory is significantly termed an "importance" function (cf. J. Lewins [22]). As outlined by Fig. 5.8a-b, the Legendre transformation implements

A THEORETICAL OPTION

A "space" of objects, $q = (q_1, q_2, \ldots, q_n)$.

An affinity, aversion with respect to some states, q_i.

A functional $F(u,q,t,)$ expressing

a) Probability that state q leads to a goal state.

b) The affinity or aversion with respect to goal states.

c) The relation of actions, u, to these factors.

Figure 5.8a

A THEORETICAL OPTION (Cont'd)

The functional F is usually not independent of path.

Construct a set of new variables, p_i, each $\perp$ to a variable q_i.

$$W_{(p,q)} = \sum_i (p_i q_i) = \underset{(u,q)}{\text{Max}} F(u,q,t) + \underset{(u,p)}{\text{Min}} G(u,p,t) \; ; \quad \delta W = 0.$$

Conjugate relations.

Leads to a path-independent analysis in (p,q)-space (i.e., reduces dynamic problems in q-space to static problems in (p,q)-space.)

Figure 5.8b

the key strategem of general value-decision theory: the conversion of extremalization problems that are time and path dependent in object-space to problems depending only on initial and terminal conditions in phase-space. The Legendre transformation may also be used, alternatively, to transform an object-space representation of an extremalization problem into one expressed solely in terms of a conjugate space—"momentum-space" in physics, "value-space" in general theory.

The promising possibility that seems to open, through explcitation of existing mathematical structure, is the delineation of essential distinctions between (1) concepts of substantive objects (things) v. their formal conjugates (values), (2) criteria of admissibility and procedures for testing the admissibility of these types of constructs respectively, and (3) rigorous interpretation of the complementary relationship between objective (primal) v. normative (dual) modes of rational analysis.

The basic rationale for the utilization of selected structures from mathematical analysis might be summarized under the following theses:

(1) that cybernetic characteristics of the finite cognitive agent entail the relativity and reductivity of all conceptual objectifications—and, hence, the necessity for complementary representations of nonsimultaneous but equally relevant substantive v. valuative aspects of all existants (enduring "things" qua systems);

(2) that suitably paired theoretic paradigms, designed specifically to satisfy the conditions of formal duality, are required in order to provide adequate means for rational analysis of the objective v. normative aspects of selective system response; and

(3) that primal v. dual modes of analysis so formulated can be shown to be complementary in general and correspondent, i.e., equivalent, under specific conditions identifiable with optimal response.

As these dominant theses suggest, the long standing dichotomy of naturalist v. idealist philosophies need not represent a necessary or irreparable cleavage. A synthesis of reductionistic v. holistic perspectives is at least envisionable in terms of the complementarity of alternative modes of rational inquiry.

Rational Canons

Heretofore we have not known, literally, what it would mean to be "rational" in a context of inquiry where

(1) organizational viability of a multi-level, multi-goal system as a whole is centrally relevant;

(2) evolutionary processes realizing novel forms of organization and behavior (rather than predeterminate reaction processes) constitute the phenomena of interest; and

(3) valuative (ethical, aesthetic, evolutionary) aspects of optimal organization (in addition to minimal normative, factual, and logical necessities) complete the array of sufficient conditions for adaptive system response.

Here again, as in the earlier case of extremal principles, we are not totally lacking any previous conception. As argued persuasively by C. Lévi-Strauss [23], the very mark of the pre-civilized human mind is that it totalizes. Human intelligence is natively sensitive to complex wholes and to valuative assessment of what is significant in the intricate relationships of immediate experience. But for the critical tasks of (1) selecting among alternative conflicting insights of creative intelligence and (2) instituting dependable control of its own cognitive processes, a merely intuitive version of rationality is deficient. These standing problems seem to have forced the invention of an alternative analytical mode of rationality, a way of thinking characterized by decomposition of the totality of experience and its recomposition in more comprehensible—though necessarily more abstract—reductionistic models. Throughout subsequent centuries of development, a clear appreciation of appropriate interplay between intuitive v. formal resources of human mentality has proved to be an elusive goal. At present it appears that there is a pressing need to redress the balance of emphasis between dialectical and analytical reasoning.

The rise of the modern systems approach might well be described as a massive readjustment of emphasis, a return swing from the traditional exclusion of valuative considerations from scientific inquiry. The valuative aspects of normative-adaptive behavior now generally encountered in systems science do not admit of adequate representation by recourse solely to the present analytical basis of objective scientific inquiry. Theories relevant to explanation and prescriptive control of adaptive systems entail significant extension of the characteristic structure of objective theories, specifically:

(1) addition of a decision-parameter space to the conceptual model,

(2) construction of an adjoint formal system,

(3) assumption of a set of hypotheses constituting terminal value posits, and

(4) recourse to tests for admissibility that are sensitive to criteria for vindication rather than confirmation of the theory.

In response to the charge that such theories could not be "scientific" theories, one must answer that the extensions envisioned can be achieved in no other way than by continuation of the basic project of rationalization that created science. And that project, as we have tried to indicate in Fig. 5.9 , essentially consists in successively extending the objectives and therefore the domain of rational inquiry.

The system sciences, in attempting to formulate a conceptual and theoretical basis that would more adequately accommodate the complexity of intuitively significant total-systems, cannot simply reassert a naive holistic approach in abandonment of scientific rigor. The attainment of rigor and of more comprehensive scope are simultaneous requirements; and the instrumental change that would make this possible is the establishment of canons of rationality sufficient to insure warrantable cognitive control of theory construction in the newly extended domain of normative behavioral inquiry.

The problem of cognitive control or, technically, the task of instituting adequate rational canons, must be posed in a manner that avoids two perennial deficiencies which would otherwise subvert the very possibility of "warranting" normative theories. First, the reductionistic tendency to associate rationality solely with categorical or logically imperative criteria marks a failure to recognize that the problem is essentially one of total self-organization on the part of a cognitive agent, a question of the optimal design of a self-control system capable of providing holistic criteria for unambiguous selection among alternative cognitive decisions. This

OBJECTIVES of RATIONAL INQUIRY

Sub- process	Criteria
DESCRIPTION, unambiguous	semiotic
DEMONSTRATION, valid	logical
PREDICTION, warranted	perceptual aesthetic
PRESCRIPTION, vindicated	pragmatic evolutionary synaesthetic
CONCEPTUALIZATION, admissible	holistic

Figure 5.9

is to say that the creative institution of provisional, extralogical criteria throughout an escalade of practical, theoretical and metatheoretical decisions has not been explicitly construed as a legitimate aspect of the rationalization of thought. Rationality has not generally been interpreted in terms of the optimality of a system of controls expressly designed to foreclose relativistic freedom at every level of cognitive decision and so lead to determinative description, prediction, prescription, and action. An attempt to rationalize decisions in general is equivalent to an attempt to optimize the design of a process control system, where the design must be devised in part by the reflexive use of the process itself. This "design-problem" interpretation of rationalization is only vaguely appreciated; and there, in short, lies the nature of the first of the two deficiencies.

The second inadequacy—actually a result of the first—is associated with the absolutist tendency to consider the complex of rational control as insulated from evolutionary effects, thus severing the mental process of rationalization from its stem in the more general process of emergence. In contrast with the premise that human intellectual advance involves an emergent (creative) process that must be viewed simultaneously from biological-psychological-sociological perspectives, this conception presupposes that man, as the "rational animal," has a stripe that never changes. One characteristic of the human—his rational nature— is arbitrarily presumed to be exempt from modification. This view of rationality as the control of thought and action in accordance with some specific set of absolute, immutable, universal principles, totally obscures the evolutionary development of distinguishable rational modes that is the principal clue to "improved" cognitive control. There are, admittedly, certain principal commitments (primarily logical in character) so fundamental to the control of thought that, since their explicit enunciation, no sane human being has been seriously disposed to suggest their modification. It is this evidence upon which the absolutist depends for intimations of universality. But these commitments are but core-elements of the multi-level, multi-stage hierarchy of ontological, epistemological, axiological, syntactic, semantic, pragmatic and aesthetic commitments that comprise the whole of a distinctive rational format. The persistent admissibility of these logical "core-commitments" does suggestively parallel the even longer persistence of certain fundamental features of physiological design that have recurred in every lower category of the Chordate phylum. The finite character of the cognitive agent, moreover, insures that any system of rational controls must terminate, at its apex, in a collection of ultimate commitments effecting provisional closure and thereby serving _qua_ absolutes-- "hypothetical absolutes," if you will. But what is important as a distinction is that the entire system of cognitive controls must ultimately be viewed, like any instrumental control system, as a modifiable feature of the overall design of an adaptive system.

The task of instituting rational canons for the more comprehensive context of normative inquiry therefore consists in creative modification, i.e., systematic extension, of conventional criteria of rational decision.

As we attempt to indicate in Fig.5.10, the total array of controls relevant in decision as to the admissibility of a normative theory (a theory applicable to optimal behavior) includes distinct classes of (1) formal, (2) empirical, (3) pragmatic, (4) aesthetic, and (5) evolutionary criteria. Nominally, these categories are concerned with (1) syntactical well-formedness and logical consistency, (2) perceptual reproducibility and testability, (3) interpretability and practicability, (4) cybernetic elegance or simplicity, and (5) meliorative trend (viability) and stable-optimal organization. The ramifications involved in establishing their systematic relationships and in codifying their respective test procedures are clearly quite imposing; but it appears that nothing less than this will suffice as an adequate foundation for rational normative inquiry.

Beyond these components of a philosophy relevant to evolutionary process, subsequent innovations are required:

(1) unification of the supposedly disparate methodologies of axiomatics, experimental science, and axiology (or value-inquiry);

(2) codification of alternative techniques of systems analysis based on objective-predictive and normative-prescriptive modes of inquiry respectively.

Such developments, however crucial they may be technically, are methodological in character and therefore subsidiary to metascientific reconstruction in the sense that they are derivative. Since these considerations can legitimately be detached, we may thankfully defer them. The self-assigned task of this preview was simply to show the magnitude

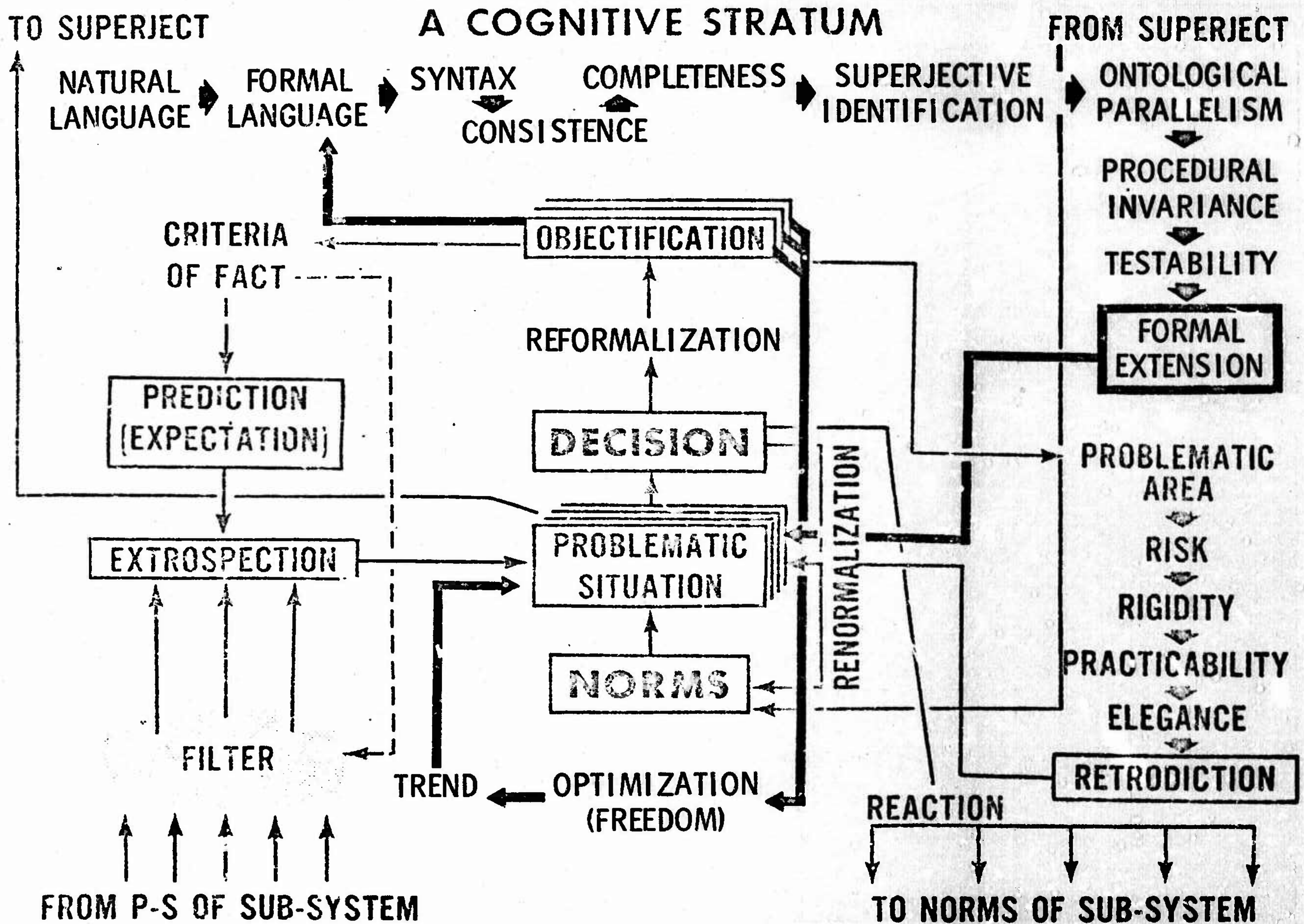
A COGNITIVE STRATUM
TO SUPERJECT
FROM SUPERJECT
NATURAL LANGUAGE
FORMAL LANGUAGE
SYNTAX
CONSISTENCE
COMPLETENESS
SUPERJECTIVE IDENTIFICATION
ONTOLOGICAL PARALLELISM
PROCEDURAL INVARIANCE
TESTABILITY
FORMAL EXTENSION
CRITERIA OF FACT
OBJECTIFICATION
REFORMALIZATION
PREDICTION (EXPECTATION)
DECISION
RENORMALIZATION
PROBLEMATIC AREA
RISK
RIGIDITY
PRACTICABILITY
ELEGANCE
RETRODICTION
EXTROSPECTION
PROBLEMATIC SITUATION
NORMS
FILTER
TREND
OPTIMIZATION (FREEDOM)
REACTION
FROM P-S OF SUB-SYSTEM
TO NORMS OF SUB-SYSTEM

Figure 5.10

of the project of interdisciplinary synthesis, and visionary developments sufficient to this end have already been broached. In view of the profound change in rational modality that interdisciplinary synthesis entails, this topic raises a target so large that one could hardly have failed to hit it. Countering this advantage, however, is the danger that a project so enormous may come to be viewed as an enormity. It is this defeating sense of impracticability that one is required to combat.

The project comes down to an intensification of the vernerable effort of men to extend the scope of reason. It is true that this renewal of effort must be made in the face of more imposing threats of impasse and more intractable phenomena than heretofore encountered in scientific inquiry. Admittedly, we have to deal here not with extension of already reasonably codified disciplines but, rather, with the initiation of a novel mode that could hope to provide (1) concepts that are relevant, (2) methods of inference that are warrantable, and (3) cognitive models that are interpretable and practicable over a more comprehensive domain of experience than any that science has previously essayed. In Table 5.7 (p. 5-19) we represented the domain of rationality as a spectrum, ranging from the formal sciences through the humanities, stratified by cognitive levels from practical decision to primitive conceptualization. By the shading of Table 5.7 we conceded that with regard to normative-theoretic inquiry almost all of the work of rationality--that is, the task of systematic construction--remains to be done. But it seems that we ought to view this challenge in the most hopeful terms as giving powerful incentive to multidisciplinary cooperation. Surely there is at hand a preconception of a unifiable domain of rationality sufficiently coherent to attract the concerted attention of mathematics, philosophy, the life and social sciences, and particularly the precursor system sciences.

Modern systems research is thus a study in contrast. It introduces a profound innovation in conceptual format that, when used to reconstitute the objects of inquiry, at least intimates that the compartmentalized world of scientific discourse might legitimately be vested with more of the coherence that marks our intuitive comprehension. But the attending task of interdisciplinary synthesis that it raises now calls for equally profound modifications of the criteria and procedures of "rational" inquiry in order to secure the indispensable warrant of testability for the novel type of theories required by norm-directed behavioral systems. The abiding problem of rationalization of the human mentality once again calls for new enterprise in systematic philosophy.

Part III. PROLEGOMENA

Part III: PROLEGOMENA

PROGRAM—

<u>Present</u> a deposition of first principles essential to appreciation of innovations in philosophic method.

<u>Select</u> a point of entry into the iterative process of philosophical development: the cognitive agent situated in action—replete with the full complexity of aesthetic, creative, and control capabilities.

<u>Characterize</u> the situation of the cognitive agent in terms of an evolutionary paradigm posited as holding throughout geosphere, biosphere, sociosphere, and noösphere.

<u>Characterize</u> the cognitive-semiotic capability and the cognitive agent in action as an adaptive system.

Chapter 6

RENEWED ENTERPRISE IN SYSTEMATIC PHILOSOPHY

From classical systematic philosophy we appropriate the antique term "prolegomena" in reference to our present task: the laying down of initial considerations essential to the approach to be taken in a new enterprise. This mark of respect for continuity is the minimal requirement of historical piety in the face of great exertions of the past. In order to avoid a misleading suggestion, however, it is necessary to emphasize immediately the changed conditions under which "first principles" originate and the distinct functions they are created to serve when they are set forth, as they will be here, not in the guise of dogmatic certitudes but as policy-commitments of a cognitive-entrepreneurial effort. We have earlier insisted that the initial issue in philosophical construction—when inquiry in general is conceived in terms of a hierarchy of cognitive <u>decision</u> processes—must be the strategic provision for "management" of cognitive operations involved in the central activity of theory-construction. The first necessity is to mount a self-correcting, self-amplifying process of innovation and selection by which we may hope eventually to secure methods, theories, and concepts that prove to be more adequately comprehensive and systematic.

Whitehead [1] in his Davies Lecture (Columbia, 1932) drew the essential distinction in this way:

> The history of European thought, even to the present day, has been tainted by a fatal misunderstanding. It may be termed The Dogmatic Fallacy. The error consists in the persuasion that we are capable of producing [philosophical intuitions] which are adequately defined in respect to the complexity of relationships required for their illustration in the real world....Our right understanding of the methods of intellectual progress depends on keeping in mind this characteristic of our thoughts....Our task is to understand how in fact the human mind can successfully set to work for the gradual definition of its [fundamental] ideas. It is a step by step process, achieving no triumphs of finality.

In this light the following abstract will serve to indicate the marked extent to which we shall depart from the absolutist stance of the classical systematist.

By "new enterprise" we refer to a reconstitution of the task of systematic philosophy as that of evolving a stable yet modifiable structure of fundamental premises by way of successive iterations of intuitional (dialectic) and formal (analytic) phases of inquiry. The notion of iteration raises the issue of appropriate entry into a cyclical process. The crux of this chapter then consists in establishing the finite cognitive agent—situated in context and in action, replete with the full complexity of aesthetic, creative, and control capabilities—as the initial focus of attention, the appropriate point of entry in the cyclical process of philosophical system-building. The issue of the competence of the cognitive agent has brought systematic philosophy at present to a state nearing debacle, and it is the treatment of this issue from which any legitimate reconstruction must take its rise. A priori commitments, entrepreneurial in role however intellectual their nature, will therefore be advanced as provisional rather than dogmatic directives for management of "mission-control" of philosophical reconstruction. Commitments of this type have been broached already in Part II: identification of problematic situation, selection of ultimate objectives, strategic concept of the mission of adaptive modification of foundations. New perspectives, aims, and methods of philosophy in a reflexive mode constitute further entrepreneurial commitments providing the rationale for introduction of the innovative aspects of (1) iterative reconstruction and (2) imposition of explicit performance criteria for an "improved" philosophical system.

COGNITIVE COMPETENCE IN SYSTEM-BUILDING: SKEPTICISM AND REACTION

In the history of modern and recent philosophy, two principal criteria of admissibility for conceptual systems have been brought to bear with the best intentions of constructive criticism but with disastrous practical effect on the fragile constructions of classical systematics. Warrantability (in an overly demanding version of positive confirmation) was the criterion destructively applied in David Hume's skeptical attack on the rational defensibility of causal relation and inductive inference as early as the 18th century. Following a resurgence of systematic philosophy based, in the following century, on more voluntaristic primitive assertions (as against a priori assertions presumed to be absolute and necessarily applicable to experience), a sense of futility in the face of the requirement for warrantability appeared to settle into a form suggested by the question Why can't philosophers agree? More explicitly, there seemed to be a resigned conviction that philosophy, by virtue of its attempt to deal with "ultimate" commitments, could not in principle provide access to any test procedure that would effectively select among incompatible alternative systems all of equal status in their origins. The second criterion, interpretability, was employed by linguistic and logistic analysts of the 20th century in an even more devastating critique of prior claims to competency in system-philosophy. The attack in this case struck at the very meaningfulness of the enterprise of philosophical system-building.

The situation is plain enough: any present day advocate of renewal in systematic philosophy must be prepared to offer some way through or around the historical criticisms that have rather completely dismantled the ambitious constructions of the past. To this end we briefly review in this section the rationale and historic effect of Humean skepticism and, in a following section, that of modern logical empiricism and linguistic analysis.

(continued on next page)

Rudiments of Hume's Critique

It is characteristic of theories of knowledge, as it is of theoretical projects in general, that their impetus is derived from the existence of some intriguing body of phenomena which calls for an adequate rationale. That men should be concerned about questions involving (1) the nature and extent of knowledge, (2) the sources and methods of knowledge, and (3) the validity of knowledge, clearly presupposes that they are already in possession of a reasonably coherent system of knowledge.

In this regard a perplexing situation has existed in modern and recent philosophy by virtue of the indecisive treatment which as perennially been given David Hume's Treatise of Human Nature (1739-40). In an essential section of his Treatise (Bk. I, Part III: "Of Knowledge and Probability"), Hume conducted an analysis of the type of knowledge which is obtained from empirical data by inferences that are not demonstrative. This type presumably includes all our knowledge except that derived from the formal inquiries of logic and mathematics on the one hand and certain forms of immediate observation on the other. The analysis of such knowledge led Hume to a skeptical conclusion that has proved as difficult to accept as to refute. Against later theories of knowledge attempted from a basis in strict empiricism, Hume's conclusion—itself an early result of radical empiricism—tended to disclaim the very existence of any system of inferential-factual knowledge which epistemological theory might presume to support.

The groundwork of Hume's analysis of empirical knowledge rests upon considerations which he termed the "elements" of his philosophy. These comprise a rather complex collection consisting of (a) epistemological and metaphysical principles, and (b) a set of definitions and postulates[1] which were selected, after detailed preliminary investigation, as being relevant to the critical need for "a science of man," i.e., experimentally based psychological theory.

A great deal of attention has been focused upon Hume's psychological postulates, with the clear implication that their application in analysis of the conscious states of the human organism determines the conclusion of his investigation of empirical knowledge. The "quantum" character[2] assigned to perception by Hume's postulates does ultimately prove to be a decisive operational factor in his line of argument and skeptical conclusion. It seems apparent, however, that Hume's basic philosophical commitments, i.e., his empiricism and nominalism contribute even more fundamentally as directives to his selection of psychological postulates. It is imperative, therefore, that any review of his analysis consider a wider context which would include the interaction of philosophical principles with psychological postulates.

From the very outset in the Treatise, Hume [2] insists upon the priority of epistemological investigation in the general philosophic

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1. The term "postulate," not used by Hume, is employed her to denote a purported factual statement asserted on the basis of experience but utilized in argument as a formal commitment.

2. By "quantum character of perception" we refer to the notion that every impression and every idea is a distinct, isolated and independent particular—an irrefragable unit of experience. This notion was, of course, suggested earlier by John Locke; Hume stated this doctrine explicitly and developed its implications systematically.

enterprise and the rejection of traditional rationalism in favor of a scientific empiricism.

> It is easy for one of judgment and learning to perceive the weak foundation even of those systems which have obtained the greatest credit....Principles taken upon trust, consequences lamely deduced from them, want of coherence in the parts and of evidence in the whole, these are everywhere to be met with in the systems of the most eminent philosophers, and seem to have drawn disgrace upon philosophy itself.
>
> 3

The expedient which is suggested as the only hope for success in philosophical research is the attempt to extend our conquest of sciences which intimately concern human life. In proposing to erect a scientific philosophy on this new basis, Hume asserts that there is no question of importance whose decision is not sensitive to the science of man and none which can be decided with any certainty before we become more thoroughly acquainted with the extent of human understanding, achieving an explanation of the nature of the ideas we employ and of the operations we perform in our reasoning procedures.

The one solid foundation which we can have for the erection of a scientific philosophy, Hume maintains, must be laid upon experience and observation. Apart from careful and exact experiments which provide consistent factual evidence for our principles and hypotheses, he finds no recourse for philosophy. All attempts to predicate the ultimate original qualities of human nature are to be immediately rejected as presumptuous—products of a type of metaphysical reasoning which has never achieved

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3. Ref. 2, Introduction, p. xvii. (Note: Each excerpt following in this section will cite the Treatise, Ref. 2, in terms of Hume's organizational schema, viz., Book, Section, Part.)

anything except endless controversy. No justification of even our most general propositions can be given except by the evidence of experience, nor can we go beyond experience or establish any (factual) principles which are not founded on that authority.

