Erkenntnis 13 (1978) 261-278.

Testability, Disreputability, and the Structure of the Modern Synthetic Theory of Evolution

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I

Philosophers and scientists often voice the complaint that despite the apparent comprehensiveness and theoretical ornateness of modern-day evolutionary theory, the theory is somehow less reputable than the theories used in the physical, chemical, and social sciences. This avowed distaste for the modern synthetic theory can take the forms of a stronger and a weaker thesis. The stronger claim, which might be labelled the contemptibility thesis, maintains that evolutionary theory is worthless since it amounts to no more than a simplistic tautology to the effect that those organisms that survive are fit, and, those that are fit, survive. Given the relative immunity of tautological propositions from refutation or test by empirical facts, proponents of the contemptibility thesis would claim that tautologies are hardly the stuff of which useful scientific theories are made.[1]

The weaker thesis concerning the dissatisfaction many commentators feel in confronting contemporary evolutionary accounts might be labelled the disreputability thesis. This view does not deny that contemporary evolutionary theory is non-tautologous in character, but, evolutionary theory seems more prone than most theories to a number of serious defects and ailments.[2]

Firstly, evolutionary theorizing is rarely sullied by any specific predictions or retrodictions concerning organic events at any level of biological organization.

Secondly, the theory seems to possess a disquieting amount of elasticity or flexibility with regard to explaining organic phenomena. Anything and everything in the empirical biological world seems to be compatible with evolutionary explanations. Refuting evidence or crucial experiments that could realistically jeopardize an evolutionary account seem extremely few and far between.

Thirdly, evolutionary theorists seem willing to assume and postulate mechanisms, variables, and conditions almost willy-nilly in their attempts to explain evolutionary changes. In evolutionary explanations the theorist simply assumes everything he needs to make the explanation work. There seem to be few if any restrictions on the hypotheses and conditions that can be posited to explain the most peculiar and bizarre examples of biological diversity and change.

Fourthly, evolutionary theory is frequently alleged to have little systematic power or theoretical robustness. Its models and explanations are not heuristically useful or provocative and, since it is difficult to get a handle on what the theory's content and scope is, it is difficult to say how well the theory succeeds in drawing together a body of empirical data. Finally, the disreputability thesis contains a fifth component change to the effect that the theory is significantly poorer, both with respect to its ability to generate predictions, and

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with respect to its capacity for empirical refutation, falsifiability, and testability, than are theories from other domains of scientific inquiry. Thus, not only are the absence of predictions, crucial experiments, and refuting instances endemic to evolutionary theory itself, but these attributes and characteristics are absent to a degree significantly higher than that found in other scientific domains.

It should be noted that few proponents of the disreputability thesis have articulated all of the component claims which have been presented as constituting this thesis. But it seems fair to say that each of the component charges against evolutionary theory has, in fact, been made at one time or another by critics of the theory and that, furthermore, the amalgam of claims presented under the rubric of the disreputability thesis are the tacit motive sources for much of the disquiet and distaste philosophers and scientists frequently experience when confronted with contemporary evolutionary accounts.

A good deal of critical attention has been directed at the contemptibility and disreputability theses by philosophers and evolutionary biologists concerned to defend evolutionary theory against the critical claims contained in these theses. The contemptibility thesis is usually dismissed as frivolous since evolutionary theory would seem to contain more than a single tautological premise concerning survival and fitness.[3] Minimally, there are a series of existential claims made in the modern synthetic theory of evolution concerning the existence of certain factors or genes, the existence of some amount of variation among these genes in their distribution patterns among organisms, and a claim about the differential reproduction of organisms that is to some degree correlated with their particular genetic make-up. In addition to these existential propositions, which surely admit of empirical confirmation and test, it is doubtful whether survival and fitness can really be analytically defined to fit the requisite tautological propositional form since, as the history of evolution clearly shows, survival and fitness do not always go hand in hand.

Assuming that these sorts of counter-instances are sufficient to give the lie to the contemptibility thesis, the problem still remains of addressing the more serious and substantive concerns expressed in the claims of the disreputability thesis. Although proponents and opponents of both these theses often neglect the fact, it should be evident that any serious analytical evaluation of evolutionary theory cannot progress very far without some attempt being made to explicate the contents of the theory itself. In order to make a proper assessment of the disreputability thesis, it is necessary to have available at least a brief synopsis of the modern synthetic theory of evolution.