Tenets of empiricism as philosophical supports for his analysis thus enter in an explicit fashion early in Hume's Treatise (Book I). Before considering these elements further, however, it will be helpful to review Hume's introduction of his definitions and postulates. It is in the service of justifying the selection of these elements that the basic philosophical position is invoked.

All the perceptions of the human mind, according to Hume, resolve themselves into two distinct kinds which he terms impressions and ideas. The distinction between these types is to consist merely in the respective degrees of forcefulness with which they appear in consciousness.

> Those perceptions which enter [the mind] with most force and violence, we may name impressions, and under this name I comprehend all our sensations, passions and emotions, as they make their first appearance....By ideas I mean the faint images of these in thinking and reasoning such as, for instance, are all the perceptions excited by the present discourse...[except, of course, our immediate sensations].
>
> 4

It is not clear whether Hume purposefully left the term "perception" undefined. From his usage it appears that any conscious state of the human organism is to be considered as an instance of an indefinite physiological situation which the term "perception" may signify. Apparently there is to be attributed an implicit connotation of awareness (detection) of

4. Bk. I, Part I, Section I.

sensation or reflection which, in modern psychology, would be indicated by the overt behavior of discriminatory response or by covert behavior imputed on the basis of a subsequent verbal report.

A second division of perceptions, which Hume extends to both impressions and ideas, is the distinction between simple and complex perceptions. Simple perceptions (ideas or impressions) are such as admit of no analysis or separation into parts. Complex perceptions are, on the contrary, capable of distinctions and analysis into parts. Hume's use of this distinction is that of limiting his earlier general assertion that ideas are images of impressions. What he finally intends to assert is that every simple idea has a simple impression which resembles it and every simple impression a correspondent idea. With respect to complex ideas the matter stands quite differently.

> I observe that many of our complex ideas never had impressions that corresponded to them, and that many of our complex impressions never are exactly copied in ideas. I can imagine to myself such a city as the New Jerusalem, whose pavement is gold..., tho' I never saw any such. I have seen Paris, but shall I affirm that I can form any such idea of that city as will perfectly represent all its streets and houses in their real and just proportions? [5]

The first general proposition which Hume establishes, then, amounts to a formalization of John Locke's earlier rejection of innate ideas: "all our simple ideas in their first appearance are derived from simple impressions, which are correspondent to them, and which they exactly represent."[6] Simple impressions therefore constitute the necessary and sufficient

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5. Bk. I, Part I, Section I.

6. Bk. I, Part I, Section I.

conditions for the appearance of corresponding simple ideas. Hume points out the fact that whenever by accident the sensory faculties are impaired, as in deafness or blindness, there inevevitably exists a corresponding lack of emergence of one class of simple ideas. Thus, impressions are necessary antendents of ideas. Hume considers, on the other hand, the experiment of affording naive subjects a given sensory experience and observing that they immediately give evidence of the attainment of a new concept. Hence, impressions are sufficient to the appearance of ideas.

Affirming the empiricist position of Locke, Hume finally asserts that impressions are related to ideas as causes to effects. On the only possible interpretation of "causes and effects" at this early stage in the Treatise, i.e., on the Cartesian interpretation which includes under causation a principle of sufficient reason, it appears that we may fairly interpret Hume's thesis in these terms: Simple ideas appear in the conscious mind if and only if correspondent simple impressions have appeared prior to them.

This doctrine of the priority of impressions to ideas must be understood with a limitation, viz., that we can form secondary ideas which are images of the primary (ideas). In an additional qualification, impressions are divided into two kinds, (1) sensation and (2) reflection; and the second type of impressions may be derived conversely from ideas in the following manner.

> An impression first strikes upon the senses, and makes us perceive heat, cold, thirst or hunger, pleasure or pain of some kind or other. Of this impression there is a copy taken by the mind, which remains after the impression ceases; and this we call an idea. The idea of pleasure or

> pain, when it (reappears in our consciousness), produces new impressions of desire and aversion, hope and fear, which may properly be called impression of reflexion.... These again are copied by the memory and imagination, and become ideas; which perhaps in their turn, give rise to other impressions and ideas. So that impressions of reflexion are only antecedent to their correspondent ideas; but posterior to those of sensation, and derived from them.
>
> 7

The introductory mention of the operations of memory and imagination in the passage just cited opens Hume's consideration of complicated mental phenomena involving (1) the reflexive relation of impressions to ideas, and (2) the association of simple elements in the attainment of complex ideas, particularly abstract ideas.

We may discover by experience, Hume claims, that when any impression has been present in the mind, it may make its appearance again as an idea in one of two ways: either (1) retaining a considerable degree of its original "vivacity," or (2) exhibiting a complete loss of the aesthetic-kinaesthetic context of the original impression.

> The faculty by which we repeat our impressions in the first manner, is called memory, and the other the imagination....Though neither the ideas of the memory nor imagination,...can make their appearance in the mind, unless their correspondent impressions have gone before..., yet the imagination is not restrained to the same order and form with the original impressions; while the memory is in a manner tied down in that respect, without any power of variation.
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> 8

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7. Bk. I, Part I, Section II.

8. Bk. I, Part I, Section III.

> The qualities, from which this association arises, and by which the mind is after this manner conveyed from one idea to another, are three, viz., resemblance, contiguity in time or place, and cause and effect.
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> 9

The association of ideas is, for Hume, an activity of the mind, habitual in character, which supplies a union or cohesion in cognition which is not necessarily present in fact among the objects of cognition. The effects of this habitual activity are obvious and remarkable, he observes, but as to details of its operation he holds that they are mostly unknown and must be presumed to constitute innate capabilities of human nature.

> Amongst the effects of this union or association of ideas, there are none more remarkable, than those complex ideas, which are the common subjects of our thoughts and reasoning, and generally arise from some principle of union among our simple ideas.
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> 10

The marked effect of Hume's nominalism is nowhere more evident in the elements of his philosophy than in his consideration of the attainment of abstract complex ideas. In agreement with Berkeley, Hume contends that any abstract idea is itself individual, however general it may become in its application to classification of particular entities as belonging or not belonging to the class signified by that abstract idea. Abstract ideas, therefore, are apparently conceived as models endowed with an indefinite

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9. Bk. I, Part I, Section IV.

10. Bk. I, Part I, Section V.

range of variability; and like any complex idea, they comprise me[illegible]
association of simple ideas or an image of a collection of si[illegible] [illegible]ions.
This interpretation, of course, has an obvious import with regard to the impossibility of relations (especially causal relations) being considered as inherent, objective or necessary in natural phenomena. In the reasoning which Hume subsequently presents, he undertakes (1) the resolution of abstract ideas of relations into component ideas with their correspondent impressions, and (2) the analysis of the principles of association by which simple components are assembled into abstract ideas with purported objective reference. It is this analysis of the abstract ideas of relations which supports Hume's essential argument for skepticism with respect to empirical knowledge.

This analysis begins with the categorization of seven kinds of philosophical relations, of which four: (1) resemblance, (2) contrariety, (3) degree of any quality, and (4) proportion in quantity or number depend solely upon comparison of ideas which are immediate and distinct in the Cartesian sense. These relations comprise, for Hume, resources of certain knowledge. The remaining three relations: (1) identity, (2) time and space relations, and (3) causation depend upon recourse to reasoning which reduces to comparison of ideas referred to impressions when one, both, or neither of the related objects is present to the senses. With respect to identity and time-space relations, the mind cannot and need not go beyond what is immediately present to the senses. It is causation only, Hume says, which purportedly gives access to relations which are not actually presented in impressions at any time.

> It appears that, of those three relations which depend not upon the mere ideas, the only one, that can be traced beyond our senses, and informs us of existences and objects, which we do not see or feel, is causation.
> ...We must consider the idea of causation and see from what origin it is derived....It is impossible perfectly to understand any idea without...examining that primary impression from which it arises.
>
> 11

Upon examination of examples of cause and effect, Hume concludes that we must not search for any particular qualities which, as impressions, could engender the idea of causation. It is, rather, from certain elementary relations—contiguity, succession, and constant conjuction—that the abstract idea of causation is derived. These elementary relations, however, are presumably ideas which depend upon memory and hence upon impressions actually presented at some time. In addition to these, the idea of causation depends upon a crucial relation, the necessary connection of causally related objects, which apparently involves something like a postulate of sufficient reason for which (as in the case of causation itself) no grounds appear to exist in impressions.

From Hume's position in empiricism, causal relations, as well as the particular postulate of necessary connection, can certainly not be supported by *a priori* assertions or even by the certain knowledge derived from comparison of ideas. These relations must, therefore, issue in some manner from observation and experience; and, in view of the lack of primary impressions corresponding to the idea of causation, the obvious question for Hume is: How does experience give rise to such a principle as causation?

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11. Bk. I, Part III, Section II.

For Descartes, as for Scholastic philosophy before him, the connection of cause to effect was supposed to be necessary, as logical connections are necessary. In fact, the relation of causation had traditionally been more or less assimilated to that of antecedent and consequent in logic. Hume's analysis produced the first serious challenge to this view and so opened the modern treatment of causation. Hume's point is this: the idea of one event or object necessarily producing (causing) another is discoverable neither from the ideas of the two objects by reasoning nor by recourse to any impression in experience. Since we can, in fact, entertain an idea of causal relations, it must derive from experience because the connection is not logical; yet it cannot depend merely upon experience of any particular objects A and B since we can discover in the experience of A no impression of anything which must lead to the production of B. We experience merely the constant conjunction of two elementary relations, (1) contiguity and (2) succession, with respect to the impressions actually presented in any purported instance of causal relation. We never experience the production of any object or event by any other—there exists no impression of such production. Moreover, we can, without contradiction, always separate the distinct impressions of factual objects taken as causally related. Thus, it is possible to consider the crucial "felt" necessity of causal relations as dependent upon the regularity of the inference from impressions to causal relations, rather than the inference depending upon the necessity of causal relations.

Skeptical Conclusion

According to Hume, then, neither apodictic (certain) knowledge nor probability can provide support for the supposition of uniformity in nature, which would be required in order to construe causal relations as necessary relations. Hence, there exists no incorrigible basis in reason for inductive inferences from impressions to causal relations. The uniformity postulate, in fact, is conceived by Hume as representing merely a formalized "description" of the outcome of mental operations characteristic of the association of ideas. And probable reasoning, rather than affording support in the form of a fundamental rational basis for causal relations, actually represents merely instances of inductive inference in accordance with the principles of association of ideas.

> Thus not only our reason fails us in the discovery of the ultimate connexion of causes and effects, but even after experience has informed us of their constant conjunction, 'tis impossible for us to satisfy ourselves by our reason, why we shou'd extend that experience beyond those particular instances, which have fallen under our observation. [12]

Probable knowledge (empirical knowledge via inductive inference) therefore depends only upon associations characteristic of the human mind. Cognition, in this sense, Hume contends, derives from those "original qualities of human nature" which are so refractory to explanation. Thus, cognition of this type is as inexplicable as sensation. However, causation did appear to Hume to involve a peculiar sort of mental phenomenon—an automatic or determined situation termed "belief," i.e., the invariable calling up of ideas related to a present impression by virtue of past experience of constant conjunction of impressions. Thus, while causal relations are philosophical

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12. Bk. I, Part III, Section VI.

for Hume, they are also natural relations. They are "in nature" at least in the sense that they are invariable educed by the mind in response to coherent experience.

In attempting to reasch further to a psychological consideration of belief, Hume allows himself to refer to causation in a sense which he, in general, has condemned. Belief is to consist merely in a certain manner of conceiving an object, viz., belief bestows additional "force or vivacity" upon an idea. Thus, belief, in every case, is attained by virtue of the principles of association of ideas operating upon an immediate forceful impression, leading without any necessary directive in reason to a related idea or <u>expectation</u>. Hume, by definition, terms this event an instance of custom; and belief is therefore derived solely from habitual relation of ideas. Yet Hume speaks of a present impression as the <u>cause</u> of this internal phenomenon of belief in the sense that a given belief is <u>determined</u> by repetition of a specific context of immediate impressions. If Hume's earlier reasoning be respected, we have no basis for supposing that associations consistently conjoined in the past with certain impressions must necessarily recur in future similar circumstances. On Hume's analysis, we can no more conceive of necessary expectations in psychology than we can conceive of necessary causal relations in the physical world. When, speaking strictly in Hume's terms, we say A causes B, all we have a <u>right</u> to say is (1) that in past experience, A and B have consistently been conjoined in terms of succession or contiguity, i.e., no instance has been observed of A not succeeded or accompanied by B; and (2) that while A and B have been consistently related causally by associational habit, there can exist no reason for considering A and B as necessarily related in fact, nor any reason for expecting A and B to be causally related by association in future experience.

In summary, Hume concludes his argument in this fashion:

> I am sensible that of all the paradoxes which I have had...to advance in the course of this treatise, the present one is the most violent, and that tis merely by dint of solid reasoning I can ever hope it will have admission, and overcome the inveterate prejudices of mankind. Before we are reconciled to this doctrine, how often must we repeat to ourselves, that the simple view of any two objects or actions, however related, can never give us any idea of power, or of a connexion betwixt them: that this idea arises from a repetition of their union: that the repetition neither discovers nor causes anything in the objects, but has an influence only on the mind by that customary transition it produces, ...?
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In the domain of probable knowledge, which corresponds with the domain of phenomena causally related via inductive inference, Hume thus concludes that the human mind can secure validation of such knowledge neither by recourse to experience nor by the support of reason. A final elucidation is given by Hume's notion of the prototype of inductive inference. His description corresponds to a basic type later to be termed "animal inference," viz., expectations which are fixed without recourse to reflection.

> ...Past experience, upon which all our judgments concerning cause and effect depend, may operate on our minds in such an insensible manner an never to be taken notice of, and may even in some measure be unknown to us. A person who stops short in his journey upon meeting a river in his way, foresees the consequences of his proceeding forward; and his knowledge of these consequences is convey'd to him by past experience....But can we think that on this occasion he reflects on any past experience...in order to discover

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13. Bk. I, Part III, Section XIV.

> effects? No surely; this is not the method in which he proceeds....Custom operates before [there is] time for reflection,...experience produces a belief and a judgment of causes and effects by a secret operation, and without once being thought of.
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> 14

Hume's interpretation of such evidence results finally in the following amplification of his skeptical conclusion: that probable reasoning, attributing causal relations by means of inductive inference, is merely a special case of sensation. And the fixation of belief is therefore dependent upon an aesthetic-kinaesthetic context—upon feelings, in short.

> All probable reasoning is nothing but a species of sensation. 'Tis not solely in poetry and music we must follow our taste and sentiment, but likewise in philosophy. When I am convinced of any principle, 'tis only an idea which strikes more strongly upon me. When I give the preference to one set of arguments above another, I do nothing but decide from my feelings concerning the superiority of their influence.
> ...Belief is more properly an act of the sensitive, than of the cognitive part of our natures.
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> 15

This ultimate outcome of his investigation of empirical knowledge is clearly not the result that Hume anticipated. The subtitle of his Treatise is "An Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects." It seems evident that he started with the notion that experimental inquiry yields factual knowledge. He ended, however, with the conclusion that, since belief is never unconditionally rational, we cannot attain any apodictic knowledge with refers to factual entities.

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14. Bk. I, Part III, Section VIII.

15. Bk. I, Part III, Section VIII; Bk. I, Part IV, Section I.

After establishing his argument for skepticism, Hume found no recourse for the rest of his philosophy but to fall back upon credulity and lack of precision. His skepticism apparently cannot be actually maintained in practice. Yet it has had the consequence of disarming subsequent efforts to incorporate knowledge, valuation, and action under any philosophical system that might hope to be distinguishable as "more rational" than another; and it has continued to challenge the claim of scientific method to represent a rational procedure assuring systematic enlargement of our understanding. The basic philosophic issue which Hume's argument raised, and which has not until recently been unreservedly joined, is this: Can strict empiricism afford a self-sufficient basis for experimental inquiry? And as a corollary: Must even our empirical knowledge depend ultimately upon some basis in *a priori* assertions? If, as Hume's argument seems to show, no justification of induction can be provided from the standpoint of empiricism, it must be admitted that the antimetaphysical version of philosophy which Hume advocated leads to its own destruction—to the definite failure of scientific philosophy. If, in addition, Hume's objections to the "credulity" of *a priorism* appear to be sustained, a skepticism mitigated only by self-deceit is the rather miserable alternative.

Reaction in Science and Philosophy

No decisive confrontation of Hume's skepticism has appeared in empiricist philosophy for the cogent reason that accomodative modifications have gradually been made in the regions of scientific (empiricist) thought—modifications which accede to a limited acceptance of skepticism. This habituation to skepticism has been extended now even beyond the limits set by Hume to become incorporated in the foundations of the formal sciences with recent treatments of the issues of decidability, completeness, and consistency of axiomatic systems.

It is not clear to what extent Hume's contentions directly produced the profound change toward an acceptance of skepticism in science. It seems apparent that very complicated factors have contributed to that gradual relinquishment of the "quest for certainty" which marks recent objective science. Whatever our conclusion on this point, it is clear that Hume's acuity in analysis and his inability to accept confortable inconsistencies enabled him to detect a serious error in the characteristics assigned to the knowledge acquired by means of the scientific method of his time. This he was able to do even during the introductory phase of the Newtonian model of scientific thought—a model eventually modified, after some two hundred years, along lines which Hume's reasoning would have dictated in the beginning.

The current model of scientific thought construes empirical knowledge as logically conventional and empirically probable; the claims of certainty and necessity have indeed been relinquished. The fundamental embarrassment of empiricism inputed by Hume's reasoning has been avoided by the maneuver of changing the referent for the term "knowledge." Hume apparently anticipated this when he repeatedly insisted that men will never rest in a skepticism interpreted as implying that nothing can be known. The Baconian premise that knowledge is power is now engrained deeply; and we insist that where we evidently have the capability to predict and control the course of events with considerable precision we have knowledge, regardless of what epistemological characteristics we are forced to assign to such knowledge.

If, in the slow evolution of the intellectual climate, scientific method has acceded to a limited skepticism, this development yet represents a temporizing response to the essential challenge laid down in A Treatise of Human Nature. What Hume's argument appears to have shown incontrovertibly is that induction is an independent principle, incapable of being inferred without circularity from experience or from other logical principles. Every attempt to establish the validity of empirical knowledge upon rationalist grounds has failed; induction apparently cannot be assimilated to deduction in a monolithic model for scientific thought. Hume, therefore, still presses hard upon the contemporary philosopher, persistently requiring in the interest of an intellectually respectable and aesthetically satisfying theory of knowledge some justification for dependence on inductive inference—a dependency implicit in the whole prospectus of experimental science. For the practicing scientist, the evidence that induction has "worked" is apparently sufficient justification of its validity. This practical justification may be pressed one step further to the consideration that inductive inference simply constitutes the way in which humans actually do think. It is, as Hume said, the fundamental habit of the organism. The philosopher, however, can hardly accept this as an adequate basis for a theory of knowledge, at least not without a great deal more exertion. Surely it is no adequate justification of inductive belief to show that it is a habit. It is a habit; but the question is whether it is the best or the only possible habit.

With regard to the appropriate direction of philosophic effort in this situation, the general tenor of Hume's work has continued to urge philosophy, and especially epistemology, toward a psychological bent. The challenge of skepticism has forced some philosophers toward investigation of the primal habits of the human organism—the tendencies (1) to form expectations and habits of action by virtue of the impact of stimuli upon a selective, responsive organism, (2) to generalize upon experience in the attainment of concepts, (3) to symbolize concepts significantly for the purpose of reflective mental operations, and (4) to fix upon beliefs which, if not clearly selected upon rational criteria, at least <u>seem</u> overpoweringly to be based upon "reasons." Recent proponents of this line of investigation, primarily pragmatists and behaviorists, e.g., C. S. Peirce, John Dewey, C. I. Lewis, apparently have considered the required justification of induction to consist in explanation of behavioral characteristics of the human organism in instrumental terms. This course anticipates an explanation which would show that the habit of induction-generalization is <u>instrumentally</u> necessary.

A second group of philosophers, primarily logical empiricists, e.g., Hans Reichenbach, Rudolph Carnap, Richard von Mises, sheer away from "psychologism" as they do from rationalistic <u>a priorism</u>, electing to attack the problem of induction on purely logistic grounds. The ambition for this line of investigation has been a justification of induction which would show, on the basis of a logical reconstruction of the procedures utilized in experimental inquiry, that inductive inference represents an optimal strategy in the selection of posits for the direction of action in the future—a method justified in virtue of its assurance of success, if success is attainable by any means whatever. It is the mark of this group of investigators that they emphasize much more strongly than the pragmatists the connection of probability theory with any epistemological theory which centers upon induction as its key problem.

Other reactions in philosophy are highly significant: (1) the revision of rationalism by Immanuel Kant and the "philosophy of unreason" (Rousseau, Schopenhauer, Nietzsche) which despite great substantive disparities arose alike out of response to Hume's purported demolition of the grounds for warranted factual knowledge, (2) the emphasis or organismic holism which—as counter to Hume's psychological "atomism"—typifies the more recent philosophies of Bergson and Whitehead as well as the Gestalt psychology of Karl Koffka.

Under our entrepreneurial commitment to conduct philosophical investigation in a reflexive mode, each of these themes of reaction (below) will reappear in the unfolding of our substantive commitments: (1) revision of the characterization of cognitive processes initiated by Hume, as carried forward by American pragmatism, (2) consideration of optimal strategy and policy in construction of cognitive models and methods of inquiry, as featured in logical empiricism, (3) formulation of categorical norms for a generalized adaptive decision system, a project suggested by the nature of the Kantian program, (4) insistence on a holistic, organismic, evolutionary system schema in consonance with the convictions of Bergson and Whitehead—even (5) a limited accedence to certain intimations of philosophies of "unreason," insofar as creative cognitive capabilities entail arbitrary (unreasoning) trial-dissolutions of traditional conceptualizations.

It is not by way of an intentional attempt at eclectisism, however, that association of these disparate elements will occur in our own response. The central dilemma posed by Hume's critical philosophy is the equal inadmissibility of either strict empiricism or dogmatic a priorism as self-sufficient grounds for rational warrantability. This dilemma calls imperatively for the introduction of objective and normative dual-controls in order to secure the warranted admissibility of cognitive models in general. As we shall hope to show in later detail, it is in virtue of our attempt to extend the domain of rationality by incorporating formal, factual, and valuative aspects of warrantability under a more comprehensive normative prototype of inquiry that our response to Hume's dilemma fortuitously corresponds with several prior reactions to Humean skepticism.

ALTERNATING DIALECTICAL vs. ANALYTICAL PHASES OF INQUIRY

Of philosophers, so old Archilochus seemed to suggest, there are but two basic varieties: The foxes, who know many things, and the hedgehogs, who know one big thing. In modern parlance these are the analysts, who take their problems one at a time and try above all for clarity and unchallengeable rigor, as against the dialecticians, who strive to view the world of experience as a systemic whole on the basis of some comprehensive synthesis however hazardous.

It can scarcely be disputed that in current fashion the analysts have taken the day. The times are not propitious for a resonant conclusion: With some such pronouncement one might summarize any 20th century account of the general withdrawal of professionals from the tasks of philosophical synthesis and system-building. Plotinus, who gravely supposed that the object of study for philosophy was τὸ τιμιώτατον (the things that matter most), would no longer recognize his discipline. Contemporary philosophy has been preoccupied with tightly formulated issues of interest to specialists in logic, linguistics, and scientific method: the meaning of meaning, the reduction of the number of primitive propositions required for deductive logic, the status of sense data, the question whether <u>a priori</u> statements are all of them, or only some of them, tautologous.

The ascendancy of analysis in the twentieth century, and the simultaneous decline of systematic attempts at synthesis, admittedly issued primarily from a reasonable rejection of excesses which had occurred in metaphysics. School philosophy had culminated in systems of thought rife with "seductive" fallacies, as a new breed of logistic and linguistic investigators termed them: the confusion of analogy with generality, the confusion of pictorial and emotive meanings with empirical meanings. The desire for comprehensive knowledge had led to dependence on concepts for which interpretability and applicability to the experienced world could not be demonstrated and crucial assertions for which no adequate test procedures could be envisaged. It was by way of an essentially sound critical reaction to deficiencies in system-philosophy that a concerted movement toward analytical rigor arose.

The range and breadth of this reorientation could be adequately traced only in detailed lines of development initiated by a number of originative figures: among them, Bertrand Russell on logical theory, Rudolph Carnap on application of modern logic to epistemology and philosophy of science, G. E. Moore on ordinary language analysis and Ludwig Wittgenstein on general theory of meaning. However, the strategic commitments and general program of analytic philosophy—which alone are of introductory interest here—can be given in their simplest terms by review of the most radical and hence most distinct component of the analytical movement, the position of logical positivism as developed initially by participants in the Vienna Circle.[16]

The emergence of logical positivism occurred under the immediate influence of significant new developments in mathematics and experimental science.[17] Two primary features of this movement stem from the direct impact of empirical science on philosophy, as, indeed, the alternative label "logical empiricism" seems to acknowledge. The first of these

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16. The Vienna Circle had its origin in regular but informal discussions of the philosophy of science among mathematicians and physicists of the University of Vienna prior to World War I. Apparently these sessions dealt with critique of earlier versions of empiricist philosophy, the positions of David Hume, J. S. Mill, Auguste Comte, and more lately, Ernst Mach. After the war, the publication of Ludwig Wittgenstein's _Tractatus Logico-Philosophicus_ (1921), and particularly its new general theory of meaning, provided renewed impetus and the Vienna group drew in philosophers at Berlin as well as at Vienna. The men usually named as associated in this period are: Hans Hahn, Philipp Frank, Moritz Schlick, Rudolf Carnap, Friedrich Waismann, Otto Neurath and (at Berlin) Hans Reichenbach and Walter Dubislav. In the period 1931-40, numbers of papers appearing in the journal _Erkenntnis_ developed the manifesto of this group. From about 1938 onward, its influence spread to England, with Waismann's presense there, and to America, where Carnap, Reichenbach, and Frank, in association with Charles Morris, made _The International Encyclopedia of Unified Science_ (Chicago, 1938, _et. seq._) a principal repository of logical positivist publications. Introductions to the positivist movement are to be found in A. J. Ayer, _Language, Truth and Logic_, London and New York, 1936, rev. ed. 1946 and Philipp Frank, _Modern Science and Its Philosophy_, Macmillan, 1949.

17. The developments referred to were: (1) studies in the foundations of mathematics (Russell, Hilbert, Brouwer) terminating in controversies that were undeniably philosophical in character, (2) startling revisions of basic concepts and theories in physics (advanced principally by Einstein, Planck, Bohr, Schrödinger, and Heisenberg) and (3) the initiation of quantitative techniques of investigation in behavioristic psychology (Pavlov, Watson, Hoisington, and Dashiell).

features is the insistence that philosophical constructions must partake of the characteristic virtures of scientific knowledge: clarity and consistency, testability and accuracy, precision and objectivity. The interest and motivation lying behind this insistence are perhaps best summed up in the banner phrase "the rise of scientific philosophy.[18]

Given the general strategy of revising philosophy so as to make it square with scientific practice, the most widely debated move was the adoption of a criterion of factual meaningfulness under which the conclusion followed that traditional methaphysics is not meaningful. In their basic classification of statements, the logical empiricists distinguished between analytic and synthetic statements: Synthetic statements predicate a relation involving experiential referents; analytical statements comprise mere arrays of significant symbols constructed in conformance with the rules of some formal calculus. Traditional categories for a priori and a posteriori statements similarly were retained, distinguished in virtue of the sort of evidence which is required in each case for demonstration of the truth of the given type of statement. A posteriori statements depend for verification upon correspondence with empirical observation. A Pricri statements represent prescriptions expressed in the form of the tautology; their truth-value is therefore independent of experience. The positivist criterion of factual meaningfulness rested upon these distinctions, and it involved two requirements. In order that a statement have factual (empirical) meaning, it must (1) refer to an experiential entity, and

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18. Hans Reichenbach's The Rise of Scientific Philosophy (1951) is the source of this phrase, though it should be emphasized that Reichenbach himself ultimately subscribed only to a moderate variant of the radical initial position of logical empiricism.

(2) it must be verifiable. That is, there must exist, at least in principle, the possibility of observable contingencies which would have bearing on decisions as to the truth or falsity of the statement.

Under this criterion, synthetic a posteriori statements alone can have factual meaning. It follows that a sentence is factually meaningless if it belongs to any of the following categories:

(1) expressions violating the syntactical formation rules of a given language

(2) analytic sentences

(3) self-contradictory sentences

(4) sentences containing extra-logical terms for which no operational definitions can be provided.

(5) sentences whose verifiability is logically impossible under assumptions of the system of discourse of which they are a part.

In opposition to traditional commitments, the position of logical empiricism is that synthetic a priori statements must be disallowed. On assumption, a priori assertions are admissible only as prescriptions; and no assertion can be conceived as prescribing in fact the character of forthcoming experience. In view of the dependence of metaphysics on synthetic a priori assertions, and particularly in view of the general failure to provide operational definitions or to specify verification procedures in metaphysics, the conclusion of logical empiricism is that speculative synthesis of philosophical systems is nonsensical.

The second major feature of a science-oriented philosophy then follows directly. The program of logical empiricism was shaped in adherence to a drastically reduced notion of the province proper to philosophy. Neither the construction of a philosophical world view (as in the rationalist-idealist tradition) nor the formulation of directives for a way of life (as in the efforts of certain of the early Greeks) was acceptable as a legitimate aim. Philosophy was conceded to have an important clarifying role which might aid or guide the development of a scientific world view; but it could not by mere reflection pre-structure, much less prescribe, conclusions which are attainable only by empirical inquiry. In the past, so the early positivists maintained, philosophy has attempted to utilize purely verbal modes of explanation in dealing with problems which only scientific investigation can adequately resolve. In this way, pseudo-problems have arisen out of linguistic confusion. Hence, the pursuit of unambiguous meanings and unimpeachable methods by way of logical analysis of language and inferential procedures, the eradication of pseudo-problems bred by mere confusion—these are the aims which positivists considered properly assignable to philosophy in the work of ground-clearing, that is, in the discrimination of empirically answerable questions.

Analysis, as a systematic procedure for getting clear as to (1) what we mean by our fundamental concepts and assertions and (2) what we are about in the enterprise of prediction-explanation, therefore constitutes the only version of "systematics" admitted by proponents of scientific philosophy. Regarding this commitment the language-oriented analysts have heavily reinforced their science-oriented counterparts. The approach of Wittgenstein in the early period of studies for his Tractatus, and that of A. J. Ayer and C. L. Stevenson in the first wave of English analytical philosophy, was no less reductionistic of traditional aims than that of the early radical positivists. While the later Wittgenstein of the Cambridge seminars—given to dismantling his own original basis for the Tractatus—was all the more distrustful of any attempt at synoptic treatment of philosophical problems.

The style of analytic philosophy has swept much of the field before it in the middle decades of this century. Some of the major figures of twentieth-century philosophy, to be sure, stand apart from this analytic orientation: George Santayana, Henri Bergson, C. S. Peirce, and John Dewey. In their respective strains of aesthetic, evolutionary, pragmatic, and behavioral interests none have been inimical to system-philosophy; and all have undertaken to contribute positively toward systematization, though hardly in the style of Whitehead's attempt at a unifying tour de force (his Gifford Lectures of 1923-28, printed in 1929 as Process and Reality). Their grouping early in this century, however, is significant. The dearth of offerings in systematic philosophy is an unmistakable feature of recent decades. Concerted emphasis of the analytic mode has gone far toward changing the accepted character of the philosophic enterprise. The nature of the change has been in keeping with a commendable desire for rigor and a laudable intellectual modesty, as to observance of severe restrictions on the area of competence, the feasible aims, and the disciplinary role to be claimed. The insistence of the analysts has been for the rational and empirical ideals of critical philosophy, that is, for the ideals of logical rigor and conceptual discrimination, interpretability and empirical confirmation. Their efforts have been almost totally disregardful of additional but equally demanding ideals of speculative philosophy, that is, the aesthetic and pragmatic ideals of coherent theoretical structure and adequate coverage of human concerns.

The symptoms here are clearly those of a reaction to excess that is itself excessive. One might view philosophical inquiry as being driven into oscillation by the alternation of perturbing and restoring "forces," or more aptly, by the alternating attraction of antithetical demands for rigor vs. comprehensiveness. The obvious response to this situation, if viewed as a problem involving overshooting reactions, would be to take up the task of designing cognitive controls that might more adequately preserve a balance of emphasis between the dual objectives and the dual procedures of analysis and synthesis.

This suggestion, for all its weakness as a crashing oversimplification, is not misleading. The approach we shall take in all that follows is fairly intimated. It should be admitted at once, however, that even in the widest excursions of alternating philosophical modes, something important is always to be gained, if only in the negative sense of exposure of a cul de sac to be avoided. The excursion of contemporary analytic philosophy clearly has gained something of importance in a much more positive sense. By emphasis of meaning and method, it has established the conclusion that certain criteria of admissibility must be conceded to have the status of sine qua non conditions with regard to warrantable conceptualization in general. If the specific criteria initially instituted by contemporary critical philosophy are unnecessarily restrictive, as we shall maintain, they have at least been established on grounds very close to the center of all the operations of the cognitive agent. For any compromise of the interpretability and applicability of the output of the cognitive process forecloses the possibility of tests for reliability. Without recourse to the type of warrant attainable only by testing, there is, in the proper sense, no basis for "rational" selection among the conflicting alternatives that unbridled imagination can so readily supply—to our ultimate consternation.

It would not be sensible to attempt now to disregard the basic conditions for meaningful accomplishment instituted under the analytic orientation. Yet, as we have shown in preceeding sections, an eminently meaningful aim—i.e., extension of technical capabilities in decision science—admits of no course other than renewed effort in the type of philosophical system-building that the analysts rejected. We cannot, of course, return to that state of intuitive confidence in reason that marked the period of monumental ambitions in metaphysical system building. On the contrary, we shall have reason to maintain constant concern for realistic limits of the cognitive capability. But systematic structure we must have; and the middle way that we take would therefore be outlined as follows: (1) that philosophical commitments must be developed sufficiently to yield relevant normative-theoretic constructions, and (2) that only on evidence of adequate prescriptive control in practical decision making should the broader development of a full scale metaphysical position be undertaken. Specifically, this course indefinitely defers the cosmological component of a systematic philosophical position. Attention is concentrated, rather, on epistemological, ontological and axiological components which must provide foundations immediately necessary to the development of normative systems theory and applied analysis.

PHILOSOPHY IN A REFLEXIVE MODE

The phrase "philosophy in a reflexive mode" provides a key to what is essential to this approach. The basic connotations of this key phrase are given in the notions of self-awareness and self-characterization of activities on the part of the cognitive agent and, above all, in the notion of provision for feedback from initial outcomes applied to self-corrective management of a concerted program of activity. The novel aspects of this conception then consist in (1) a willingness to submit to criticism the entrepreneurial policy commitments that normally act as undisclosed determinants in philosophical investigation, and (2) a determined effort to conform to such commitments as having the status of prolegomena, albeit prolegomena of such prosaic character that their import has usually gone unnoted in the traditional presentation of a philosophical system.

It is precisely this failure to expose the intuitive, informal "underside" of the creative activity of philosophizing, we feel, that accounts in great measure for the uninterpretability and inapplicability which have persistently flawed the output of systematic philosophy on the conventional approach. Concrete generalizations as initial commitments of a philosophical system have traditionally been presented in the form of highly sophisticated outputs of a multifaceted, inexplicit preparatory program of inquiry. Only a culminating <u>formalization</u>, essentially, is opened to public scrutiny. The procedure owes perhaps too much to an idolization of axiomatic rigor. Beginning with <u>a priori</u> formal commitments (seemingly out of nowhere though certainly not so) the typical procedure has been that of theory-development under the application of correspondence or transformation rules. In the event that such a formalization, under interpretation, yields an object theory having explanatory or normative significance, the system—in addition to representing an aesthetic accomplishment in the sense of a conceptual systhesis—constitutes a contribution toward deliberate rational control of practical judgment and action. What is the situation, however, when limitations on the scope of interpretation are disclosed? What recourse is available in the face of the inevitable disclosure of the incompleteness of the system? Conventionally, it is only by withdrawal from formalized operations, by renewed engagement in covert creative processes of trial interaction and intuitive judgment, that an alternative system can emerge as a next-generation formalization, bearing a new claim to represent a general schema systematically interpretable in experience. The status of the novel philosophical system will depend directly on its serviceability as a synthesis, i.e., on the range of its generalizations, on the coherence of its organization of interdependent commitments, on the extent to which it simultaneously satisfies a veritable battery of formal, factual, and valuative criteria of admissibility. These requirements indicate the great disparity between the respective functions of philosophical systems as against the formal systems typical of logic and mathematics. In purely formal-analytic construction, the aim may legitimately be limited to the attainment of internally consistent, abstract systems of independent commitments that need only be productive of significant demonstrable consequences. Neither this aim nor the larger aim of successive embedment of abstract systems suffers seriously from a procedural isolation of the process of formalization from its creative source in informal-intuitive conceptions. Any such decoupling of the iterative phases of intuition and formalization in philosophical construction, however, has the gravest consequences. Just so long a incompatible metaphorical bases, thematic orientations, readings of problematic situations and opportunities, programmatic aims and criteria of performance remain unattended and unrecounted in systematic philosophy, the ensuing constructions must remain radically individualistic in character and resistant if not disruptive of concerted disciplinary advance.

Strong interdependence among the components of a philosophical system—an almost organismic refinement of coordination—is a demand inherent in the function of such a system. No broadly acceptable rudimentary structure open to sustained, cooperative efforts toward improvement can be envisaged, it seems, except by way of explicit elucidation of "managerial" control principles and strategies for philosophical construction, that is, by way of programming the construction process itself—so far as that may be possible. To this end we begin by proposing in advance of substantive philosophical commitments an explicit set of supradirectives. These correspond to the type of entrepreneurial directives that have served heretofore (sometimes without conscious awareness of the investigator) only as ambiguous, sub rosa constraints on the conceptual "operations" of philosophy proper, viz., the positing of formally primitive commitments.

Entrepreneurial Policy-Commitments as Prolegomena

The supradirectives of concern here are those that, however informal they may be, in fact dictate the choice of strategy, program, and performance criteria for the enterprise of systematic philosophy.

Strategy. We shall make a deliberate attempt—from the beginning—to control the design of a philosophical system so as to ensure that formal primitive commitments are made in consonance with the nature of the cognitive agent in situ and in actu. Specifically, we attempt to ensure that the system will be (1) functional in terms of characteristic needs for reflective-rational control of cognitive decision and (2) relevant over the total range of decision processes: (a) the biological-psychological-social matrix of conceptualization and symbolization, (b) the hierarchical array of operational-programmatic-organizational decision making, (c) the aesthetic-creative-control component processes in cognition, (d) the meliorative (problem solving) and conative (goal seeking) modes of rational behavior.

Of the essence in this strategy is avoidance of the parochialism and the reductionist perspective scathingly attributed to "armchair" philosophy by W. M. Dixon in The Human Situation [3]:

> I find myself in great astonishment at the remoteness of philosophers from the world in which they live. One wishes they would thumb the leaves of the historical record before they constructed their admirable theories. They should, after the manner of the artists, have made some preliminary studies. They should have cultivated the acquaintance of plotters and revolutionaries, of angry souls in underground dwellings. They would write more convincingly if they had consorted, even in imagination, with cave-dwellers and lake-dwellers and tree-dwellers, talked with buffoons and mountebanks and charlatans...as well as with priests, prophets and professors. They might have

learned something from the cynics as well as the logicians, from Vikings as well as Christians, [from stark men, berserker fighters quicker with a blow than a word....]

What have Hegel or Kant to say of such people, or the structure of their minds?

We shall do well to follow the advice implicit in this passage, to begin by attempting to bring into view the whole context of the cognitive enterprise and the complex capacities of the whole man. The chapters immediately following may, indeed, be regarded as just those "preliminary studies" recommended by Dixon above.

Immediate Program. Chapter 7, The Cognitive Agent in Situ, deals with the domain of adaptive systems as an evolutionary context. With the realization that inquiry itself constitutes an adaptive decision process aimed at systematic control and consistent improvement of behavioral programming for operational (action) decisions, the following thesis is posed: that decision systems in general are inherently embedded in a complex of interconnections characterized by a tri-level minimal configuration. Meaningful consideration of any decision system of reference presupposes, in addition, recognition of some ecological supersystem as well as some collection of organizational subsystems. The implication is, further, that decision at any particular level of organization must be construed as sensitive to information-control relationships that extend throughout an indefinite hierarchy of systems. Though our ultimate concern is for the decision process at the cognitive level, involving human beings organized in social-cultural institutions, an intervening methodological problem confronts us in the inescapable intimation that our interest is sensitive to the effect of conformal processes extending possibly throughout the whole of a vast hierarchy of levels of organization.

The problem at this point becomes a matter of structuring the expanded domain of interest in terms of some relevant taxonomic scheme. Primitive notions for a taxonomy of adaptive systems are advanced for a cosmographic domain of systems generated by the process of natural selection, with this surprising preliminary result: the concept "adaptivity" is shown to be descriptive of a property common to viable systems in general and therefore incapable of providing any major "phyletic" distinctions. In the process, however, the connotations of two fruitful concepts are clarified: (1) emergence, and (2) systemic complexity. Rough measures of systemic complexity are then employed to order emergent systems (all of which are, of course, adaptive systems) within a total domain that is everywhere conformal with respect to the utilization of selective-adaptive control processes for the maintenance of viable organization.

As a comparison-piece to this global description of situation, Chapter 8, The Cognitive Agent in Actu, concentrates on the activities characterizing the cognitive-semiotic capability. The universe of discourse and inquiry is identified with the total domain of phenomena associated with conceptual objectification, where this capacity is construed in terms of a unique modality of adaptation and the proliferation of one particular line of development in the evolution of behavior. Major suppositions posit (1) an evolutionary paradigm holding thoroughout four embedded regions (geosphere, biosphere, sociosphere, and noosphere) and entail (2) the conclusion that interdependent biophysical and cultural aspects of evolutionary process are necessary to an understanding of conceptual objectification and cognitive control. Successive historic modifications of accepted regimens of rational thought provide clues to identification of criteria of optimal cognitive organization and characterization of the optimization process in terms of extremalization of semiotic freedom and cybernetic "elegance" in systemic control. The line of advance in scientific method is suggestive of possibilities regarding contemporary modifications leading to the emergence of a normative rational prototype.

In contrast with various historic characterizations of the cognitive agent (alternatively based on idealism, rationalism, radical empiricism mechanism, naive sensationism, physiological behaviorism) Chapter 9, The Finite Cognitive Agent, poses the cognitive agent as a "constructivist," operating formatively and creatively, within inherent limitations, on a flux of physical perturbations associated with a universal nexus of elemental interactions. Necessary, sufficient, and minimally sufficient characteristics of the cognitive agent are outlined. The import of our entire set of preliminary studies is then derived from implications of the status of the cognitive agent as a finite system (i.e., a system with finite lifetime, finite memory store, finite set of control states, finite-rate cybernetic processes via finite linguistic sequences and discrete symbolic structures as cognitive models). In contrast with the latitude allowed by the vagueness of sub rosa commitments in traditional systematics, these implication have the effect of sharply restraining previous excesses of confidence in "limitless" capabilities of human reasoning. In every instance they constitute constraints as to what realistic extent we may assign to cognition a capability for coherent organization of the universe of experience and discourse. Collectively, these implications lead to choices of commitments construed as formal primitive assertions characteristic of the only type of philosophical system that lies within the competence of cognitive agents so constituted as in our preliminary studies.

Long Range Program. In view of the limited competency of the finite cognitive agent, our program will be shaped by (1) a clear recognition of the provisional character of any philosophical construction whatever, coupled with (2) the realization that—on this view of the inaccessibility of absolute foundations for inquiry—the legitimate and realistic objective must necessarily be the attainment of a self-correcting and self-amplifying process of iterative modification. The reduced ambition of such a program requires only that successive reconstructions shall exhibit a coherent trend toward stability with respect to explicit test procedures and criteria of performance.

The construction of an innovative philosophical position is analogous to the injection of new procedural standards in inquiry. It is only on the basis of an existing formulation that activities and outcomes admit of insight regarding the institution of improvements. The presumptions of existing formulations are clear, but also clearly inescapable, in the ordinary language, the contemporary technical concepts and scientific conclusions that we must utilize as determinants in the choice of philosophical primitives which are then to have controlling force. There is an unavoidable circularity in this, as witnessed by the fact that one principal service of a philosophical system--the institution of increasingly adequate control for the cognitive process, the "rationalization" of this process—is directly affected by the initial informal characterization of cognitive agent and cognitive process. Yet how else can fruitful innovations be generated except by initial suppositions reflected in this essential characterization? Control principles must always be cogently designed to meet explicit requirements of the process to be controlled.

That this type of circularity does not lead to vacuous reinforcement of suppositions can be established only on evidence for corrective and amplifying effects via iteration, that is, evidence for correspondence (as against equivalence) relations between suppositions and conclusions which admit of theoretical "gain" with regard to a converging trend in successive modifications. In his Logic: The Theory of Inquiry, John Dewey [4] argues in justification of such a "bootstrap" operation, maintaining that inquiry must develop, in progress, innovations which the outcome of further inquiry may vindicate as standards. His assertion is that there is no single instance of improvements on scientific methods not attributable to the self-corrective aspect of inquiry; his thesis is that standards are never ab extra.

While our aim is establishment of formalized metacommitments which will purport to control the admissibility of theories constructed at the object level, it is necessary to initiate our iterative process by employing (prior to justification) a provisional set of object concepts and object theories—with the proviso that the metatheoretical structure must ultimately be shown to admit the initiating object constructs as consequents. During the preparation of this work, the authors have moved through several such iterations, in a sense recapitulating historical modifications of inquiry. We shall consider here only the latest cycle (initiating object theory—emergent metatheory—revisionary object theory) with the aim of exhibiting evidence for convergence. Satisfaction of this criterion cannot be taken to indicate that the resulting system is immutable but, rather, that continuing iteration can be expected to progress under a slower rate of "mutation," the existing structure being consistent and stable with respect to the preponderance of its characteristics over at least a few cycles.

Performance-Criteria. It has appeared to some men of sober judgment that systematic philosophy is never to be free of the interminable irresolution produced by sheer temperamental adherence to one or another of its many conflicting systems. Resignation before irreconcilable differences, acceptance of a final division between basic human interests expressed in worldly v. other-worldly orientations, for example, has the ring of soundness in Herbert Feigl's [5] account:

> Profound differences in personality and temperament express themselves in the ever changing forms these two kinds of outlook assume. Very likely there is here an irreconcilable divergence. It goes deeper than disagreement in doctrine; at bottom it is a difference in basic aim and interest.
>
> The tough-minded and the tender-minded, as William James described them so brilliantly, are perennial types, perennially antagonistic. There will always be those who find this world of ours, as cruel and deplorable as it may be in some respects, an exciting, fascinating place to live in, to explore, to adjust to, and to improve. And there will always be those who look upon the universe of nature and experience as an unimportant or secondary thing in comparison with something more fundamental and more significant.

Yet an alternative view is at least equally plausible: (1) that the interests of every serious and persistent thinker range in fact across the domains of the real and the ideal, the factual and the valuative, separately featured above; (2) that the expression of balanced interests is impeded by the necessity to master difficult shifts in emphasis—between rigor v. comprehensiveness, between the way things are v. the rationale of their becoming, between positive knowledge v. commitments vindicable only under uncertainty, between tactical effectiveness v. strategic viability—but (3) that any typological splitting of the human personality (as above) amounts simply to misconstruction of the underlying problem: that we have as yet no criteria of performance adequate to direct a sustained sequence of improvements in all that we would wish to accomplish by the construction of philosophical systems.

This issue need not be resolved here and now, however. Whether the enterprise of systematic philosophy—the attempt to organize thought so as to ensure warrantable judgments in all of human affairs—is one, or two, or many enterprises at once, the role of performance-criteria is central to success. Where no reference can be taken to intermedidate measures of effectiveness, no goal-oriented direction can be defined and no outcome of process can be construed as "progress." To a large extent it is this anticipation of the need for interim guidance-control that has shaped our version of philosophic method, viz., a two-stage, iterative process of successive refinement in construction of (1) a fundamental scheme of ideas and (2) an attending collection of metacontrol principles laying down conditions of legitimate theorizing in these terms. The practical necessity is for interim evaluations of the conceptual elements-in-relation that are in service provisionally as a systems-theoretic schema—a synoptic paradigm—for general use in (1) observation and analysis and (2) subsequent theory-constructions variously aimed at characterization, representation, prediction, explanation, and control of experience.

For guidance of this process of trial-rejection-reformulation we shall invoke the use of tests sensitive to the following criteria:

(1) generality, i.e., the extent to which interpretability of the schema holds comprehensively over the range of interests consonant with the subject matter of formal, objective, and normative disciplines;

(2) serviceability, i.e., the measure of applicability and adequacy in resolution of previously obstructive problematic situations, a measure as well of the "theory-potential" of purported primitives with regard to amenability to precise linguistic, logical, and mathematical development;

(3) cybernetic elegance, i.e., contribution to coherent systematization of metatheoretical control tending toward unification of previously compartmented theoretical structures in existing special disciplines; and

(4) warrantability, i.e., evidence of convergence toward a stable and durable format under confrontation by continuing tests for formal, empirical, pragmatic, aesthetic, and evolutionary aspects of optimally adaptive cognitive organization.

Finally, in provision of an encompassing test, we shall institute the concept of "reflexive correspondence" as a categorical criterion of admissible systematic construction. We shall insist that philosophical commitments must entail a cognitive theory that is capable of adequate characterization and advancing insight into the very activity of philosophical construction itself. This rather extreme requirement is perhaps most readily understood by reference to the most frequent deficiency of traditional systematics, viz., the general inability, in terms of a given epistemological theory, to provide any adequate account of the activitity of the cognitive agent-as-theorizer in formulating the given philosophical position.

The evolutionary cast of our whole approach is brought to the fore in this criterion. A demand for correspondence of this reflexive type evokes a notion of the evolutionary process—the cognitive-cultural version of that process, at least—as <u>inturning</u> upon itself with a corrective and amplifying effect that we shall term "maximal realization." That this notion is something more than a phantasm (which it may admittedly seem to be on first encounter) can be established only by subsequent development of a well-defined measure of "realization" in three senses of the term: (1) adjustment to reality, (2) gainful advantage in transactions, and (3) actualization of the action-potential inherent in a given system configuration. For the present we must rest on the bare assertion that this concept will have a fundamental role in the philosophical position we shall designate as "evolutionary realizationism" and that our principal cosmological posit—if we were disposed to undertake such a rarefied exercise—would superpose the following law-like regimen on the whole of nature: that "what goes on" there consists in transactions among individual systems subject to maximization of their characteristic measures of "self"-realization, the outcome of this selective process constituting an <u>evolution</u> of the organizational formats realizable by viable systems.