II

Evolutionary theory is akin to theories in other scientific domains in at least one respect – it is not a static theory, but, a dynamic one that has undergone supplementation, revision, correction, and change over the years. Without becoming bogged down in the current debates concerning theoretical identity, theory change, and theory replacement, it does seem valid to distinguish at least three major versions of evolutionary theory that have retained enough historical continuity to be labelled as distinct versions of biological evolutionary theory; Darwin's theory, the synthetic theory of evolution, espoused by biologists such as R.A. Fisher, J.B.S. Haldane, Sewall Wright and S. S. Chetverikov, which attempted to integrate Darwin's selectional theory with classical and population genetic theory,[4] and, the modern synthetic theory of evolution most familiar from the writings of biologists such as G. G. Simpson, Julian Huxley, Ernst Mayr, Theodosius Dobzhansky, and G. L. Stebbins.[5] Since the disreputability thesis is of greater scientific interest if it can be validly affirmed against the modern synthetic account, it is this version of evolutionary theory that will constitute the focus of expository concern.

As is well known, Darwinian evolutionary theory was plagued by the absence of an accurate understanding of genetics and of the genetic mechanisms of recombination and replication. While Darwin, in his theory of pangenesis, made some tentative efforts at constructing a genetic theory of factorial inheritance, the brunt of his theoretical attention was directed at understanding factors in the physical and biotic environment that act as sources of eliminative selection of organic diversity. With the rediscovery of the work of Mendel and the rise of classical Mendelian genetics, it became possible for synthetic evolutionary theorists, such as Haldane, Fisher, Wright and the Russian population geneticists, to supplement the Darwinian account of evolution with an account of the basic mechanisms for generating genetic variation within populations of organisms – mutation, recombination, and genetic drift. The synthesis of Darwinian selection theory with classical genetics allowed the synthetic evolutionary theorists to construct idealized models of gene flow within interbreeding populations that could chart and predict the likely consequences of fluctuations in the values of mechanisms of genetic variation, population size, and selectional factors.

To a certain extent, much of the work of the modern synthetic theorists consisted of testing the empirical adequacy of the idealized mathematical models of the synthetic theorists against the real world conditions found to prevail in nature among observed populations of organisms. However, their contributions to evolutionary theory consist of important theoretical as well as empirical supplementations.

Firstly, the modern synthetic theorists attempted to provide an adequate set of mechanisms to account for the process of speciation in the organic world. Their empirical observations led them to realize the importance of isolating mechanisms upon gene flow between populations. Biological mechanisms, such as sterility, mechanical isolation, gamete and zygote mortality, seasonal and behavioural barriers as well as geographic isolating factors such as oceans, forests, deserts and ponds, and, environmental mechanisms such as climate, salinity, and food resources, were seen as central in attempting to account for the rise of new species and sudden bursts of evolutionary change and biological expansion. The attention to speciational processes and the generation of organic change above the level of interbreeding populations of organisms gave rise to a host of new biological fields such as biogeography, mathematical ecology, behavioural biology and population demography. Whereas earlier theorists had focused theoretical attention upon the process of evolution and change between interbreeding groups of organisms, the modern synthetic theorists were able to provide a theoretical account for both the genesis of new populations or species of organisms, and, for evolutionary changes in groups of organisms that did not exchange genetic information.

Secondly, the modern synthetic theorists were able to supplement the earlier synthetic account of the population geneticists with empirical information concerning the kinds of changes in the rate and direction of evolutionary change over long periods of time. Close attention to the functional and morphological properties of fossil organisms, as well as to the patterns of fossil distribution and the ecological limitations of ancient biotic and physical environments, allowed the modern synthetic theorists to explain observed rates of evolutionary change, the rise of higher taxa of plants and animals, the trends, directions, and extinctions to be found in the fossil record, and the distribution patterns of organic species. Functional anatomy, paleoecology, mathematical selection theory and mathematical paleobiology are a few of the disciplines that arose in response to the attempt to explain empirical findings concerning historical evolutionary change.

While there are numerous other important theoretical additions that could be cited, such as the attempt to incorporate the findings of molecular biology into the classical Mendelian account of genetic variation, the renewed interest in developmental variation among organisms as a source of organic or phenotypic diversity, and the close attention to the explanation, in both historical and mechanical terms, of specific adaptations, behaviours, and strategies in individual organisms, these two substantive contributions give an adequate idea of the character of the modern synthetic theorists' contributions to earlier theoretical efforts.