Chapter 7

THE COGNITIVE AGENT *IN SITU*: EVOLUTIONARY PARADIGM

INTRODUCTION

The considerations presented in this chapter ultimately concern the problem of attaining a comprehensive structuring of the domain of research areas comprising behavioral* inquiry. The propriety of generating such a project initially from the perspective of the particular interests of management science might, of course, appear to be immediately questionable. In anticipating such an objection, we would maintain that management science--insofar as it is construed as a rational activity that purports to provide resources for improving the decisions of a client organization--must encounter the acute problems of its companion behavioral sciences with respect to the analysis of systems, as well as certain particularly difficult problems unique to its own special province.

As a justification of the approach being taken, we are concerned with pointing out the origins of our interest in a taxonomy of adaptive systems, first, with respect to the unique province of management science and, second, with respect to the broader area of behavioral inquiry in general.

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*We must immediately disclaim any interpretation of "behavioral inquiry" that would identify our use of the term with the abortive attempt of the Chicago school of behaviorists (Watson, Hoisington, Dashiell, et al., 1910-1930) to carry out a radical reduction of psychological phenomena on a rudimentary mechanistic basis. "Behavioral inquiry" is intended in general reference to the acceptance of a fundamental modification of the earliest directive of inquiry. Under this modification the question: How does this system characteristically interact with other systems comprising its environment? replaces the venerable but apparently abortive question: What really is the essential nature of this thing? When, in the context of either formal or experimental investigation, this emphasis on dynamic interaction is coupled with the notion of modifiable characteristic response via internal system controls, the result is behavioral inquiry.

Prospectus for Management Science

It is presumably the decision-oriented character of management science that accounts for impending difficulties peculiar to its specialized problems. At least three primary domains of decision necessarily confront any client: (1) action, (2) policy, and (3) organization. Any attempt to provide operations research with resources for resolution of problems in all these domains (some of which are obviously quite intractable in the present state of the profession) must accept the challenge inherent in an escalade of increasingly complex theoretical projects: (a) theory of decision, (b) theory of value, and (c) theory of selective systems, i.e., a theory of organization in general. Further, the attainment of adequate comprehension of decision-valuation-organization processes collectively as determinants to behavior, and particularly the establishment of criteria for "improved" decisions, will require methodological developments that will be reflexively relevant to the human activity of theorizing *per se* as a metadecision process. Such a line of investigation can therefore not be terminated short of a theory of cognition.

Under a research prospectus very similar to that just ascribed to the management-science profession, we have recently been engaged in an attempt to develop one component of a theory of the cognitive process: a theory of cognitive controls associated not only with rationality but with evolutionary viability as well. These investigations[1] have necessitated a transformation of scientific method into a more general complementary-conformal method. Such a transformation is required for the incorporation of valuation (prescription) with knowledge (prediction) under rational control. Because of the conformal nature of the method the convergence of many specialized disciplines under a single methodological structure is indicated, and this intimation has become a focus of research activity.

An Iterative Process of Inquiry

As a consequence of this development, we have become involved in an iterative process of inquiry. Beginning with an intuitive notion of practical decision systems (the ordinary context of corporate decision making), it was immediately recognized that valuation, as a determinant to decision, necessarily entails a difficult methodological problem. If decision systems, with their concomitant value concerns, are to be placed at the center of interest in the domain of operations research, what mode of inquiry may be taken as appropriate and adequate for a rational treatment of the perennial difficulties that have characterized value judgment? It is this question, of course, that inevitably forces a rudimentary science of management into an unfamiliar region of metascientific issues and problems.

With the expectation that some modification of the presently accepted pattern of scientific inquiry would constitute a prerequisite to adequate rational control of value judgments, an examination of successive historic modifications of both scientific and axiological modes of inquiry was undertaken. The gratifying result[1] was the realization that (a) the "conceptual" mode of inquiry--developed during recent decades in the course of a revolution in modern physics--was open to reconstruction as a formal <u>dual</u> and (b) under exploitation of a resultant complementarity there emerged, in addition to the predictive format of scientific inquiry, a prescriptive format directly applicable to value inquiry. Thus the way appeared to be open for the establishment of a rational process for the control of valuation, and hence for the development of general theories of value and decision.

However, in subsequent attempts to work out the details of a rationale for prescription--a formal basis for the selection and institution of values and norms for a decision system as a subject or idiosystem*--two imposing obstructions were encountered. First, complications were injected by the realization that the cognitive process comprises not only the control process that was our initial concern, but also an aesthetic process and, even more important, a creative process--both of which entail considerations relevant to a theory of knowledge as well. The creative process (later referred to as objectification**) has been found to have a particularly crucial import. Second, the establishment of a prescriptive format for rational control of valuation, which involves the adoption of the perspective of an idiosystem (a decision system as subject rather than as object), was impeded by the observation that any such system is inherently

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*A difficult problem in the selection of terminology is associated with the use of "idiosystem" as synonymous with "system-as-a-subject." The term "self-system," which would seem to apply very naturally here, must be avoided because it is irretrievably loaded with connotations involving human consciousness. Every cognitive, human self-system is an idiosystem, of course, but in the sense that there are nonhuman systems that are subjects, meaning that they externalize (objectify) "other" systems as objects, the concept "idiosystem" must not be restricted in interpretation to specifically human self-systems.

**Objectification refers to the process of conceptualization, the modus operandi of cognition. As an extension of the more familiar notions of modeling or theorizing, its specific content is perhaps best revealed by the definition of an objectifying statement: a statement, generated by a creative process in an emergent event or act of insight and selected by policy as a basis for inquiry, that externalizes (institutes) a class of related constructs (objects) and provides a prescription whereby these constructs are meaningful and interpretable in terms of finite observations. Examples are (a) Newton's laws of motion and (b) theSchrodinger wave equation. Analogs of objectification in systems less complex than cognitive systems may be identified with the processes of concept attainment, conditioned response, perceptual judgment, reflex extrapolation, and threshold discrimination.

embedded in a hierarchy of interconnected systems characterized by a triadic unit configuration. That is, every idiosystem presupposes* the existence of some supersystem in addition to some collection of subsystems, with the extension of this configuration providing an indefinitely extended hierarchy. Considering the human individual as a reference system, for example, it is surely truistic to observe that the decisions of such an idiosystem are invariably embedded in some context selected from among many complex institutional systems -- social, professional, political, religious, and national entities at many levels of organization -- and finally perhaps in highly generalized cognitive and cultural systems that are as extensive in scope as the widest reaches theory and history will allow. Similarly, the human individual is necessarily connected intimately with a cascade of organic subsystems: neural, muscular, glandular, cellular, and finally even molecular in character.

The complication that enters with this realization concerns the possibility that analogs of the creative, aesthetic, and control processes first identified at the level of cognitive decision systems may now be consistently construed as operative at many levels in hierarchies characterized by increasing systemic complexity. As an additional complication, each subsystem

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*This shift from the mere observation that decision systems are characteristically embedded in hierarchies to the stronger claim that every idiosystem presupposes a hierarchical configuration is admittedly very abrupt. The justification of such a shift depends on primitive commitments that have been elucidated elsewhere.[2]

(or supersystem) in the hierarchy associated with a particular idiosystem must be conceived as capable of contributing to any decision process by which a unique line of behavior is ultimately selected. Meaningful consideration of a decision system as a subject must therefore take place in the context of the prototype configurations encircled in Fig. 1a. At least three hierarchical levels, as indicated in Fig. 1b, are necessarily involved in representing the pattern of communication and control that affects decision at the level of an idiosystem.

As indicated in Fig. 2 the operation of decision systems at any level of the hierarchy may be analyzed in terms of comparisons of extrospection (filtered input) with norms that instigate a problematic situation (selected via an aesthetic process) to be resolved by a decision procedure involving objectification (or an analog of this creative process) and selection among objectifications (or an analog of this control process). The extrospection of any system consists of information input from its subsystems; the decision of any system consists in the exertion of control on the norms of its subsystems. In view of this characteristic regenerative communication-control linkage, the effective hierarchy involved in any decision of an idiosystem may be much more extensive than the triadic configuration (subsystem, idiosystem, supersystem) described as a sine qua non of systems analysis. The diagram of Fig. 2, essentially a model of a cognitive decision system (e.g., a human decision maker), indicates this fact by suggesting the presence of an indefinite number of intermediate systemic levels interposed between the cognitive level of organization and the atomic level of sensory-motor transducers. It is important to note that we propose to consider decision at every systemic level as accomplished within an organizational

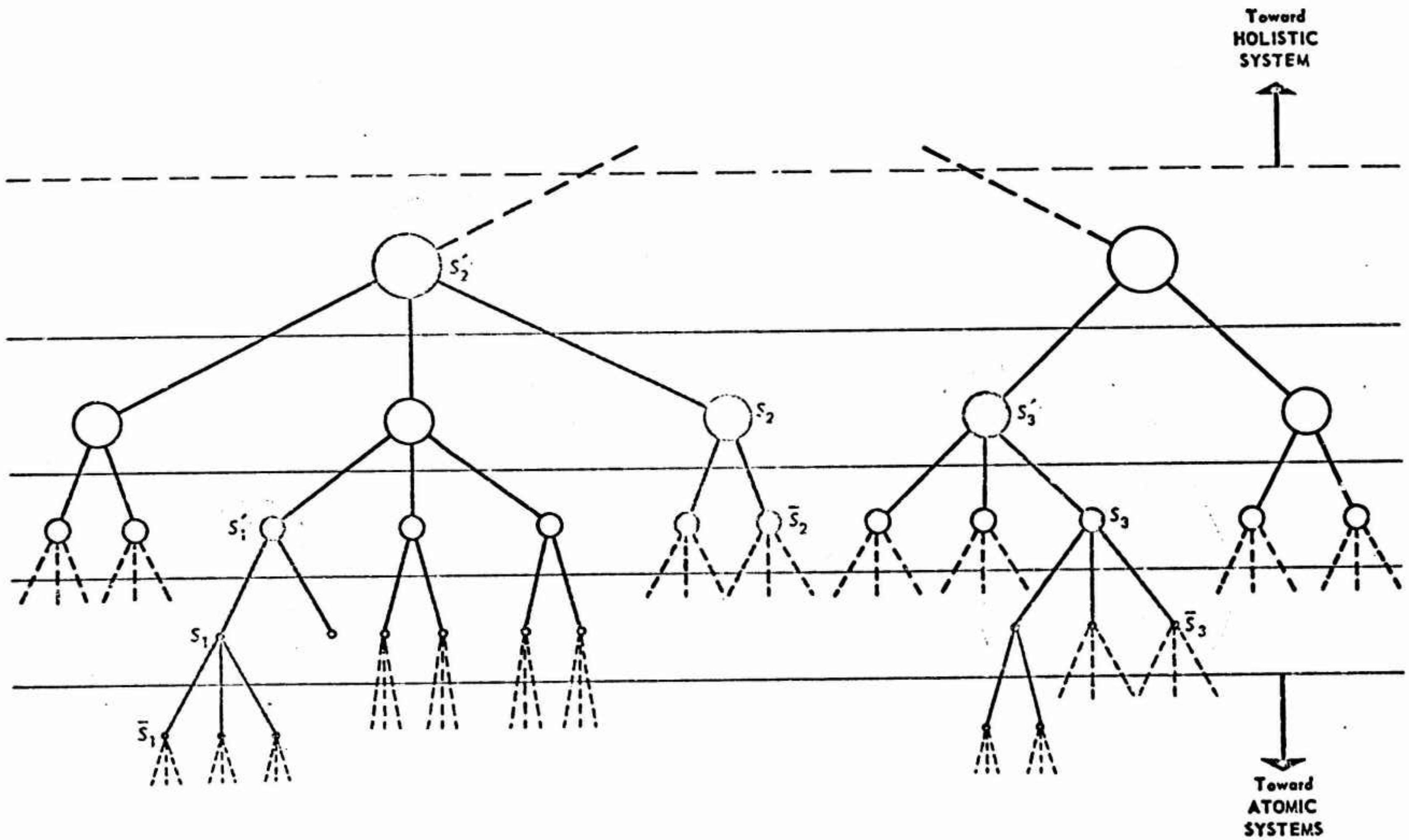


Fig. 1a—Hierarchy of Decision Systems

Prototype triadic configurations.

S_i, an idiosystem of interest at some level in the hierarchy; $\bar{S}_i$, the collection of subsystems of S_i; and S_i', the supersystem of which S_i is an element or subsystem.

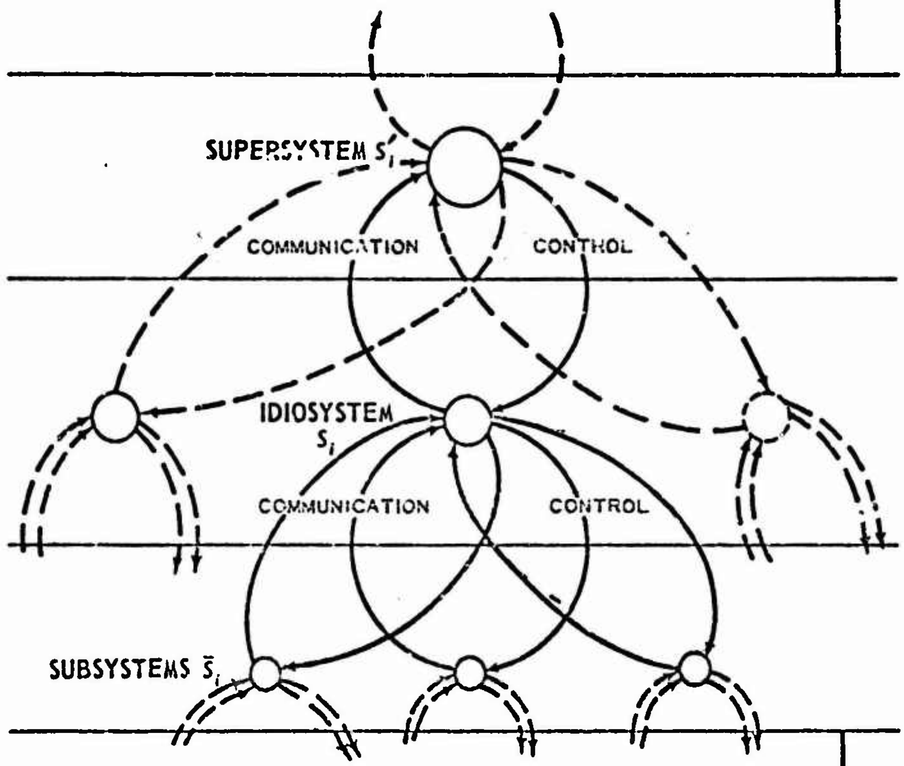
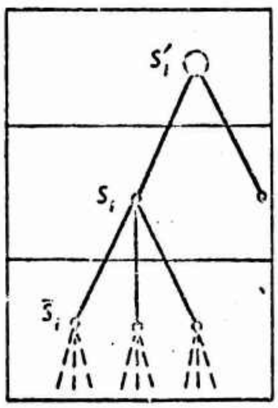


Fig. 1b—Detail of Hierarchy of Decision Systems Showing Idiosystem Communication Control

Schematic regenerative circuits.



Prototype triodic configuration.

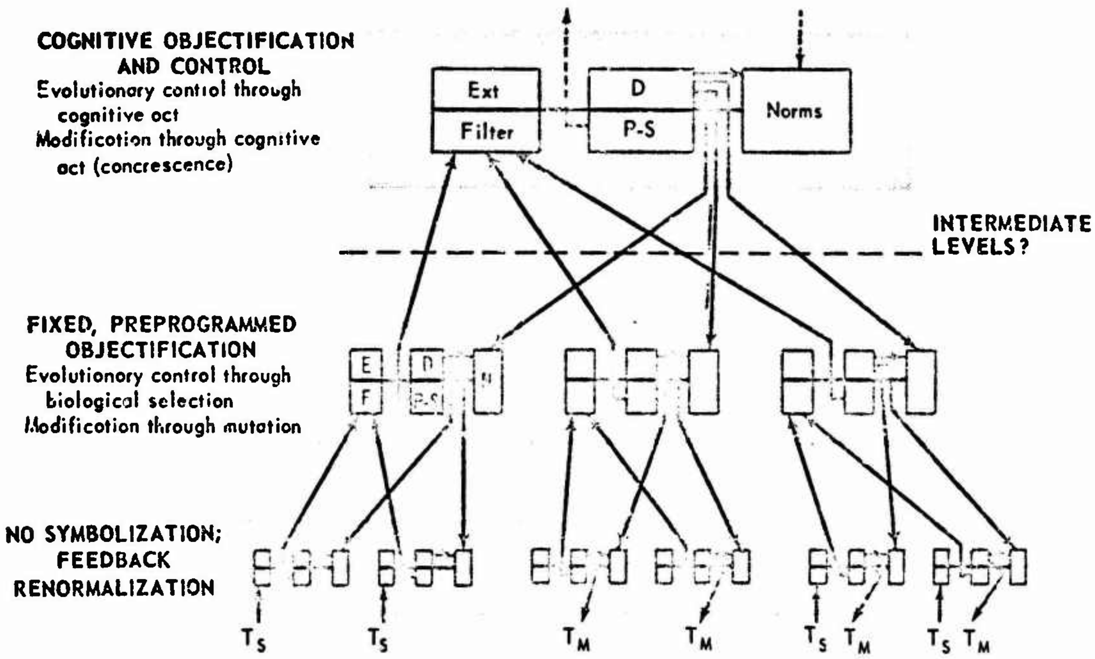


Fig. 2—Objectification and Control in Cognitive Decision System
Ext, extrospection or filtered input; D, decision; P-S, problematic situation; T_S, sensory transducer; T_M, motor transducer.

format that is conformal with the pattern of objectification and selection noted at the cognitive level. There are, however, crucial distinctions between decision processes at various levels depending on systemic complexity and hence on distinct capabilities for objectification. The disparity of operational means that may be brought to bear in order to effect selection or decision is suggested in Fig. 2 by the distinctions between (a) feedback renormalization, (b) preprogrammed objectification, and (c) objectification as a creative, cognitive act of conceptualization.

As an immediate effect of this realization of hierarchical orders of systemic complexity, the domain of interest for this line of research becomes drastically enlarged. Whereas we have previously been concerned primarily with the decision process at the cognitive level involving human beings organized in a corporate enterprise, the researcher--on the basis of theorizing in this vein--is now confronted with an inescapable intimation of conformal processes extending possibly throughout a vast hierarchy of levels of organization, both in the direction of increasingly comprehensive supersystems and in the direction of more restricted subsystems.

The problem at this point becomes a matter of structuring the expanded domain of interest in order that strategic choices may be made as to the priority of classes of systems to be investigated in detail. No clearer demand for a relevant taxonomy could possibly be made. Such a demand initiates the second generation of the iterative process of inquiry previously referred to.

Under a poorly structured initial conception of the domain of interest for operations research -- with the advantages of certain methodological developments-- the construction of theories of decision, valuation, organization, and cognition began. The progress of such an investigation leads, as has been indicated, to an enlarged problematic situation featuring inputed interconnections involving systems at many more levels than the original domain of interest explicitly provided. The appropriate next step is therefore obviously reiteration.

Beginning anew with the project of taxonomizing the presently recognized domain of interest, encountering, no doubt, additional methodological problems, one may hope to find new clues to a consequent theoretical reconstuction. The indefinite prolongation of such an iterative process, achieving at each cycle a reconstruction or refinement of theory, is of course a well-recognized characteristic of the intellectual enterprise in general. It is our interest in thus reemphasizing the very rudiments of inquiry to contribute toward the alignment of systems analysis with a more fully articulated conception of its domain of phenomena and its basic mission.

In particular it is hoped that a delineation of the special role of the prescriptive sciences in the attempt to achieve unified theory covering decision, valuation, and organization will contribute ultimately to a successful resolution of the separations between knowledge, value, and action that have plagued earlier attempts to institute rational control of behavior.

BEHAVIORAL INQUIRY--PERSPECTIVE OF SYSTEMS ANALYSIS

Although we have encountered the problem of systems taxonomy initially from the perspective of the unique province of the prescriptive sciences, it seems quite apparent that the behavioral sciences in general now tend to converge on an identical concern. Despite the diversity of their particular objectives the several divisions of behavioral inquiry commonly share an attenuated version of the situation ascribed to management science: they are all similarly embroiled in metascientific problems both conceptual and methodological in character. This situation results from the fact that a fundamental directive of rational inquiry--the continuing drive toward comprehensiveness--has carried contemporary investigations beyond the limited scope of an earlier scientific preoccupation with deterministic physical systems, i.e., any system whose successive states may be adequately construed (for predictive purposes) as uniquely determined by observable measures of its present state and the state of its environment.

With the rise to prominence of the social and life sciences, behavioral inquiry* has gradually been brought to a focus on the conception of a type of organization or system singularly in contrast with the reductionistic mechanical systems of classical physical inquiry.

New Order of Theoretical Difficulty

The increase in complexity that distinguishes behavioral systems from the simplistic interaction systems of physics has forced behavioral investigators to conceptualize sophisticated systems characteristics--e.g., selectivity, ultrastability, learning, and simulation--which, though doubtless related to the elemental concept of dynamic mechanical stability, engender a totally new order of theoretical difficulty.

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*The contention here is that, from its twentieth-century origins in the rankest sort of reductionism, behaviorism has gradually been modified (by such efforts as those of Dewey, Mead, Tolman, Cassirer, et al.) to the extent that it now provides the general support for a tremendous range of inquiry, extending at least from the investigation of simple homeostatic machine systems to the investigation of highly complex social organizations.

Morris[3] has presented the following outline of the early development in psychology of the concept "attention" that illustrates one aspect of the systems characteristic referred to as selectivity.

> The emphasis upon action implicit in the growth of modern biological science had taken at times an abortive form, as if an organism merely responded mechanically to an environment which itself owed nothing to the organism. Such a position could not long stand in the face of the facts which crystallized in voluntarism as a biological and psychological principle. For American thought, William James had marked the emphasis in pointing out the insurgent character of the organism and the way attention helped to constitute the object of perception. Dewey had isolated the basic point in his 1896 article on "The Reflex Arc Concept in Psychology": perturbations of environment actually constitute a stimulus to an organism only in virtue of the implicit response or interest which sensitizes the organism to selected features of the world capable of furthering the release of the response itself.

McDougall,[4] although he did not use the concept ultrastability explicitly, provided an excellent illustration of this construct in describing the type of behavior he considered to be most characteristic of the living organism.

> Take a billiardball from the pocket and place it upon the table. It remains at rest, and would continue to remain so for an indefinitely long time, if no forces were applied to it. Push it in any direction, and its movement in that direction persists until its momentum is exhausted, or until it is deflected by the resistance of the cushion and follows a new path mechanically determined....Now contrast with this an instance of behavior. Take a timid animal such as a guinea-pig from its hole or nest, and put it upon the grass plot. Instead of remaining at rest, it runs back to its hole; push it in any other direction, and as soon as you withdraw your hand, it turns back towards itshole; place any obstacle in its way and it seeks to circumvent or surmount it, restlessly persisting until it achieves its end or until its energy is exhausted.

In his description of the type problem of the kitten and the fire, Ashby[5] has clearly delineated that feature of heuristic modification of characteristic response known as learning.

> When the kitten first approaches an open fire, it may paw at the fire as if at a mouse, or it may attempt to sniff at the fire, or it may walk unconcernedly onto it. Every one of these actions is liable to lead to the animal's being burned. Equally, the kitten, if it is cold, may sit far from the fire and thus stay cold....Contrast this behavior with that of the kitten after considerable experience: on a cold day it approaches

the fire to a distance adjusted so that its skin temperature is neither too hot nor too cold. If the fire burns fiercer, the kitten will move away....If the fire burns low, the kitten will move nearer....Without making any inquiry at this stage into what has happened to the kitten's brain, we can at least say that whereas at first the kitten's behavior was not homeostatic for skin temperature, it has now become so. [We are concerned chiefly with one feature of this typical modification of behavior: learning involves the change of a behavioral repertoire from a less to a more beneficial characteristic pattern.]

Finally, in illustration of the concept simulation, it is possible to concoct an instance of the elementary employment of the peculiarly human capacity for "mediated" behavior that John Dewey was among the first to emphasize. Suppose that in the absence of any present necessity to act, a war party of primitive men succeed in formulating--by means of significant gestures and crude diagrams drawn in the dirt--a plan for a forthcoming attack. Such selection of behavior, mediated by a symbolic "mapping" technique in the context of a reduction, constitutes the essential feature of cognitive behavior which, by the formalization of languages and other semiotic structures, may be extended into the general enterprise of inquiry for the purpose of behavioral control.

Systems that are characterized, then, by patterns of response that are modifiable via processes involving selectivity, ultrastability, learning, or simulation--that is to say, systems that are adaptive in a very sophisticated sense--exhibit such variable activity that they have proved to be generally intractable to investigation under the traditional format of causal determinism. Yet the objectives of inquiry--prediction, explanation, prescription, manipulation--remain to be served no less in the biological and social sciences than in chemistry and physics, the areas of earlier success. The strategy of behavioral inquiry in the twentieth century has therefore understandably consisted in a tendency to accede more and more to the notion that a deterministic basis for explanation (or theory) is essentially inadequate in the study of purposive behavior.

The initial effect of this shift in strategy has been primarily methodological. The development and utilization of stochastic (as against deterministic) models is generally interpreted merely as an attempt to apply probabilistic logic and statistical inference to the analysis of complex systems. Another interpretation of perhaps greater significance, however, and one quite insufficiently recognized at present, follows from the inexplicit conceptual commitment involved in adopting the stochastic format. In any use of a stochastic model a characteristic activity that consists essentially in the generation of a line of behavior via a selection process may be covertly attributed to the system in question. Here "line of behavior" is understood as a particular path through the array of states possible to the system, and "selection" is interpreted in the elementary sense of a resolution of alternatives, by any means whatever, at successive choice points in the phase space and temporal history of such a system. In this light, additional significance must be attached to the utilization of stochastic models insofar as they constitute support for any sub rosa imputation of internal components of systems control that are presumed to be characteristic of instrumental and functional aspects of organization.

Convergence of the Behavioral Sciences

Arising nearly simultaneously in many specialized divisions of research, the conceptualization of adaptive control processes has apparently been an important feature of the decided tendency toward convergence that is now seen to involve the information sciences (cybernetics), experimental life sciences, social sciences, and, as we would maintain, the management sciences. However hazily it may as yet have been conceived, a unitary domain of interest for the whole of behavioral inquiry is apparently emerging, and this domain so far appears to comprise just the range of adaptive systems, in which internal or "idio" - control is conceived as contributing strongly to the collective determinants of behavior. (It is, quite naturally, just this aspect of internal control that is ultimately utilized to distinguish between systems that exhibit behavior and those that exhibit mere interaction.)

Terms variously used to identify general classes of such systems seem to abound in wild profusion. In the field of value theory, Pepper[6] proposes the term "selective" systems; in experimental psychology Tolman[7] has featured the notion of "purposive" systems; in cybernetics Wiener[8] referred to "communications-control" systems; in brain simulation studies Ashby[5] elects to use the explicit term "adaptive" systems, a usage shared by Bellman[9] in decision theory, while in computer technology[10] the current coinage is "self-organizing" systems -- and this collection results from the most cursory sampling of nomenclature associated with what the researcher must suspect is a unifiable conceptual domain. Under a rubric of sufficient generality, it appears possible to assimilate a vast range of systems: (a) rudimentary quality-control devices, (b) servocontrolled guidance systems, (c) automated machine complexes, (d) programmed computers, (e) simple organisms, (f) "higher" organisms, even *Homo sapiens*, and (g) human social organizations.

This is the now familiar context of general systems theory. To whatever extent the general systems approach evokes credibility as a line of theoretical advance, one will be disposed toward an attempt to attain a taxonomy of adaptive systems. Such a conceptual task is a prerequisite to the maximum exploitation of intellectual resources, i.e., the reiteration of empirical and formal cycles of inquiry in a continuing refinement of theory. One caveat, however, is glaringly obvious. Any general taxonomic structure that purports to establish conformality among so many apparently disparate entities will be utterly worthless unless it also admits a meaningful distinctions that can be shown to correspond with the several specialized concepts presently being utilized fruitfully in systems analysis. The purpose of this study is to determine whether the concept adaptive system is capable of generating such a general taxonomy.

PRIMITIVE NOTIONS FOR A TAXONOMY OF ADAPTIVE SYSTEMS

To attempt to establish a taxonomy for a complex domain is to return to long-forsaken territory because the procedure of taxonomizing is first of all a complicated version of concept attainment and therefore involves the employment of skills that tend to lapse into disuse with the development of a familiar and habitual structuring of experience. The sophistication acquired in experience is, however, not devoid of advantage. In the sense that Goethe maintained that even an observation is already a theory, the observer is prepared by experience to recognize that the first structuring of a domain of interest--however crude--constitutes a preliminary theory about the objects of that domain. A fruitful taxonomy of adaptive systems may therefore be expected to progress through successively more rigorous versions characterized first by verbalizations, i.e., models couched in natural language, followed by more nearly operational models perhaps in the form of communication-control flow diagrams, ultimately terminating in acceptable formal or mathematical models. It is possible to anticipate the development of formal models in the case of adaptive systems all the more readily because of a cue that strongly suggests the selection of the concept "characteristic response" as a fundamental criterion of classification for adaptive systems. Since characteristic responses of instrumental systems are readily amenable to mathematical representation as formal transformations, we have some basis for beginning this particular taxonomic project with reasonable confidence.

However that may be, the first order of business is the utilization of a minimal* definition of "adaptive system" in order to distinguish all the systems that may be said to be adaptive and to collect them in a common set for the purpose of further structuring. We propose to adopt the following definition: a system is an adaptive system if and only if its behavior maintains its essential variables within the limits of their respective norms. Here "essential" variables are interpreted as those measures of an environment to which the survival of the system is sensitive. (It is important to note that adaptivity is therefore inherently relative to environment.)

This definition, without explicit mention of its relative character, is due to Ashby[5]; it is a generalization that is apparently in good correspondence with the concept "homeostasis" developed by Cannon[11] in physiology as well as the earlier concept of adaptation associated in evolutionary biology with modification contributing to survival under natural selection.

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*By "minimal definition" we refer to the member of a collection of alternative definitions (for a given term) that poses the least restrictive predicate and, hence, admits as members of the defined class all the entities admitted by the logical union of the collection.

With regard to a survey of systems in a search for those that are adaptive, there are two standard strategies: the simplistic and the generalistic--or in Bertrand Russell's pungent terms the "simple-minded" and the "muddle-headed." In this case the simplistic approach would consist in beginning with the most elemental system that could be legitimately conceived as adaptive and proceeding by successive complication to cover the whole range of adaptive systems. Conversely, the generalistic approach involves an initial coarse screening of all systems to locate those that are adaptive, with successive refinement of the classification process.

That the generalistic strategy should be our choice seems quite clear. On one count the conception of an adaptive system, construed in its simplest version as a negative regenerative system, is already receiving rigorous treatment by a large body of investigators. It is only reasonable to assay a complementary approach as a possibly fruitful alternative. Second, the avowed intention of this study is the attainment of comprehensiveness and very broad generality. We shall therefore initially screen a veritably cosmographic domain of systems, where our "cosmos" is, of course, the local universe of experience and discourse. A grasp of such a total domain of systems depends on a conception of the evolutionary process as the generator of systems of interest. That this format constitutes the presently appropriate context for a taxonomy of behavioral systems is strongly supported by Simpson,[12] who has reported the adoption of this identical basis for a recent symposium concerned with theories of behavior.

> ...It is so universally accepted as not to need explicit statement that...there is, indeed, a general theory of behavior and that the theory is evolution, to just the same extent and in almost exactly the same way in which evolution is the general theory of morphology. To make the relationship more obvious and to demonstrate that morphology, physiology and behavior are aspects of organisms all inseparably involved in and explained by the universal fact of evolution became a principal object of the symposium.

In order to emphasize the fact, however, that we are not dealing initially with the technical synthetic theory of evolution now available to the specialist, the common-sense notion of a <u>process of development</u> will be utilized as a covering term. On encountering specific features that are attributable to this process as a generator of the total domain of organization, we shall have occasion to institute a specific concept of the evolutionary process derived by refinement of the vague notion of development as it appears in the context of natural language.

<u>The Process of Development</u>

The process of development—ultimately evolution—is the conceptual product of a fabulous Gedanken-experiment in which some element of the human race has participated in every generation since the initiation of systematic inquiry. The laborious reconstruction of the history of the apparently ceaseless transforming activity of our local universe still absorbs the efforts of cosmologists, paleontologists, geologists, biologists, and lately even nuclear physicists. Our information is already detailed enough, however, so that we can readily imagine—as Julian Huxley has suggested—a stopped-frame motion picture of this transformation process that would reveal the successive appearance, development, and deployment of three primary classes of systems: (a) the collection of inorganic entities and

Table 1

DEVELOPMENT SUB SPECIE [illegible]

System	Referent	Domain
Inorganic	Physicochemical aggregations	Geosphere
Organic	Biological organisms	Biosphere
Conceptual	Psychosocial-symbolic organizations	Noosphere
Synthetic	Fabricated entities	Technosphere

aggregations and, superimposed on it, (b) the collection of biological organisms and organizations of organisms and, superimposed on both, (c) the collection of psychosocial or symbolic systems. These collections may be assigned respectively to three general domains with regard to the process of development. Following the usage of Père Teilhard de Chardin,[13] these domains are termed (Table 1) the "geosphere," the "biosphere," and the "noosphere."

Although the geosphere, biosphere, and noosphere constitute exhaustive ontological partitions with respect to a particular set of properties, the class of fabricated systems is appended in Table 1 to indicate that an alternative factorization exists that may ultimately require attention. Quite obviously it would be possible, if it were thought desirable, to distinguish between natural systems and <u>synthetic</u> systems, i.e., the domain of all structures, machines, and artifacts, fabricated or assembled by the agency of natural systems. This domain, in fact, lies at the center of interest for a number of investigators presently concerned with the design of machine systems that are adaptive--the entire spectrum of work on artificial intelligence and automata. Under the strategy of this particular inquiry, however, it becomes a straightforward decision to submerge this distinction. If a taxonomy of adaptive systems can be carried out in the most general terms, and if this project subsequently leads to increased capability for systems analysis, the project of systems simulation can be readily advanced in due course on the basis laid for theories of adaptive control processes.

Returning, then, to the preliminary classifications represented by the geosphere, the biosphere, and the noosphere, and attempting to encounter adaptive systems in their most general context, the primitive notions that have been advanced in the service of explaining the main features of the process of development are examined.

Figure 3 presents a crude rendering of an initial premise from thermodynamics that asserts the directivity of energy transactions for an effectively isolated total system in progress from an initial unstable dynamic state to an eventual state of static equilibrium via a degradation process involving entropic interactions destined, finally, to deplete the potential of the original state of the system. Superimposed on this premise in the life sciences is the posit of a process of development that features a converse effect consisting of a general increase of variety and organization with respect to metastable subsystems that appear by differentiation within the total system. In contrast with the total effect of energy transactions in the system as a whole, the interactions among such subsystems are characterized by strictly local negentropic effects.

Four primitive notions--partition, duplication, variation, and competition--are presupposed by the assumption concerning the increase of variety and organization with the appearance of stable subsystems. A

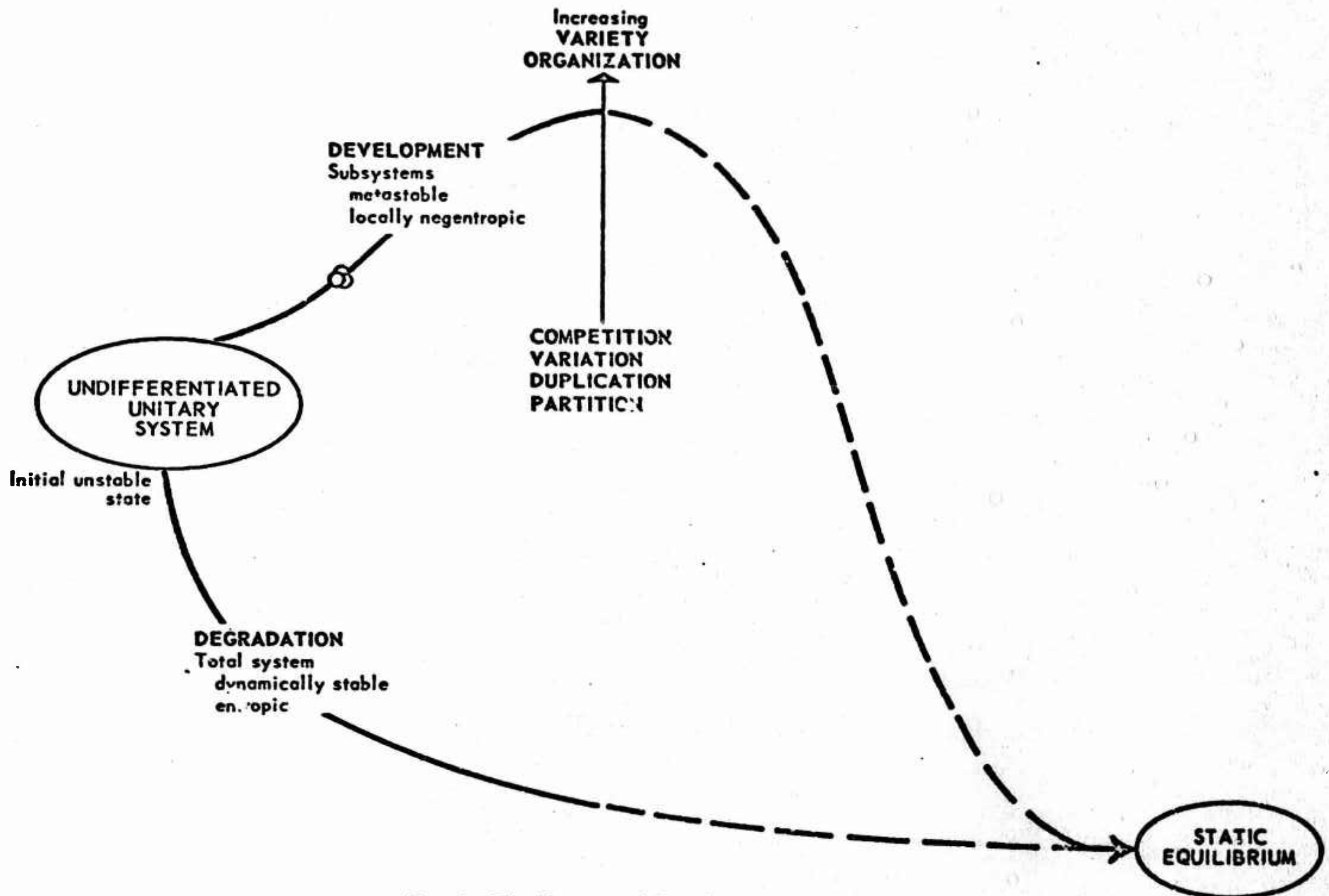

Fig. 3—The Process of Development

Subsystems could appear only by a process of partition occurring in the unitary system and could participate in negentropic reactions only within the confines of a barrier that permitted a metastable state to exist. Similarly a general increase of variety and organization among negentropic subsystems could not occur in the absence of the combined processes of duplication and variation. The primitive notion of competition is obviously no more than an assertion that the assumption of an isolated and finite character for the total system must impose on all subsystems the constraints of limited resources. An additional assumption concerning the consistent operation of the system, i.e., the constancy of physical laws controlling change in the system, is generally taken so much as a matter of course that it escapes mention.

It will be recognized immediately that these explicit commitments underlying the notion of a process of development appear to admit precisely the determinants of natural selection as enunciated in evolutionary biology. Under one specific set of interpretations they may indeed be placed in correspondence with the subprocesses of evolution--i.e., the specific formative processes whereby historic populations of organic systems are presumed to have been produced. For the purpose of this study, however, they are examined with a primary interest in attaining (1) a basis for comprehension of the "broadest" features of the complex transformations of biological organization and, if possible, (2) a unitary format for conceiving of transformations of organization <u>in general</u>.

Primitive Notions and the Process of Natural Selection

Patterned on conventional diagrams [14] of the "tree" of life, Fig. 4 presents a fragmentary version of the animal kingdom. In this characteristic type of representation, one developmental feature is singularly notable: the repeated branching of phyletic lineages from nodal points (which correspond to the successive morphological categories of kingdom, phylum, class, order, etc.) or, what is presumably the substantive referent of this, the successive displacement of existing populations by the "wedging in" of distinct new populations. An explanation for this general pattern of successive displacement has been advanced in terms of a combination of subprocesses operating, as it were, along a "wave front" of speciation* that leaves behind it an historical phyletic array (the higher categories) of viable living forms that persist with variable capacities for exploitation of their particular patterns of organization.

With regard to analysis of the gross morphological processes of speciation and phylogenesis, the specific subprocesses enunciated in evolutionary biology might be treated as interpretations of the primitive assumptions so far identified. By means of a purely figurative three-dimensioned axis system, Fig. 5 associates the modification of an imaginary distribution of synchronic populations with the several interdependent subprocesses imputed by evolutionary theory.

* Usage varies considerably, but most investigators understand "speciation" as referring to the process(es) contributing to genetic isolation between two populations (or groups of populations) with subsequent differentiation and distribution of new characters (a process that begins below the level of genetic isolation and continues above it).

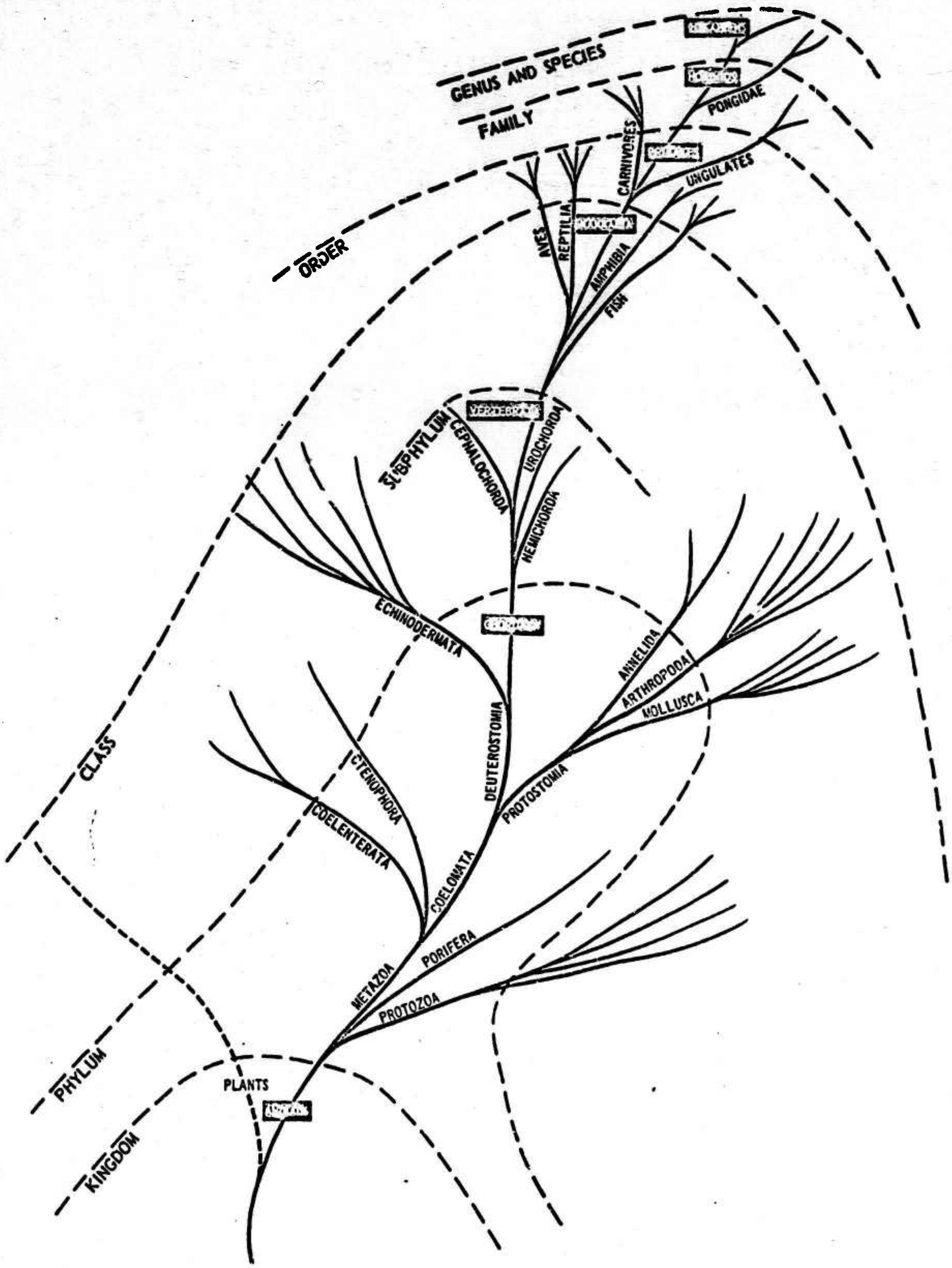

Fig. 4—Successive Displacement—Central Feature of Development

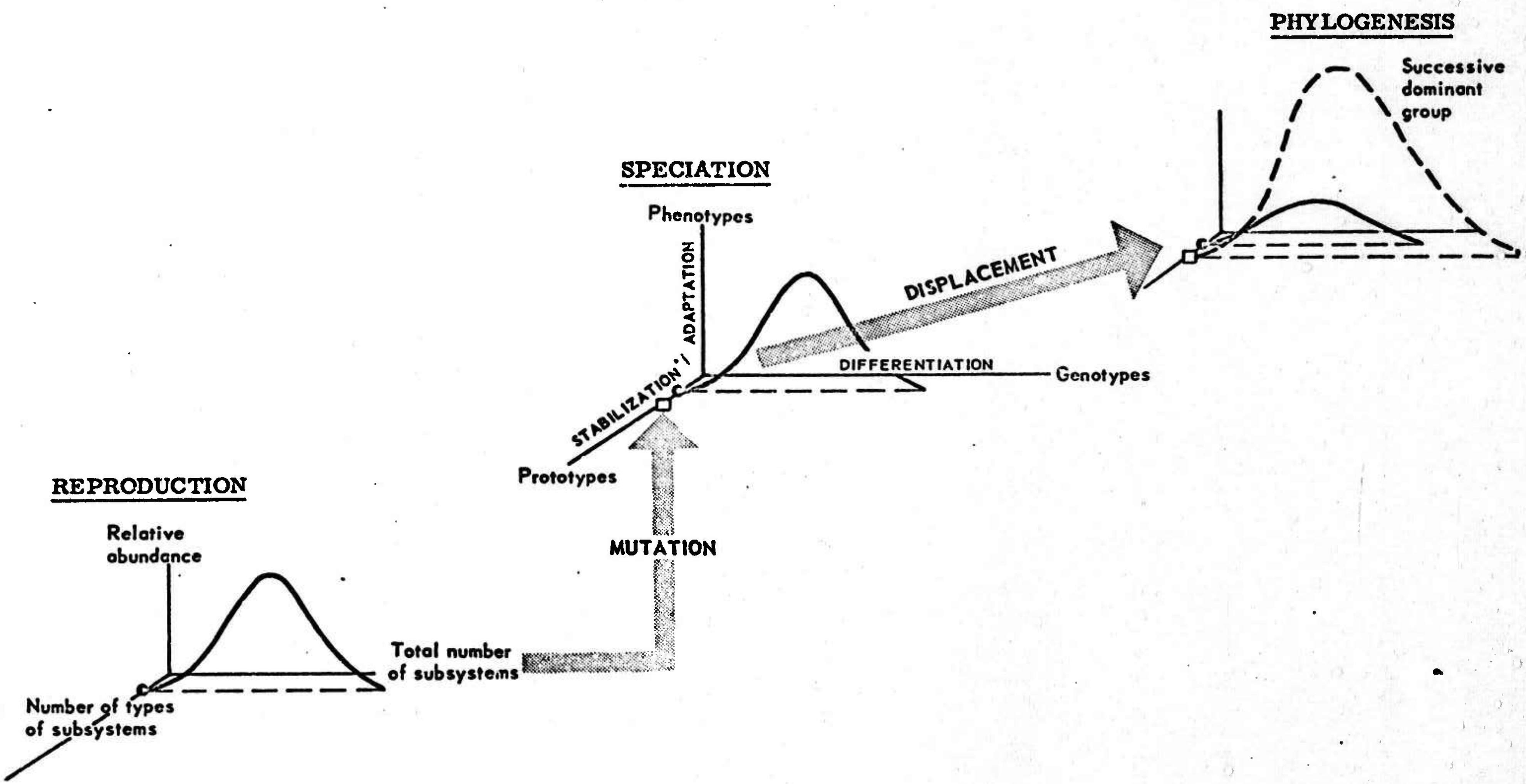

Fig. 5—Natural Selection in the Evolutionary Process

Referring to the primitives, it is immediately evident that biological reproduction may be considered an interpretation of the primitive, and therefore more general, concept <u>duplication</u>. There is a similar correspondence between the specific concept of mutation and the primitive <u>variation</u>; in addition, a relation of entailment holds between the primitive process <u>competition</u> and its biological consequence, natural selection. Any attempted vindication of these primitive notions on this obvious basis would, however, be quite premature. A more discerning examination of subprocesses elaborated in the theory of biological evolution discloses the fact that the theory involves multiple levels of integrated processes. As Huxley[15] has maintained, the individual organism comprises a process of stabilization within the process of differentiation of species, which is in turn a process within the ecological radiation of an adapted type, which is, again, a process within the successive displacement of dominant groups. Evolution, as the overall process of realizing novel possibilities of organization, has been successfully comprehended only by means of simultaneous reference to interdependent processes associated, in Table 2, with three ontologically distinct types of entities.

TABLE 2
MORPHOLOGICAL PROCESSES OF EVOLUTION AND THEIR REFERENTS

	Processes	Type of Entities	
NATURAL SELECTION	Reproduction	Individual Organisms	MORPHOLOGICAL CATEGORIES
	Mutation		
	Stabilization		
	Speciation	Genetic Populations	
	Genetic Isolation		
	Differentiation		
	Adaptation		
	Phylogenesis	Phyletic Lineages	
	Ecologic Isolation		
	Successive Displacement		

A diagram of Simpson's,[16] reproduced with added captions as Fig. 6, effectively summarizes this process-within-process feature of evolutionary theory by indicating that (A) the web of organic descent by reproduction of individuals appears as a line at the level of resolution appropriate to speciation and that (B) the web of descent in species similarly forms a line of phyletic descent in lineages (C).