While it is, of course, somewhat difficult to lay out the exact boundaries of any particular theory at a given time, it seems plausible to argue that the modern synthetic theory differs from its predecessors in that the scope and aims of the modern account have significantly widened since Darwin's day, Whereas Darwin saw his charge primarily as being that of giving a theoretical account allowing for the possibility of organic change, and, an explanation of organic diversity and distribution, the modern synthetic theory takes on the multiple tasks of accounting for change and diversity both within and between populations, of reconstructing and explaining evolutionary history, of explaining genetic, developmental, individual, speciational, and group diversity, of accounting for phenotypic and behavioural diversity and function, of explaining variations in evolutionary rates, strategies, trends, and directions, and of explaining the origin and functional role of individual and social traits and features. As the base of empirical data has grown, and, as the set of known evolutionary phenomena has grown, the modern synthetic theory has had to expand its theoretical scope and purvue to cope with the increasing number of questions and problems that have arisen concerning evolutionary phenomena.

One final comment on the content of the modern synthetic theory is in order. It might be objected that the distinction between the modern synthetic account and its immediate predecessor, the synthetic theory, is still unclear since, to a large degree, much of the work of the modern synthetic theorists seems to have been to apply various components of the population genetic account to a variety of empirical and historical evolutionary phenomena and to simply baptise these applications with glorified disciplinary names such as mathematical paleobiology or mathematical ecology. However, this claim does not appear to be a valid description of the differences between these two evolutionary theories. A law, such as Van Valen's Law concerning rates of evolutionary change to the effect that, within an ecologically homogeneous taxonomic group, extinction occurs at a stochastically constant rate, or, the lawlike proposition of mathematical selection theory which maintains that in highly unstable, fluctuating environments, species will tend to adopt reproductive strategies of rapid reproduction, high dispersal, and accelerated sexual maturation, seem to be independent of population genetics *per se* (although consistent with its tenets), and, to attend to phenomena and problems well outside the scope of the earlier synthetic account.

III

Having laid out, at least in a preliminary fashion, the tenets and content of the modern synthetic theory of evolution as it appears in the writings of its biological progenitors, one further digression is necessary as a prerequisite to examining the validity of the disreputability thesis as it applies to the modern synthetic account. For not only is it necessary to have some idea of what evolutionary biologists conceive as constituting the theory's content in order to properly assess the disreputability thesis, but it is also necessary to have some idea of how philosophers have traditionally tried to analyze the structure, scope, and contents of theories in science.

Richard Rudner in his book *The Philosophy of Social Science* presents a rather representative view of philosophical conceptions of scientific theories. Having declared that "the structural characteristics of a social-science theory are precisely the same as those of any other scientific theory,"[6] Rudner goes on to state that "a theory is a systematically related set of statements, including some law-like generalizations, that is empirically testable."[7]

Rudner then goes on to explain further what is meant by the systematic relationship of a set of statements. This relationship, in his account, and, in innumerable other discussions of scientific theories, is explicated as the familiar tripartite component view of the structure of scientific theories well known from the work of Carnap, Tarski, Hempel, and Nagel, among others. This view of scientific theories, which has, of late, come to be known as the "received view,"[8] divides a theory into an abstract calculus, a set of correspondence rules or bridge principles, that assign empirical content to the component elements of the abstract calculus by relating the primitive terms and well formed formulas of the calculus to descriptions of empirical or experimental real-world events, and, an interpretation or model for the abstract calculus which fleshes out the logical structure of the deductively organised statements of the calculus in terms of more or less familiar conceptual or vizualizable materials. Such is the stuff of which scientific theories are thought to be made.

In addition to this compositional analysis of scientific theories, the received view specifies the nature of the systematic organization to be found among these component elements. Theories are held to be deductively organised in a hierarchy that is analogous to the deductive structure found in Euclidean geometry. All the laws and propositions of a theory are seen as deducible from a core set of axioms or premises. A deductive axiomatic pyramid is thought to be the single valid model of structural analysis for all theories in science. The deductivist thesis is thought to be universally representative of the systematic organization of scientific theories.

Rudner's comments concerning social-scientific theories are illustrative of the views of devotees of the received view of scientific theories. His claims, and the dual claims of the received view that the structure of scientific theories is correctly given for theories from any field by the tripartite compositional and deductivist analyses can be labelled structural uniformitarianism.

In specifying the nature of scientific theories Rudner also alludes to the fact that law-like generalizations ought to appear as a part of the constitutional makeup of a theory. Since proponents of the received view of scientific theories root the explanatory efficacy of such theories in the ability to arrive at conclusions via induction or deduction from statements that are universal in form, Rudner's attention to law-like statements can be seen as an elliptical reference to the general validity of standard nomological-deductive, statistical-deductive, and inductive-statistical accounts of explanation in scientific theories. The claim that explanation works the same way in any scientific theory also constitutes a key claim of the received view which can be referred to as explanatory uniformitarianism.