With regard to the possibility of employing the given set of primitive notions in a comprehensive account of the evolutionary process, the complication injected by even this sinplified analysis of its convoluted subprocesses raises appreciable difficulties. By the adoption of certain fairly obvious modifications, however, it is possible to attain alternative primitives that appear to be interpretable at every operational level in the integrated processes of evolution and therefore representative of legitimate holistic aspects of the general transformation of biological organization. The replacement of competition by its corollary, selection, provides one such concept, and its implications can be immediately exploited in the investigation of adaptive systems. As indicated in Table 2 (left margin), natural selection is understood as subsuming the totality of evolutionary subprocesses. While it often construed merely as effecting the successive displacement of dominant groups, it is to be noted that selection is in fact presupposed at every level in the evolutionary process. At the level of the individual organism, for instance, any putative genotype that appears as the result of mutation will be said to have proven nonviable under selection if the individual mutant does not succeed in maintaining stabilization. Similarly, species that do

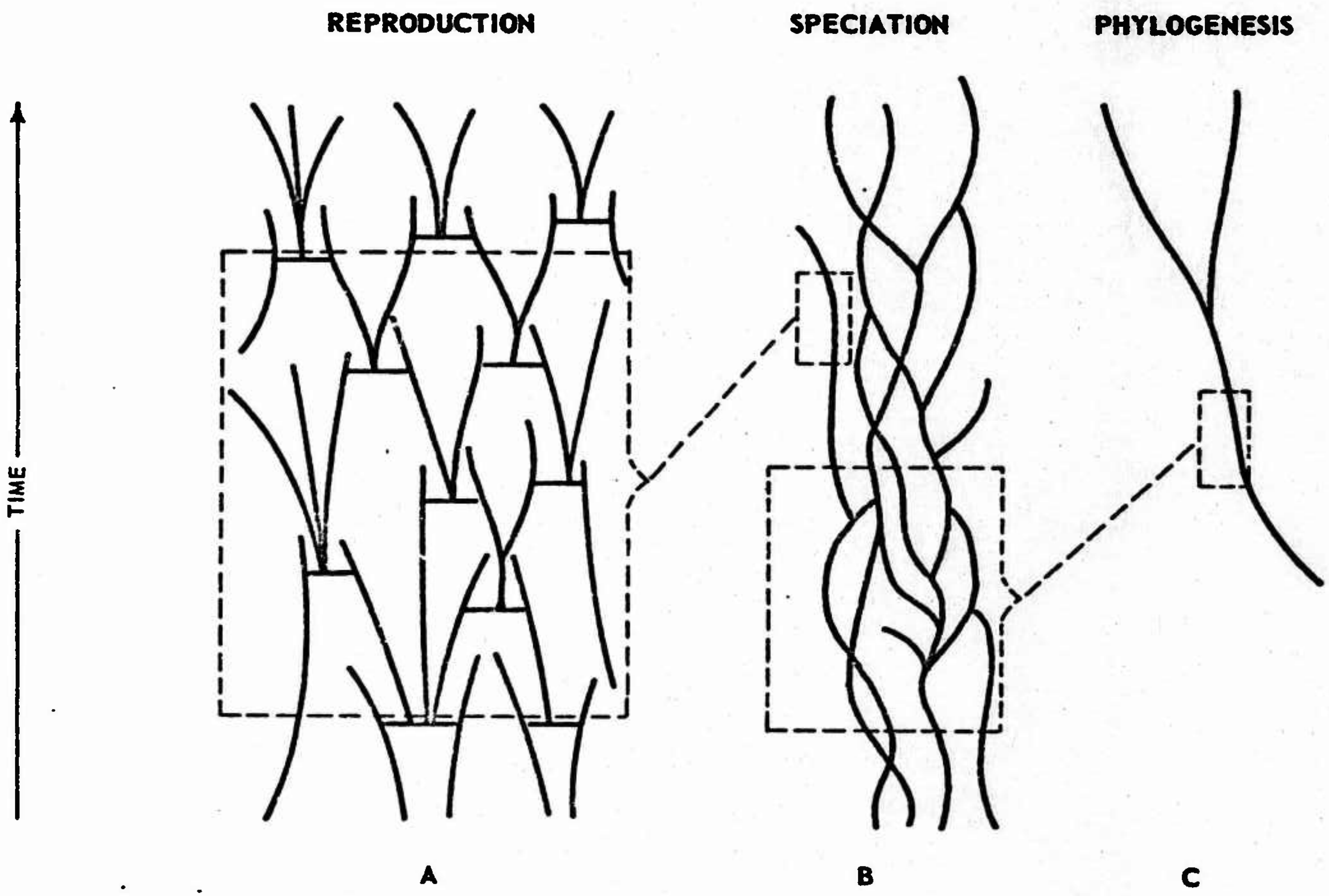

Fig. 6—Patterns of Organic Descent

A, greatly simplified suggestion of individual descent; ascending lines are ontogenies and cross-bars represent sexual reproduction.

B, simplied diagram of descent in a species; lines are demes or other local subdivisions, each of which has an included individual pattern as in A.

C, diagram of descent in lineages; lines are lineages, each of which has an included pattern like B.

not successfully contribute to the exploitation of an ecological domain by some phenotypic group are considered abortive under selection.

An appreciation of the pervasive influence of natural selection leads to a realization that has the greatest significance for a survey of adaptive systems.

Adaptation and Natural Selection

Under our definition of an adaptive system as one whose behavior maintains its essential variables within the limits of their respective norms, it is seen that every system existing in the context of natural selection will necessarily be an adaptive system. Systems that are adaptive in this miminal sense are precisely the only kind of systems admissible under selection. Adaptive behavior is therefore equivalent to the most general characteristic response of any viable system; the whole business of natural selection, and presumably of any selective dynamic system, amounts to the automatic generation * of subsystems that are specially resistant to the perturbations characteristic of some particu lar sub-environment, i.e., subsystems that are particularly suited to survive in their local environment.

Inasmuch as the connotation of selection, as a primitive, so far involves only the bare notion of survival under competition among subsystems for the limited resources of an effectively isolated total system, it is inconceivable that any substantive entity whatever exists or could exist independent of this general context of selection.

*Cf. W. R. Ashby, "Principles of the Self-Organizing System", in Principles of Self-Organizations, edited by H. von Foerster and G. W. Zopf, Jr., Pergamon Press, New York, 1962, p. 270.

Moreover, we must certainly concede that abstract entities (constructs, models, theories) as elements of the totality of conceptualizations, are similarly subject to competitive modification and/or elimination i.e., selection, under limited resources for coherent organization. Thus, adaptive-systemic character must be attributed to all entities. The conception of adaptive system that has been utilized cannot consistently designate any subset of systems; rather, the domain of adaptive systems must be identified with the total cosmographic domain of all existing "things" -- inorganic, organic, and conceptual. Adaptivity must be construed as merely one basic connotation of the pervasive general concept "system" -- which now clearly commands explicit status, in conjunction with selection, as a member of our new set of primitives.

The strategy of surveying the totality of systems generated under natural selection with the intention of distinguishing those that are adaptive appears to lead to a disconcerting realization that no such discrimination is possible. From the conclusion that all systems produced via evolution are adaptive, however, it does not follow that they are therefore adaptive to the same extent. For the development of this intimation concerning further distinctions, two prior considerations are especially relevant: (1) that adaptivity is inherently relative to environment and (2) that the essential connotation of the concept "system" involves a hierarchical configuration of successive levels of structural organization and interaction (cf. Fig. [illegible]). The significance of the second of these considerations is that the environmental range of any system (i.e., the range of perturbations to which the system is sensitive) is necessarily factorized

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in terms of the structural organization of that system and its specific adaptive responses determined by the totality of its control characteristics. To the extent that one can legitimately impute to various adaptive systems distinctive classes of control processes characteristic of their respective hierarchical stratifications of organization, one might hope to classify them in terms of distinguishable degrees of adaptivity.

The broad features of a scheme of classification based upon degrees of adaptivity are immediately apparent. Any system whatever may presumably be analyzed in terms of a hierarchical organizational format admitting a certain repertoire of behavioral programs with associated norms that, in turn, admit certain classes of perturbations as input and select certain sequences of states as output. A system that exhibits <u>reaction</u> effects a transformation of input to output under a fixed program <u>in</u> satisfaction of fixed norms. This is the simplest instance of adaptive behavior; and, in view of the fact that we generally attribute this type of activity to even those simplistic entities whose behavior we construe as deterministic, we would confine first-degree adaptivity to systems capable of adaptive action or <u>reaction</u> only. In the event that the characteristic response of a system undergoes modification in the course of some historical sequence of inputs, our classification of that system must, at the least, impute to it a capability for the modification of norms (as, for example, in an organism's development of tolerance reaction to a given intensity of toxic exposure). A system to which adaptive normalization or <u>renormalization</u> is attributed is thereby credited with second-degree adaptivity. Similarly, the imputation of capability for the renormalization of admissible classes of input or repertoire of [illegible] programs and norms, e.g., any instance of learning (ranging from the [illegible] of [illegible] habits by conditioned animals to the institution of new [illegible] conceptual entities, theories, commitments, or rational controls via the creative act of a cognitive agent) would be [illegible] or reorganization to be associated with third-[illegible].

It would seem to be a straightforward conclusion that the classification of any [illegible] by such an injection of distinctions based upon the [illegible] their responses encompass this increasing [illegible]: (1) [illegible]tion, (2) renormalization, and (3) [illegible] [illegible]ations, however, are immediately recognizable. The first [illegible] realization that such a broad format of classification certainly [illegible] more than precise explication of such informal [illegible] of [illegible] (1) [illegible], animate, and self-conscious or (2) [illegible] creative. The mere attainment of a unifying conception [illegible] of homeostatic or adaptive control processes [illegible] aid for resolution among the bewildering variety [illegible] organization and adaptive control that are to be [illegible] of viable systems. The second obstruction, [illegible] the first, is the intimation that various analogs of [illegible] renormalization may well constitute operational characteristics of [illegible] systems persisting under the process of natural selection. This [illegible] of classes of adaptive processes is [illegible] that is involved in survival and that any format of [illegible] that it may appear to have some claim to indefinite survival [illegible] evolution) might be presumed to represent an "[illegible]" [illegible] selection in some earlier environmental context where analogs of all the adaptive processes were relevant to survival. The alternative, of course, is to suppose that the more elementary systems are simply incapable of "higher" adaptive processes, since it is certainly not necessary for fruitful theorizing to impute reorganization capabilities to them; and, in this case, the durability of their organizational format would be attributed merely to the circumstance of balanced rates of attrition and production.

However this may be, the identification of degrees of adaptivity based upon a range of homeostatic processes is certainly inadequate for the purpose of classification. In order to obtain increased resolution of distinctions, it is obviously necessary to add to the notion of distinctive classes of control processes some consideration of the complexity of specific systemic configurations.

Emergence and Systemic Complexity

We have so far had occasion to consider a generalized concept of evolution -- i.e., an overall process of realizing novel possibilities of viable organization -- in terms of two primitive notions: (1) a primitive entity, system and (2) a primitive control process, selection. These notions alone have been emphasized initially for the clarification they lend to the concept of adaptivity. It is clear, however, that this set of primitives does not yet provide an adequate basis for comprehension of the general transformation of organization inasmuch as it does not incorporate any process accounting for the appearance and exploitation of initial deviations, as would be required for the generation of varieties of organizational prototypes that could then be resolved via selection. In the specific case of biological evolution, for example, the appearance and expliotation of gestalt novelty via the successive processes of mutation, differentiation-adaptation, and phyletic splitting are not accounted for by the reconstruction of primitives so far.

Our recourse at this point is to complete this reconstruction by the institution of additional primitive notions, as indicated in Table 3.

TABLE 3

PRIMITIVE CONCEPTS FOR A TAXONOMY OF ADAPTIVE SYSTEMS

Ontological Category	Primitive Concept
Entity	System
Process	Emergence
generative	objectification
	partition
	concrescence
regenerative	selection
	deviation-amplification
	deviation-reduction
Value	Viability
(index or criterion)	(adaptive range)

The principal innovation exhibited in this collection of primitives involves an amplification of the concept of evolutionary process by the incorporation of two component processes under the notion of emergence: (1) the primitive generative (or creative) process of objectification by which the bare existence of any system is initiated and (2) selection among objectifications, the primitive process of stabilization (or control) by which the continuing existence of any system is maintained within the competitive context of some reductive totality (or supersystem). Each of these primitives is analyzable in terms of pairs of counterposed processes. Objectification comprises the combined processes of partition and concrescence; selection comprises the combination of deviation-amplification and deviation-reduction processes characteristic of the mutual causal relations (or interactions) among the elements of any "system". The connotations of these primitive terms are given in the following tabulation:

OBJECTIFICATION

Partition admits of the sporadic isolation, within a totality, of unique combinations of elements of that totality -- e.g., the occurrence of genetic and exologic isolation in biological speciation.

Concrescence is associated with the incorporation of previously distinct systems within an integral format of organization provided by the appearance of an additional hierarchical level of systemic norms capable of exerting unified control over the novel collection of subsystems -- e.g., the coalescence of lipid and polymeric molecules in the formation of biotic cells or the formulation of a theory that encompasses two or more previously disparate theories.

These two processes collectively represent the modus operandi of organization and their combination under the single term "objectification" is indicative of the premise that varieties of novel entities are generated only by "spin-off" of subcollections of entities accompanied simultaneously by systemic "union" of the elements of such subcollections. "Objectification," as synonymous with "organization,"is chosen as the term of reference for this pair of processes primarily because it seems to purvey more effectively the notion of the origination of the existence of a "thing".

SELECTION

Deviation-amplification has the essential connotation of "morphogenesis", i.e., the reinforcement of deviations of structure or function of a system by amplification of the effect of an initial perturbation, with a consequent divergence from initial conditions and characteristics -- e.g., the exploitation and extension of fortuitously adaptive modifications in the development of biological phenotypes or the "escalation" of conflict in international relations.

Deviation-reduction is associated with the more familiar aspects of systems control known as "homeostasis" and "morphostasis". This is the regulating or stabilizing process characterized by negative feedback of control and detection information as in the autonomic processes and motor activity of organisms or the automatic stabilization of economic supply-demand.

It seems clear that this pair of counterposed processes is consonant with the essential feature imputed to systems in general, i.e., mutual causal relations among subsystems (where "mutual causal relation" refers to the notion that elements within a system influence each other simultaneously. Deviation-amplification and reduction therefore are processes necessarily attending this imputation of the possibility of both positive and negative feedback. Taken together under the single concept of selection, these processes account for the selective course of development followed by a given system in the maintenance of stability as a viable organization. In the sense in which objectification concerns the process by which a system comes to be (i.e., exist), selection concerns the process by which any system becomes whatever it does become.

A second innovation is to be noted in the proposed collection of primitive concepts, this one engendered by the consideration that the concept "selection process" is inextricably connected with the notion of a criterion of selection. This is to say that the specification of a criterion for the admissibility of certain definite consequences (or products) is an indispensable component of the specification of any process whatever.

In this connection, viability has been assigned the status of a primitive criterion (value) with adaptive range as the index or measure of the viability of any organizational format produced via objectification-selection. This injection of a value-criterion has the crucial effect of imputing directivity to the process of emergence. The adaptive range of successive dominant groups can presumably be extended only on the basis of (1) superior elegance, precision, and efficiency of structure and function in combination with (2) the addition of new hierarchical levels of organization that admit extensions of range and degree of systemic freedom with regard to detection, information processing, and behavioral control. If the process of emergence is selective under the criterion of viability with its measure, adaptability, the implication is that increasing orders of systemic complexity will be correlated with the appearance of "emergent" systems.

Thus, the immediate consequence of this collection of primitive constructs is the conceptualization of emergent systems as those prototypical systems that have initially exhibitied, as innovations in their time, novel formats of organization that have supported successive increases in adaptive range on the basis of correlative increases in systemic complexity. A unique line of behavior on the part of the total evolutionary system might be identified with that "leading edge" of emergence that connects just the successive prototypes appearing along the primary course of historical development. In a very real sense this line of successive emergent systems may be said to embody a continuing course of "improved," i.e., more adaptable, organization ; although the persistence of archaic systems indicates that survival, as distinguished from evolutionary viability, can be maintained by systems that are suitably adapted to a given environment despite their having been superseded in the general advance toward increased adaptive range by more adaptable systems whose complexity renders them already capable of successful adjustment to major shifts of environment that clearly would extinguish their more primitive contemporaries.

TAXONOMIC FRAMEWORK

It certainly appears worth while to pursue the identification of just those emergent systems that have initially exhibited features of viable organization that have tended to become stabilized throughout the subsequent course of development. A structure representing the historical succession of emergent systems can obviously provide a natural taxonomic framework for at least an ordering of adaptive systems in terms of a hierarchy of successively more sophisticated systems characteristics, both structural and functional.

The identification of emergent systems depends, of course, on historical reconstructions derived from many disciplines. Nevertheless the task is not so formidable as it might appear, due to the implication that evolutionary emergence is correlated with increasing systemic complexity. Table 4 presents a list of the properties that have been utilized for the identification of emergent systems. These have been assigned on the basis of rough measures of increasing orders of systemic complexity.

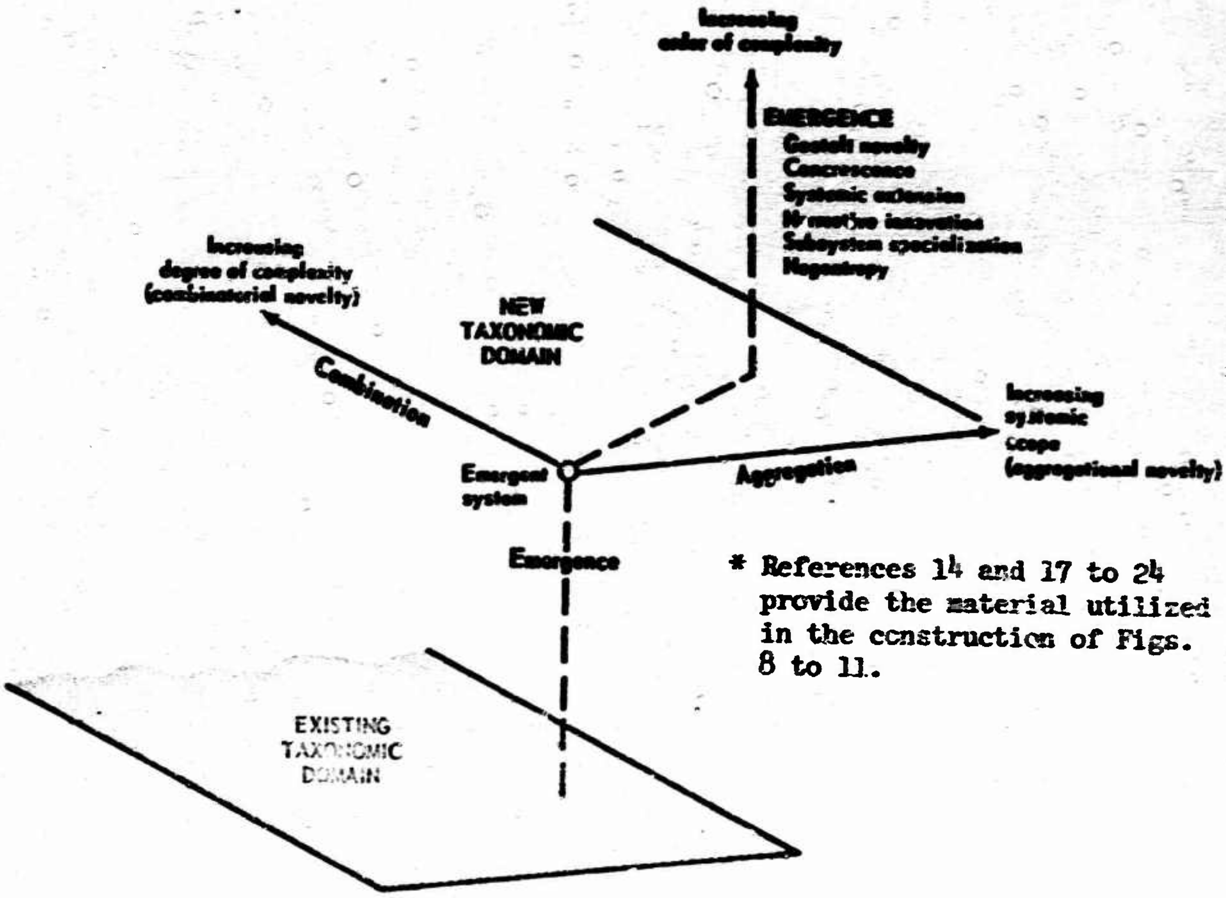
A major complication here involves the distinction between an emergent increase in order of complexity and the general increase in the scope and degree of complexity of systems attributable to combinatorial novelty and sheer aggregation. With regard to the organizations of organisms (e.g.,symbiotic aggregations, colonies, tribal and familial groups, cultural societies) sometimes referred to as "supraorganisms," this distinction is somewhat difficult to maintain. In the domain of psychosocial systems particularly, organizations of organisms clearly enter directly into the emergent process. But as a basic format of classification it appears advisable to attempt to distinguish (as in Fig. 7) properties of emergent systems from those of combinations and aggregations.

Such a format provides for the construction *,[14,17-24] of "lattices" (Figs. 8 to 11) that exhibit, for the geosphere, biosphere, and noosphere, respectively, a hierarchical configuration of emergent systems arising within the total system of natural selection. In these lattice structures the appearance of an emergent system is indicated by a "quantum jump" vertically along the dimension of increasing order of systemic complexity. Increasing systemic scope and degree of complexity--secondary in significance for the taxonomic project--are merely suggested roughly by lateral displacement.

TABLE 4

PROPERTIES OF EMERGENT SYSTEMS

Property	Explication
Gestalt novelty	A feature of organization based on a novel format; in contrast with combinatorial novelty, which may be attributed to any distinctive aggregation of elements from a given collection, gestalt novelty is a property of an assemblage of elements that introduces structural innovation via the institution of a new form of organization
Concrescence	A process consisting of the "growing together" of previously distinct systems to form a unitary, integral structure; chemical evolution provides very clear examples, e.g., the coalescence of lipid and polymeric molecules in the formation of biological cells; in the realm of ideas, concrescence might be illustrated by the formulation of a theory that encompasses two or more previously disparate theories
Systemic extension	The organization of elements (themselves systems) in hierarchical levels connected by regenerative information-control linkages providing for selectivity at every level represents the basic connotation of "systemic character"; in an emergent system this character is maintained with the incorporation of a new level of organization; this is the most radical version of adaptability as a means to continuing viability
Normative innovation	The appearance of an additional level of organization requires the institution of norms relevant to selectivity at that level; for example, objectification as an emergent event involves not only the conceptualization of related object constructs but also the institution of norms controlling selection among object constructs
Subsystem specialization	In addition to the institution of new levels of organization and new norms, emergence involves the modification of previous subsystems in terms of (a) articulation or differentiation of structure and (b) renormalization or normative innovation; this property of emergent systems is associated with the increasing complexity, efficiency, and elegance of both structure and behavior that mark those systems that are viably competitive under external (i.e., environmental) selection
Negentropy	Two features—(a) the transfer and transformation of energy with net gain of potential by a local, metastable system and (b) the communication and transformation of information with an increase in degrees of freedom in the "decision space" of such a system—constitute properties of an emergent system that provide the possibility of a general increase in variety and organization



* References 14 and 17 to 24 provide the material utilized in the construction of Figs. 8 to 11.

Fig. 7—Emergence and Systemic Complexity

The general interpretation of Figs. 8-11 may be summarized in the following manner. The successive shaded plates represent distinctive taxonomic domains of entities that have been generated by emergence. The totality of synchronic populations at any era of archeological time comprises some cummulative collection of these domains; and each domain therefore represents just the sub-collection of populations generated by combinatorial and aggregational exploitation of a prototypical format of organization provided by the appearance of an emergent system. Emergent systems (represented by the large circles at the leading edges of the shaded plates) are presumed to have appeared as the outcome of the evolutionary process operating in the context of the previous accumulation of systems. With the appearance of a new prototype of organization (say, for example, the atom), combinatorial possibilities admit of a taxonomic array of distinguishable systems based upon this format--in this case, the familiar table of atomic elements suggested in Fig. 8 by displacement along the axis corresponding to that one labelled "Combination" in Fig. 7. Similarly, various aggregations involving all these combinatorial types are now admissible, and these (e.g., protogalaxies, stellar nebulae, stars, etc., as gaseous aggregations of atoms) generate a second taxonomic array of macroscopic entities. The plan of Fig. 7 would indicate that such arrays should be suggested by displacement along the axis labelled "Aggregation." Since this convention would produce illegible diagrams in Figs. 8-11, these arrays have been indicated just wherever convenient for giving the intended impression that each shaded plate is to represent the new taxonomic domain resulting from both combinatorial and aggregational exploitation of the novel format of a prototypical or emergent system. The total effect, then, is one of taxonomies within a taxonomy, i.e., the incorporation of previous specialized taxonomies within the proposed general taxonomy. The suspicious regularity of the dotted lines connecting the specialized taxonomic domains in Figs. 3-11 is, of course, merely figurative. While it has been possible to impute connectivity throughout the gross stages of evolution by virtue of the identification of successive emergent systems, details of the lines of descent are simply not available even for organic descent in biological phyla--surely the most assiduously investigated area of evolutionary phenomena. The connective lines of Fig. 8-11 are therefore to be interpreted merely as indicating that a given emergent system is imputed to have arisen out of the general context of the taxonomic domains preceeding it in time (and therefore below it in the diagram).

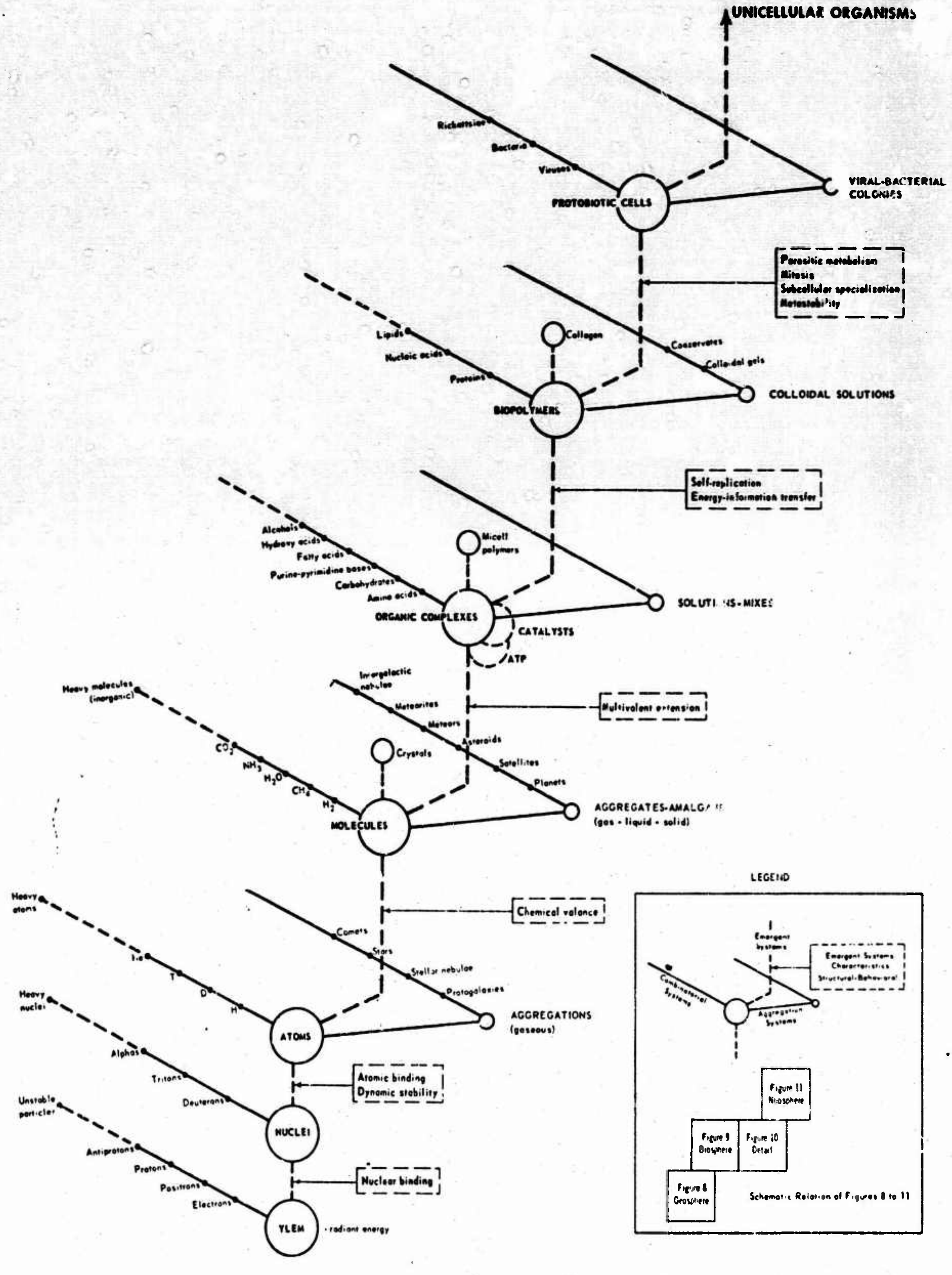


Fig. 8—Emergent Systems, Geosphere

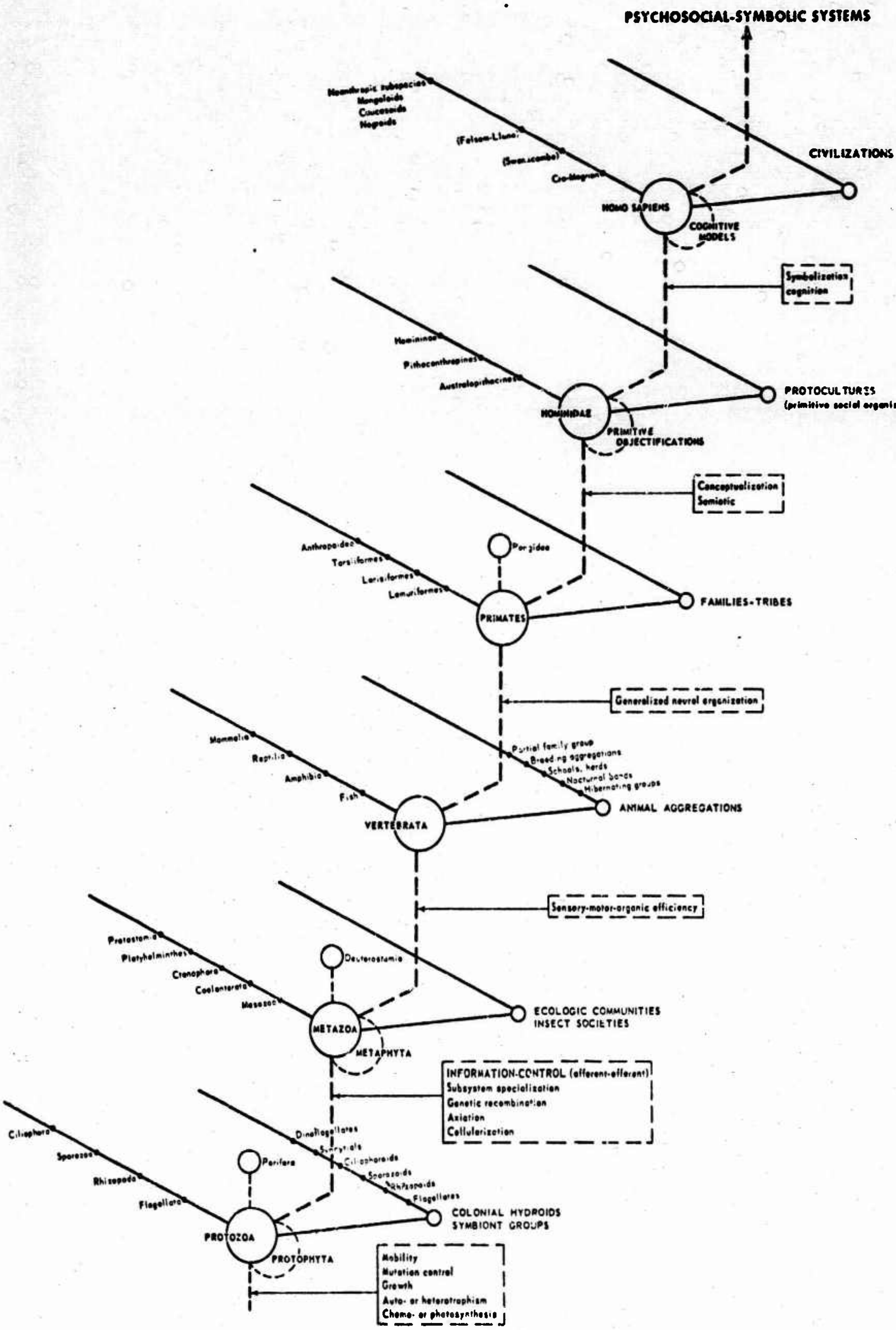


Fig. 9—Emergent Systems, Biosphere

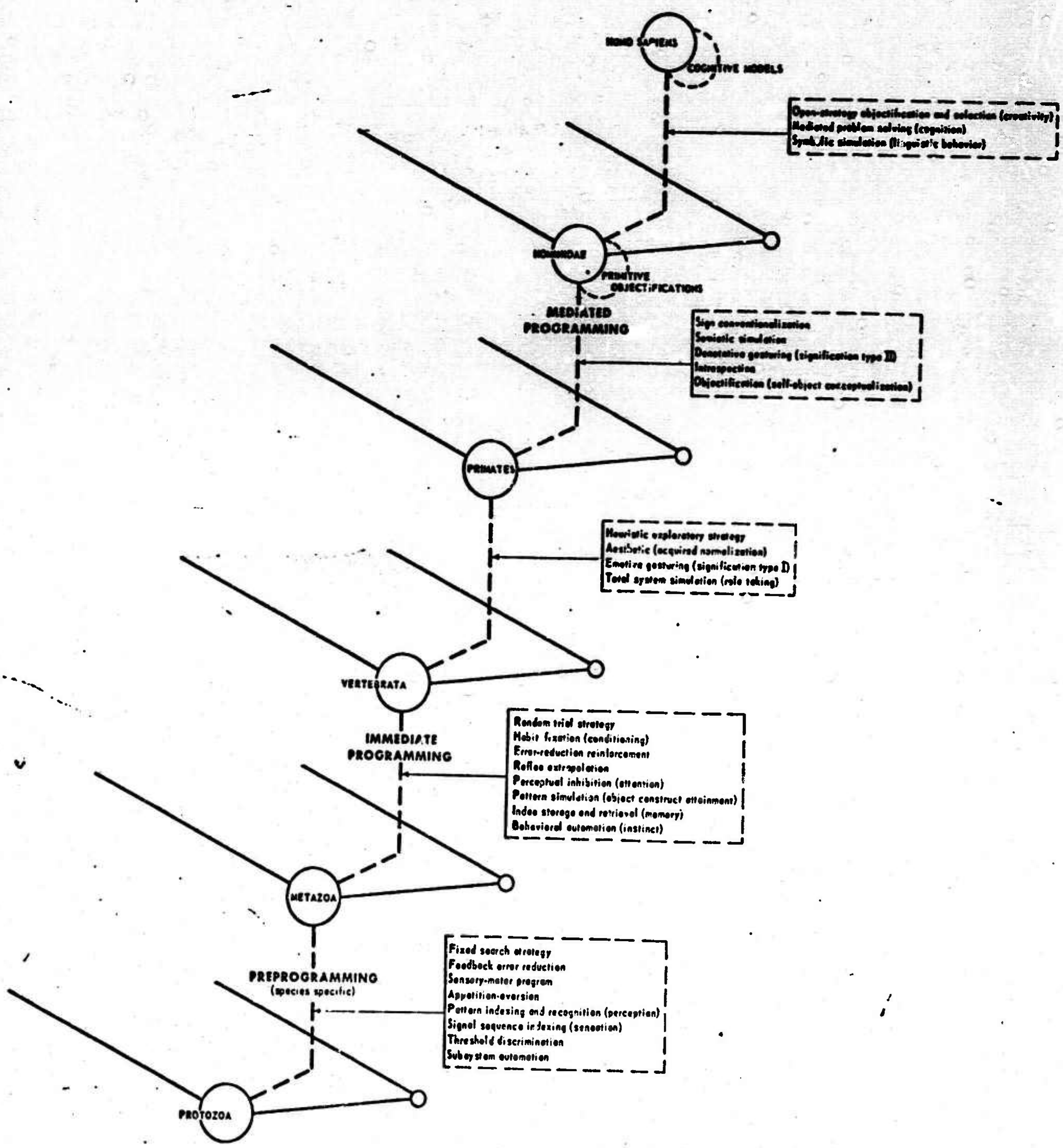


Fig. 10—Detail of Emergent Systems, Biosphere Information-Control Process

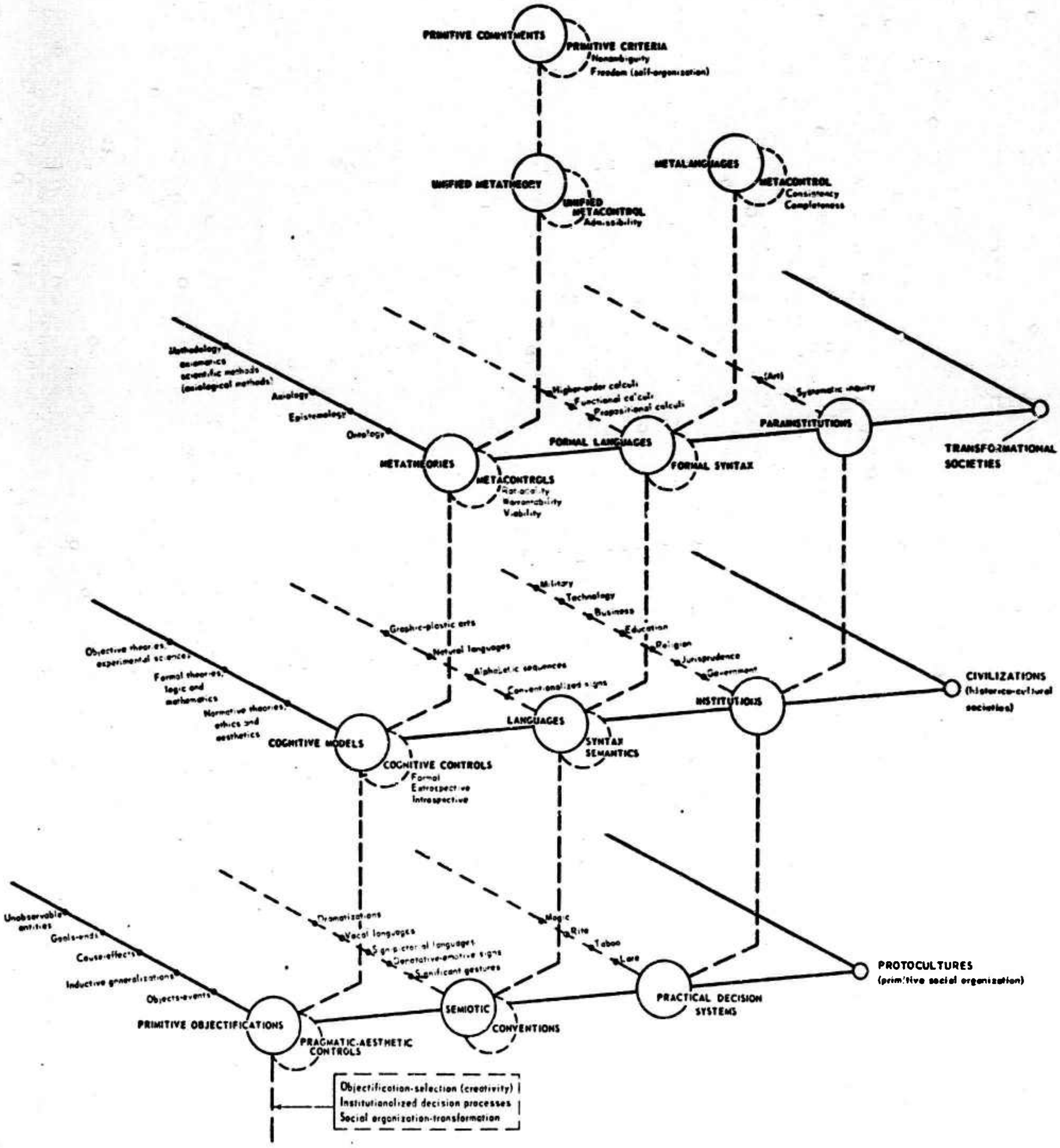


Fig. 11— Emergent Systems, Noosphere

Taxonomic Refinement

With the attainment of a unitary hierarchy of emergent systems it is clear that we have available a taxonomic framework capable of effecting a rudimentary ordering of the domain of adaptive systems. The immediate requirement for further taxonomic refinement is the formulation of some continuous measure of systemic complexity. Such a measure must provide the resolution necessary for classifying adaptive systems in detail within the context of the basic conformality provided by their common property of viable organization.

In pursuit of the previous intimation that the concept "characteristic response" may provide the clue to the fine structure, an attempt has been made to enter, at each step of emergence (figs. 8 to 11), some indication of the more important advances in behavioral capability. With the psychosocial systems of the noosphere the increasing sophistication of characteristic response culminates in two vastly complicated procedures: the objectification of (1) object-constructs and theories and (2) norms or controls for selection among object-theories. It must therefore be anticipated that the formulation of a continuous measure of systemic complexity based on increasing sophistication of characteristic response (which is almost certainly correlated with the complexity of structural features) will require extensive creative effort. At present a very promising approach is suggested by the possibility of typifying adaptive systems by a measure defined on degrees and ranges of semiotic freedom, i.e., free capacity of the system available for control of its behavioral program. In common-sense terms, such an approach would feature the classification of adaptive systems in terms of the extent to which their characteristic responses approach autonomy, i.e., self-organization involving the absorption of degrees of freedom by programmed decision procedures.

The mere representation of the cosmographic domain of systems as a unitary hierarchy is no more than an illustration of a generally accepted premise concerning connectibility with the total system of natural selection. There has long been a prevailing intimation of a unitary process of development; it had been advanced even earlier than Aristotle's explicit notion of a "great chain of Being" and it recurs in almost every systematic philosophy--most notably perhaps in Hegel's dialectical system and most recently in Whitehead's conception of process and reality. There can be at present little question as to the intuitive admissibility of this premise. The problem now, as always, is to render this vague intimation operationally meaningful, to vindicate the notion by attaining a rationale of sytemic development that possesses predictive and prescriptive significance. That is, we must be able to show, in detail, how the patterns of development and behavior for specific adaptive systems are conformal with a unitary format of organization and transformation. It is our conception that the rudimentary taxonomy proposed here can contribute toward such an achievement. The entire spectrum of disciplines comprising the behavioral sciences may profit from new interconnections among specialities that are found to be associated--under a refined taxonomic structure--with adaptive systems that share a common level of complexity despite substantive disparities. This is to say that when we are able to distinguish specific orders of complexity within the world of "black boxes," we shall be able to cooperate more effectively in the common task of their investigation.

Chapter 8

THE COGNITIVE AGENT *IN ACTU*: COGNITIVE-CULTURAL EVOLUTION

It is not the possession of some measure of freedom per se but the initial acquisition of a new *dimension* of freedom that is the mark of man's distinction, the signal that his appearance must be interpreted as an emergent event. This conclusion is qualified, of course, by the fact that his exploitation of an additional range of freedom is clearly correlated with instrumental modifications that are mere extensions along dimensions of freedom attained earlier by protohominids--e.g., the upright posture admitting of bipedal locomotion and accessory limbs, the opposed-thumb design of a hand accommodating alternative grips for power and for precision, the ventrally oriented face allowing marked separation of glottis from velum, the increased size and convolution of the brain permitting sophistication in information processing. The weight of evidence, however, unmistakably indicates a new modality of behavior--an organizational modification involving the strategy of behavioral control--as the primary characteristics that is distinctively human. Presumably it was this new modality that provided the critical competitive edge. In the beginning it was just barely that--an edge, neither as reliable as conditioning nor as immediately effective as instinct; but it was enough. It would do. In the long range, it initiated a self-amplifying sequence of developments that allowed man to burst into a New World so spacious that its effective limits have not yet been discerned. In technical terms this is the world of the conceptual objectification. And the new modality of behavior--the new way of acting--that implemented entry into it was semiosis (symbol-using), with cognition--a new way of thinking--as its correlate. In more familiar terms this is the world of idea and symbol, of mind and model, of thought and language, of creativity and expression. The fixation of the habitual activity of symbolizing and the institution of a general strategy for controlling action by the construction and manipulation of conceptual models represent the central evolutionary features that now permit us to justify the ancient conjecture that man, from the beginning, was caparisoned for the business of getting dominion.

It will be generally admitted that the development of the historic agencies of man's dominance--the great institutional triad of religion, science, and art--has depended ultimately upon the power of significant symbols to render thought coherent, communicable, corrigible and therefore capable of interlacing human individuals in a nexus of socialized creativity and control. That society and civilization rise on the wings of the symbol and the thought for which it stands is an easy truistic conclusion. It covers everything and explains nothing. Yet it would be a serious error to suppose that this holistic conclusion is uninformative and therefore bootless. Just such an "empty" generalization is required for establishing the boundaries of a domain of inquiry and a manageable reduction of phenomena. This initial task must always be accomplished by laying out at least one consideration that holds without exception over some area of attention.

In this connection consider, for example, the service of the concepts organism and life (process) in delineating the familiar domain now commonly referred to as the "biosphere". Biological considerations are relevant over just that range of entities for which these concepts are everywhere meaningful and applicable.

In precisely this sense, with the addition of the terms "conceptual objectification" and "semiotic-cognitive process", we demarcate a triadic domain of psycho-social-biological organization: (1) a mental otherworld of organizations of idealized entities (the noosphere of Pere Teilhard de Chardin) that curiously interleaves (2) the biosphere of organisms and (3) the sociosphere of accultural organizations of organisms.

Our supposedly innocuous generalization, attributing to symbolization and cognition the status of unique and ubiquitous factors in the development of culture, now becomes recognizable as a critical commitment. It represents a metadecision as to what phenomena are going to be regarded ultimately as relevant to our interest. It amounts to a premise concerning what acculturation, fundamentally, is all about inasmuch as it established the following major presupposition: that cultural evolution--the emergence of increasingly viable social institutions as an extension of biological evolution--is interdependent with "noetic" evolution, the emergence of increasingly stable and durable organizations of ideas and modes of abstract thought.

MAJOR FEATURES OF SCIENTIFIC ADVANCE

This minimal appreciation of suppositions is just sufficient to allow the shaping of a program of analysis appropriate for the identification of primary features of scientific advance and the assessment of their significance. A commitment providing for the essential relevance of successive modifications in ways of thinking carries us over the inevitable troublesome questions: What is science? or How shall "science" be construed? What sort of event constitutes a "scientific" advance? A specific domain of cultural development may be envisioned in which "science" is quite properly construed as an institutional decision system characterized by the employment of inquiry as a strategy for the fixation of belief and the control of action. In this institutional sense its significance would need to be assessed in terms of the cultural impact of technological advances, in terms of the potential and liability of nuclear fission and fusion, interplanetary exploration and communication, induction-selection of genetic modifications, automation of physical and logical processes, cybernetic control in man, machine and society. On a level of greater generality, the import of the predictive scope and explanatory adequacy of advanced theories would require assessment: relativistic and quantum mechanics, information theory in communications and in genetics, mathematical theories of optimal control, physiological-psychological-economic theories of behavior. On this view of science as means and its works as resources for institutional control, we encounter the enterprise not of one but a thousand essays. If we are to penetrate within striking range of future insight regarding the convoluted significance of science as a cultural institution, a prerequisite seems obvious. We must explore the principal feature of the great unitary gestalt envisioned in our initial generalization--the inherent connectivity that holds throughout the triad of biosphere, sociosphere and noösphere; we must concentrate first upon the omnipresent theme of a cognitive modality that links these fundamental matrices underlying acculturation in general.

Science, as you are asked to conceive it from this cosmoscopic point of view, represents quite simply a particular proliferation of the cognitive-semiotic mode of behavior. It is to be identified with an evolutionary lineage, a sequence of successively emergent but nonetheless connectable ways of thinking; and this lineage is to be intimately associated with correlative appearances of prototypical formats for the organizations of ideas. At this remove, historic instances of scientific advance will be distinctively marked by the advent of "improved" versions of the cognitive modality itself, i.e., by modes of thought that serve the basic function of cognition with increasing adequacy and effectiveness.

But what is the basic function of cognition? This is the immediate rejoinder that finally sets the shape of this program of analysis. Here is a clear demand that the fundamental nature of the semiotic-cognitive complex be laid bare so that identification and appraisal of the major features of scientific advance may be based upon the extent to which sophisticated intellective developments constitute basic amplifications of this elemental complex underlying all cultural development. David Hume's prescient observation in the Introduction to his *Treatise* strikes across almost two centuries to assure us in this selection of a program:

> 'Tis evident that all the sciences have a relation, greater or less, to human nature; and that however wide any of them may seem to run from it, they still return back by one passage or another. Even mathematics, natural philosophy, and natural religion are in some measure dependent upon the science of Man; since they lie under the cognizance of men, and are judged of by their powers and faculties. 'Tis impossible to tell what changes and improvements we might make in these sciences were we thoroughly acquainted with the extent and force of human understanding and could explain the nature of the ideas we employ, and of the operations we perform in our reasonings.

THE COGNITIVE-SEMIOTIC COMPLEX

Our preliminary analysis of cognition may be drastically abbreviated by the utilization of existing groundwork. It is to the enduring credit of certain American pragmatists and behaviorists (principally C. S. Peirce, John Dewey, and G. H. Mead) that they achieved an account of the semiotic-cognitive process now widely conceded to be essentially correct in its basic features despite the existence of recognized limitations.

Perhaps the chief contribution of the behaviorists has been their emphasis on the *mediating* character of cognitive activity. It was upon their insistence that we came generally to an appreciation of the cognitive process as "standing between" and connecting the stimulatory phase of a problematic situation with the manipulatory phase of overt behavior. In contemporary parlance, any such connective process is described as a program, a transformation of input to output constituting one aspect of the characteristic response of some selective system. Reflex response and conditioned behavior are immediately interpretable as programmatic in this sense, and it was by virtue of their close consideration of these elementary processes that the behaviorists recognized that cognition must represent a higher order process of reprogramming--a modification of prior characteristic response. It is to the purpose of reconstituting a behavioral repertoire in the face of the frustrating failure of some previous program that the cognitive process moves into action; and the central characteristic of cognition--in contrast with the immediacy of reflex response--is that it brings to bear a constellation of mental agencies (attention, pattern recognition, memory, imagery, inference) upon decision problems in reflection, that is, in a context that is insulated from physiological tensions that would call for an immediate act. Whenever such a procedure leads from a trial-reorganization of repertoire to anticipatory selection among new alternatives to later action resulting in satisfaction of norms or attainment of goals, this provisional reprogramming of behavior is reinforced as a new basis for uniform response to problems of a given kind. This is the primitive foundation for the prediction and control of experience exhibited by cognitive decision systems, and the further institution of systematic procedures for reflective mediation of behavior constitutes, in John Dewey's phrase, the "creative use of intelligence."

It is impossible to overemphasize the conclusion that the very notion of reflective mediation presupposes that cognition cannot be a process embedded in the continuous flux of immediate interaction between the cognizing system and its environment. The chief requirement for reflection is clearly a capability for considering an action-decision space--a present array of behavioral alternatives--itself as merely one among other higher order alternatives. Cognition must therefore be conceived as operating within a virtual-decision space, an extended domain of attention admitting of simulations that are susceptible to idealized rather than actual manipulation. A reflective system must be <u>self</u>-conscious, i.e., capable of considering itself both as object and as subject within some holistic context of interaction with an "other" system constituting an element of its environment. In attributing reflective capability, we attribute to a cognitive system the curious ability to consider, within its own decision space, a gestalt in which the cognitive system itself is represented as merely one of the distinguishable components. Is it possible that any sort of system whatever can be capable of generating "within itself" a system more extensive than itself?

The answer is, of course, that a symbol-using system can do this, but it remains to be seen what "this" may involve. In an interpretation that is just the converse of the early emphasis of the pragmatists on thinking as an internalization of the symbolic process, we may view symbolization as an externalization of the conceptual process. It is the function of a particular organization of symbols to stand perceptibly for an imperceptible organization of concepts, to present a formalized perceptual system that is homomorphic to an ideational one both in terms of relations and admissible operations. The essential advantage provided by symbolization is that of permitting the "mapping," and therefore the fixation, of conceptual relations that would otherwise be too diffuse and ephemeral for concentrated attention. To be able to hold imperceptibles before the mind systemically, the cognitive system must have access to a model providing stable perceptual counterparts. That these perceptual counterparts must be formalized signs (i.e., symbols) follows from the fact that it is not their intrinsic character that is significant but their operational service in the simulation of systems possessing the quite different ontological status of merely conceivable existence. Symbolization therefore may be interpreted as a way of "acting for the sake of thinking." As such it is clearly neither separable from nor independent of the cognitive process that the pragmatists so trenchantly described as "thinking for the sake of acting." This complementarity must be central to the nature of the cognitive-semiotic process inasmuch as it constitutes our only adequate explanation for a completely general observation: that the formalized manipulation of symbols is generative of novel concepts and that the intuitive (non-formalized) manipulation of concepts is generative of novel symbols in a continuing iterative process.

With just this minimal understanding of the role of symbolization, we are able to recognize that the puzzling question concerning the possibility of a system capable of considering a holistic gestalt "within its own decision space" represents, in reality, a pseudo-conundrum. Systems of symbols undeniably constitute agencies of cognitive systems as surely as artifacts do, and any agency may legitimately be viewed as an extension of the system it serves. In view of this, we immediately perceive the fallacy of identifying the ultimate decision space of a cognitive system with its somatic self, the totality of its distinct physical states. With the objectification of conceptual entities and relations in symbolic structures, a noetic self--a mental-organizational aspect of self--necessarily diffuses throughout the entire array of symbolic models that serve as agencies of the given cognitive system. Thus, the ultimate decision space of a cognitive system, the locus of its ultimate self, and the ultimate matrix for its program of self-control, are coextensive with an indefinitely extendable semiotic space. If this entails the existentialist conclusion that the human being, as a cognitive agent, has no specifiable essence, or if, again, it entails the still earlier insight that "It doth not yet appear what we shall be...," we must be prepared to make the most of it.

The previous appearance of conundrum, at least, may be completely dispelled. No problem is involved in supposing that a symbol-using system should be capable of generating, within the semiotic space of its noetic self, a system more extensive than its somatic self. In this light, a fairly precise description of the minimal conditions for cognition may now be stated: a cognitive system must be capable of (1) objectifying in a cognitive model (a symbolic system) an organization of abstract entities (a conceptual system) that constitutes, at least provisionally, the form or pattern of interaction characteristic of a substantive dual-system composed of its own soma and that of an "other"; (2) simulating, via manipulation of symbols, the specific courses of interaction that result from alternative initial conditions (including alternative programs of action); and (3) selecting from among these alternatives a course of interaction that is preferred under criteria associated with its constraints, norms, and goals (see Tables 8.1 and 8.2).

By virtue of the attainment and extension of this complex capability, man became the first deliberative decision maker, the first to be capable of taking a role without acting it, the first to be capable of figuratively playing out alternatives in anticipation of action and of comparing consequences without paying the price of failure in terms of actual physical stress. Any organism that can control its selection of immediate action by the employment of memory and imagery is a thinker; but one that can further control the selection of contingent plans of action by means of the creative activity of conceptual objectification is a fore-thinker, a thinker let loose to exploit that new dimension of freedom we have referred to as a semiotic decision space.

Our analysis will fall short, however, if we rest with the view that the maximization of this freedom alone constitutes the whole

COGNITION: MINIMAL CONDITIONS

Principal Capabilities (conceptual)	Subsidiary Capabilities Presupposed (communication-control)
OBJECTIFICATION	PRE-PROGRAMMING (SPECIES-SPECIFIC)
	signal detection
	information processing
SIMULATION	autonomic control
	heuristic info-processing
	IMMEDIATE REPROGRAMMING
	attention
SELECTION	sensory-motor control
	conditioned learning
	heuristic self-conditioning

MEDIATED REPROGRAMMING

Table 8.1

Table 8.2

HIERARCHY OF INFORMATION-CONTROL PROCESSES
(Cognitive Behavior)

PSYCHOLOGICAL TERMINOLOGY	CYBERNETIC TERMINOLOGY
PRE-PROGRAMMED (species-specific) PROCESSES	
Signal detection	Threshold discrimination
Automatic control	
Homeostasis	Subsystem automation
Appetition-aversion	System renormalization
Reflex behavior	Sensory-motor programming
Information processing	
Association	Signal sequencing
Sensation	Sequence indexing
Perception	Pattern indexing
Memory	Index storage
Abstraction	Index reduction
Heuristic information-process control	
Expectation	Precursor extrapolation
Imagery	Pattern simulation
Perceptual judgment	Pattern recognition
IMMEDIATE PROGRAMMING	
Attention (selectively maintained)	Perceptual inhibition
Sensory-motor control	
Guidance control	Feedback error reduction
Sensory experimentation	Exploratory detection
Heuristic programming	
Trial-error	Quiescence-pattern hunting
Habit fixation	Error reduction reinforcement
Conditioned behavior	Modification of characteristic response
Heuristic program control	
Signification	Self-conditioned gesturing
Conceptualization	Concept attainment (self-other)
Symbolization	Sign conventionalization-socialization
Problem recognition	Introspection-extrospection
MEDIATED PROGRAMMING	
Simulation	Linguistic behavior
Cognitive control (mediated heuristic programming)	
Objectification	Object theory construction
Simulated trial-error	Decision procedures
Prediction-prescription	Fixation of belief-action
Inquiry (mediated heuristic control)	
Objectification-selection	Systematic testing (cognitive models)
Semiotic control	Applicability
Formal control	Validity
Extrospective control	Warrantability
Introspective control	Viability
Re-objectification	Object-theory reconstruction
Meta-inquiry (meta-theoretic control)	
Primitive commitment	Formalization
Ontological	
Epistemological	
Methodological (procedural)	

function of the cognitive-semiotic process. There is a popular tendency to construe freedom as a supreme or intrinsic value, an end in itself; but a more critical assessment yields the conclusion that freedom, despite its strategic value for problem solving, actually constitutes a problematic situation of its own insofar as it is antithetical to decision. Just so long as alternatives remain open, no specific decision can issue. A resolution among alternatives, a foreclosure of freedom, is the prerequisite of decision.

With regard to instinctive or conditioned activity, the problem of decision is solved by biological automation; species-specific programs for motor control of the human body associate perceptual judgments and expectations with "cocked" responses that are automatically triggered by specific stimulatory inputs. The decision problem generated by the acquisition of freedom via conceptual objectification is, however, quite another matter. Here the question is one of selecting, from among an indefinite number of possible objectifications, the specific cognitive model that is to serve crucially as the format of simulation, determinative to subsequent deliberative expectations, decisions and actions. We will do well to distinguish this situation as the metadecision problem inasmuch as it involves a higher order (policy) decision concerning the adoption of a format for determining subordinate (action) decisions. This is the problematic context of decision-beyond-decision that has perennially confronted the "bootstrap" operation of thinking about how to think. Freedom, in any context, is attained at the price of introducing ambiguity. Cognition opens alternatives of action that must be resolved via a simulation utilizing some particular cognitive model (essentially a theory). At the same time it opens alternatives regarding possible cognitive models that must be resolved by the adoption of some definite policy; further, it opens alternatives of policy that must be resolved by the establishment of unique organizational objectives; and, finally, it opens alternative organizational objectives that must be resolved by the envisionment of some specific principle(s) that serve, however provisionally, as ultimate commitments.

The import of this hierarchical array is the conclusion that cognitive decisions in general are actualizable only with respect to prior decisions, ultimately with respect to commitments. It is a poignant realization that this is no more than a variant of the premise with which Western philosophy began. The hard-won achievement of two millenia consists primarily in boldly facing up to this relativism that lies rooted in the nature of cognition. Relativism, as a primitive commitment, may be weakened to admit ultimate closure by absolutes determinative to decision only at the price of foreshortening our conception of human freedom. Only a thoroughgoing relativism appears to be commensurate with the kind of freedom man has by virtue of the cognitive capability--the freedom to reconstitute deliberative decisions at any level whatever, the freedom of creativity. With cognition man got freedom and, getting freedom, necessarily bore away with it the unforeseen relativity of cognitive decision--a spectre that has been the clamorous subject of radicalists in every generation.

Yet it is simply and shatteringly fallacious to suppose that relativism is necessarily obstructive to the very conception of stable and viable principles as a basis for the cognitive enterprise. What relativism does entail is an immediate demand for cognitive control, a demand for the establishment of criteria of admissibility capable of resolving ambiguity throughout the hierarchical levels of decision and metadecision. Not sheer maximal freedom but <u>optimal organization</u> appears to be finally admissible as an idealized terminal objective, an intrinsic value, for the cognitive system; and <u>decidability</u>--a condition associated with unambiguous selection among alternatives--is necessarily linked with freedom as a complementary criterion of optimality. Optimal organization, as an idealization, certainly connotes long range viability of strategic posture as well as continuous effectiveness of tactical response for the relief of stress and the attainment of immediate goals. While the potential of the cognitive system for viability and effectiveness may be maximized by the creative capability for conceptual objectification, this potential can be actualized only by a corresponding control capability implementing selection among objectifications.

As we so generally observe, the nature of a problematic situation holds the clue to its solution. In this case the reflective capability of cognition, based upon a semiotic dimension of freedom that is in itself problematic, provides also the means whereby that problematic freedom may be appropriately constrained; that is, it admits of the creative institution of successively improved criteria for the admissibility of a cognitive model, or what is the same thing, the selection among alternative cognitive models.

This problem of cognitive control, in traditional terms, is the problem of rationality; but we now pose this problem in a manner that hopefully avoids two deficiencies that have perennially obstructed an adequate treatment. First, the reductionistic tendency to associate rationality solely with categorical or logically imperative control marks a failure to recognize that the problem is essentially one of total self-organization on the part of a cognitive agent, a question of the optimal design of policies capable of providing for holistic, systemic cognitive control. This is to say that the creative institution of provisional, extra-logical criteria throughout the hierarchy of action, policy, and organizational decisions has not been explicitly construed as a legitimate aspect of the rationalization of thought. Rationality has not generally been interpreted in terms of the optimality of a system of norms incorporating the entire array of controls expressly designed to foreclose the relativism of cognitive decision and so lead to determinative prediction, prescription and action. An attempt to rationalize decisions in general is equivalent to an attempt to optimize the design of a control system for the cognitive process, where the control system must be devised by the reflexive use of the cognitive process itself. This "design-problem" interpretation of rationalization is only vaguely appreciated; and there, in short, lies the nature of the first of the two deficiencies.

The second inadequacy--actually a result of the first--is associated with the tendency of absolutism to consider the comple. of rational control as insulated from evolutionary effects, to sever the mental process of rationalization from its stem in the more general process of emergence. In contrast with the premise that human mental development involves emergent events that must be viewed simultaneously from biological-psychological-sociological perspectives, this conception presupposes that man, as the "rational animal," has a stripe that never changes. One aspect of the human personality, at least, is presumed to be exempt from modification--his rational nature. On this view of rationality as the control of thought and action in accordance with some specific set of absolute, immutable, universal principles, the admitted variability of individual and cultural commitments can be interpreted only in terms of a curious and unexplainable obliquity on the part of certain vast assemblages of heretical souls. The resolution of conflict regarding alternative conceptions of "the" universal principles can be conceived of only in terms of the violent process of dominance-suppression-revolution; and the discontinuities that are emphasized by this version of process totally obscure an otherwise notable continuity within the anthropological proliferation of distinguishable versions of rationality. By this we refer to the remarkable tendency for the thought processes of cultural victor and vanquished to become interfused, and this effect to be accompanied by subsequent discard of aspects of both versions that prove to be non-adaptive.

There are, admittedly, certain principal commitments (primarily logical in character) so fundamental to the control of thought that, since their explicit enunciation, no sane human being has been seriously disposed to suggest their modification. It is this evidence upon which the absolutist depends for intimations of universality. But these commitments are but core-elements of the multi-level, multi-stage hierarchy of ontological, epistemological, axiological, syntactic, semantic, pragmatic and aesthetic commitments that comprise the whole of a distinctive rational format. The persistent admissibility of this core no more entails its universality than does the even longer persistence of certain fundamental features of physiological design that have recurred in every lower category of the Chordate phylum. Relativism, to be sure, admits that there must exist, at the apex of any system of rational controls, a collection of ultimate commitments effecting closure and thereby serving qua absolutes--hypothetical "absolutes," if you will. But what is important as a distinction is that the entire system of cognitive controls shall be viewed, like any instrumental control system, as a modifiable feature of the overall design of an adaptive system; that such modifications--by virtue of their creative origin--shall be viewed historically as constituting an extra-biological lineage of emergent rational formats; and that the warrantability of any rational prototype shall be construed as ultimately depending upon the adaptive advantage that it confers upon the psycho-social-biological systems that utilize its control toward the attainment of optimal organization in the continuing context of emergent events.

On this view it is not conceivable that man can have or attain rationality in any unqualified sense. There is no definitive condition that can be attached to this term. "Rationality," like the term "good," denotes a completely general, idealized criterion--a concept having operational rather than substantive significance--open to any one of an indefinite number of interpretations given a specific context. It has the definite connotation of "systemic optimality of cognitive control," but this "optimality" cannot be independent of the cybernetic characteristics, objectives, norms, constraints, and the psycho-social-biological domain of interaction specific to the given cognitive system. Under the premise that all of these factors are subject to dynamic or sporadic modifications occurring in the general context of natural selection, it follows that a considerable variety of competitive versions of "rationality" must have arisen. Insofar as the very notion of process presupposes some version of process-control, it must be allowed that every cognitive agent--even a psychoneurotic one--exhibits some version of rationality. Man, therefore, may not be viewed legitimately as the rational animal but, rather, as an animal peculiarly endowed with a potential capability for extending the degree and range of his rationality, i.e., for continually enlarging the scope of his domain of interaction simultaneously with the continual refinement of his approximation to optimal systemic control.

The so-called problem of rationality is therefore not the kind of problem that anyone is ever going to solve in any sense other than the attitudinal one of purposeful alignment with an emergent process involving the indefinite extension and refinement of self-organization.

This is to admit that creativity and rationality are separable only as figments. As we saw with respect to their correlates, freedom and decidability, they must represent complementary conditions of optimal organization; and the nature of cognition must finally be understood in terms of (1) the creative function of conceptual objectification and (2) the rational function of controlled selection among objectifications.

Whatever we may ultimately come to in the way of cognitive theory, it is surely incontrovertible that certain gross features of this preliminary analysis will have to be acceded to: that the cognitive-semiotic complex constitutes (1) a creative-rational (or adaptive-control process operating to resolve (2) problematic situations (i.e., disparities between the values of actual versus potential states of a system) via (3) the construction of symbolic objectifications and the institution of (4) formal-factual-normative metacommitments that provide for the control of (5) selection among objectifications capable of determining (6) unambiguous programs of behavior that contribute toward an improved approximation to (6) optimal organization as a terminal objective under (7) the constraints of finite resources and natural (species-specific) norms of sub-systems (see the summary of Table 8.3).

EMERGENCE OF RATIONAL PROTOTYPES

In view of the evolutionary context in which our considerations have been embedded, it is immediately apparent that there can be no such thing as the rational format of cognition, no sudden discovery or unique envisionment of a definitive version of the cognitive-semiotic modality that remains indefinitely a fixed characteristic of human

Table 8.3

THE COGNITIVE-SEMIOTIC COMPLEX: FACTORIZATION

1 ADAPTIVE-CONTROL PROCESS operating to resolve

2 PROBLEMATIC SITUATIONS (disparity between values of actual vs potential states) via

3 CONCEPTUAL OBJECTIFICATIONS (symbolic systems as models),

4 SIMULATIONS (systematic manipulation of symbolic systems), and

5 NORMATIVE COMMITMENTS providing criteria for control of

6 SELECTION among objectifications and alternative

7 MODIFICATIONS OF CHARACTERISTIC RESPONSE contributing toward

8 OPTIMAL ORGANIZATION as a terminal objective under

9 CONSTRAINTS imposed by finite resources, species-specific norms of sub-systems, and given context of interaction.

response. The evidence points rather to a continuing process of modification that runs throughout the entire course of anthropological development. This, of course, does not preclude the fact that, in given eras, certain patterns or models of thought have become stabilized--usually to the point of dogma. It is just the service of the term "rational prototypes" to refer to those stable patterns which have occurred in history and which have been supposed in their time, and for long periods of time, to provide the adequate format for explanation and the control of belief and action.

At this point a premise that is rather cryptically expressed by the phrase "emergence of rational prototypes" should be made explicit. What is being presupposed is this: (1) that the continuous development of the cognitive modality is marked by one general feature, the successive displacement of models of rational thought by novel formats of cognitive organization that are capable of resolving previously obstructive ambiguities, and (2) that the succession of these emergent prototypes admits of connectivity that can be legitimately exhibited in phyletic lineages. Indeed, two major noetic "phyla"--the subjective versus objective modes of thought--are readily distinguishable in their separate courses of development through Western history, the relatively brief anthropological time-section relevant for a consideration of advances in scientific inquiry. Our interest, of course, will center upon the particular line of proliferation associated with successive versions of the objective mode--or, as it came to be called, the scientific mode.

ASPECTS OF EMERGENCE AS FEATURES OF SCIENTIFIC ADVANCE

If we have succeeded at all in laying out the essential connectivity that links the various historic formats of scientific inquiry, it will be seen in Chapter 4 that this proliferation of the cognitive-semiotic modality is marked by one most general feature--the emergence of successively dominant rational prototypes. With this general pattern before us, the major features of scientific advance are presumably identifiable as just those principal aspects of this emergent pattern that are relevant to the improvement of the cognitive modality itself. We may not pass this critical conclusion, however, without taking sharp note of the fact that, by the use of such valuative terms as "advance" and "improvement," we impute directivity to the process of emergence. This is certainly not a maneuver calculated to evoke any sense of assurance in the mind of the traditional evolutionary theorist. A simple regard for the healthy skepticism that has perennially produced in the scientific mentality a deep aversion to teleological considerations will require that we supply some cogent justification at this point.

Without fighting over the old ground of Darwin's troublesome "survival of the fittest" conception, we believe that one can provide the required justification in a most direct and satisfactory manner. The very concept of a process of natural selection that is admittedly the prerequisite to any conception of evolution, is inextricably connected with a correlative notion--that of a criterion of selection. This is to say that the specification of a criterion for the admissibility of certain definite consequences (products or properties) is an indispensable component of the specification of any process whatever. Now despite the most strenuous efforts of the biological evolutionary theorist to maintain the *sub rosa* character of his commitment, "viability" has in fact been assigned the status of a primitive value-criterion, with "adaptive range" as its index or measure. Nothing so complicated as purpose or telic design follows from this commitment, but something as simple--and crucial--as directivity does follow. The adaptive range of successive dominant systems can presumably be extended only on the basis of: (1) superior elegance, precision, and efficiency of structure and function in combination with (2) the addition of new hierarchical levels of organization that admit extensions of range and degree of systemic freedom. Any conceivable version of evolutionary process must therefore be construed as a process that selects *for* improvement, *for* advances in the sophistication and systemic optimality of organization, remembering that "optimality" must be inherently relative to a context of interaction.

It appears that this is all one needs to make the transition from the biological to the noetic evolutionary posit. If one sees in the creative innovations of new rational prototypes evidences of gestalt novelty, concrescence, systemic extension, normative innovation, subsystem specialization and negentropic gain in freedom, can one deny that the noösphere, as well as the biosphere, features directed transformations that may be legitimately interpreted as improvements or advances with respect to the stability-durability (or viability) of successive dominant formats of cognitive organization?

On this basis we may turn in good conscience to the identification of those principal aspects of the emergence of rational prototypes that, by virtue of their relevance for improvement of the cognitive modality, must represent the major features of scientific advance. These may be summarized as follows and in Table 8.4:

1) The gradual relinquishment of the "quest for certainty" with an accompanying replacement of absolutism by an alternative commitment to relativism;

2) The accretion of cognitive controls that provide increasingly adequate criteria for the admissibility (or warrantability) of conceptual objectifications (theories) in general; and finally

3) The concrescence of previously distinct theories, specialized disciplines and, lately, even disparate methodologies and cognitive modes resulting from the acquisition of more general conceptual formats (although note that every concrescence admits of a reorganized disciplinary taxonomy by partitioning under newly relevant parameters).

If the previous account of the emergence of scientific prototypes has adequately served its purpose, little justification will be required here for the selection of these aspects of emergence as major features of advance. The slow demise of absolutism in science may readily be tracked through the successive models of scientific thought. The gradual accretion of formal, experiential, aesthetic, and evolutionary controls for the theorizing process is a development almost impossible to miss, although an important recent amplification of this feature already

Table 8.4

MAJOR FEATURES OF SCIENTIFIC ADVANCE

ACCOMODATION

Relativity of Cognitive Decision

ACCRETION

Criteria of Admissibility as Cognitive Controls

CONCRESCENCE

Paradigms of Rational Inquiry

exists in unpublished work.* The continuing concrescence of cognitive models has been reasonably documented in the account of the amalgamation of formal and experimental science, the reduction of special sciences to more general ones, and the description of the present trend toward methodological and modal unification via philosophical reconstruction (see Table 8.5).

Presumably, the real question remaining is whether this limited collection is sufficient, whether it adequately encompasses the principal features of advance. In the interest of conviction on this point, consider what aspect of improvement in the cognitive modality each of these features is addressed to. Taking them in order: (1) the relinquishment of absolutism and the ascendancy of relativism are associated with the maximization of freedom; the commitment to conceptual relativism renders the cognitive enterprise open-ended, that is, open to indefinitely extendable creativity. (2) The accretion of an increasingly holistic collection of criteria for selection among alternative theoretical models is associated with the optimization of systemic control; in terms developed earlier, this effect may be described quite literally as improved rationalization of the cognitive modality. (3) Concrescence of previously disparate cognitive formats may be interpreted as a tendency toward "analogical conformity," toward the realization of a generalized metatheoretical model such that the form of any specific object-theory could be construed as homomorphic to this single rational prototype. So interpreted, concrescence must be associated with maximization of scope for the cognitive

*A manuscript on the theory of cognitive controls disclosing results of research by N. M. Smith in advance of publication.

Table 8.5

ASPECTS OF "IMPROVED" COGNITIVE MODALITY

Accomodation (relativity)	FREEDOM (Maximization)	Creativity
Accretion (holistic criteria)	CONTROL (Optmization)	Rationality
Concrescence (rational paradigms)	SCOPE (Maximization)	Universality (extensionality)

enterprise; for this effect, involving as it does the extremalization of generality, we have no alternative but to term it the "universalization" of the cognitive modality.

We submit to you the claim that (1) maximal freedom, (2) optimal control, and (3) maximal scope are precisely the minimally sufficient criteria of an "optimal cognitive modality"; and, further, that the long-standing strategic trends toward (1) conceptual relativism, (2) accretion of cognitive controls, and (3) concrescence must represent <u>the</u> principal features of scientific advance inasmuch as they collectively comprise the characteristic response of an indefinite community of cognitive agents whose general adaptation has apparently been oriented by these criteria associated with creativity, rationality, and universality.

Do we not see in this collection of historic trends an adequate schemata for perceiving--within the confusing complex of human inquiry--an emerging design of cognitive organization, a design as awesome as that of evolutionary nature since it is <u>of</u> nature? Do we not see a way of describing what it is that the cultural animal has always been in the business of doing: namely, optimizing his organization and, in the case of science, doing this via a reflexive, second-order optimization of the cognitive modality that is apparently the crucial agency of his largest purpose.

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