There has been a certain degree of tension between proponents of structural and explanatory uniformitarianism as to the descriptive nature of these theses.[9] Whereas some philosophers view these claims as accurate analyses of scientific theories on empirical analytical grounds, others see such views as being normative or valuational in character, prescribing idealised or desirable characteristics that good scientific theories ought to manifest. However, both the descriptive and prescriptive views of philosophizing about scientific theories presuppose the truth of both methodological and explanatory uniformitarianisms in analyzing scientific theories from any area or field. Both of these uniformitarian claims are central to the view that a universal or unified analysis can be given for all theories utilized in scientific inquiry.

A good deal of criticism has been directed against both methodological and explanatory uniformitarianism. Some philosophers have argued that there are disparate modes of explanation to be found in scientific theories, i.e., genetic, narrative, colligatory, empathetic and historical modes of explanation, which do not fit standard N-D or I-S models of explanation. And many philosophers have attacked the entire enterprise of the logical reconstruction of theories as both overly idealised and distorting of actual scientific theorizing. Moreover, many criticisms have been levelled against the structural uniformitarian thesis on the grounds that it is impossible to isolate theoretical or observational terms of a theory, or, to formulate valid bridge principles between an abstract calculus and a set of observational statements of heuristic models.

Surprisingly, however, the structural uniformitarian claim, that all theories in science can be treated as a set of deductively related propositions, laws, theorems, and axioms akin to the axiomatizible constructions familiar from Euclidean geometry and set theory, has received little critical attention. And it is this aspect of the structural uniformitarian thesis concerning theories, the notion that theories are hierarchically organised deductive systems, that becomes pivotal in assessing the philosophical response to the disreputability thesis concerning the modern synthetic theory of evolution.

IV

There has been a strong suspicion among a number of philosophers of science that if the modern synthetic theory of evolution could be shown to be axiomatizable and, thus, subsumable under the key uniformitarian theses of the received view of scientific theories, such a demonstration would go a long way toward showing the disreputability thesis to be incorrect. The firmness of the belief that an illustration that evolutionary theory has a structure akin to that of theories in physics and chemistry would go a long way toward allaying the doubts of these who worry about the absence of predictions, tests, and disconfirming evidence in evolutionary writings, can be seen in the efforts of at least one evolutionary biologist to credit Darwin with the formulation of both the N-D model of explanation, and, an axiomatic set of hierarchical evolutionary laws and principles. A number of philosophers, among them Michael Ruse and Mary Williams, have gone to great lengths to provide axiomatizations of evolutionary theory that conform, in all respects, to the tenets of structural and explanatory uniformitarianism.

Williams, for example, in a series of articles,[10] has argued that it is possible to deduce all the tenets of modern evolutionary theory from a small set of primitive terms, well formed formulas, and axioms. Using axioms about primitive terms defined as clans in terms of the biological relations of parenthood and ancestry, she presents a set of axioms concerning fitness and numerical size which can successfully generate a set of theorems concerning population expansion, survival, and fitness which, Williams feels, constitute the essence of the modern synthetic theory.

Ruse, in a variety of books and articles,[11] argues that the modern synthetic theory of evolution has the requisite structural and explanatory attributes to establish its legitimacy as a theory since it is possible to reconstruct all of evolutionary theorizing as a well-developed body of axiomatizable laws derivable from a core set of nomological principles and primitives supplied by population genetics. Ruse claims that, ultimately, the principles invoked by evolutionary biologists in fields as diverse as ecology, systematics, and paleontology can all be derived from the tenets of population genetics which has the Hardy-Weinberg law of gene ratios as its overriding theoretical premise.

Both of these axiomatic enterprises have as their aim the legitimation of the synthetic theory by the demonstration of structural familiarity. Both Ruse and Williams contend that the theory can be seen to offer predictions and retrodictions, to possess systematic power, to have empirical limits on hypothesizing, to be amenable to empirical test, and, to be akin to theories from other domains once axiomatization reveals the hierarchical nomological deductive structure of the theory.

The assumption seems to be that if the requisite compositional and deductivist models can be shown to be instantiated by contemporary evolutionary theory, then the other distinctive characteristics of acceptable or legitimate scientific theories, predictions and explanations, must be present somewhere in the evolutionary literature.

V

The value of axiomatization and of correctly elucidating the proper structure of a theory would seem to be plainly evident in the efforts of Ruse and Williams in silencing those who advocate the disreputability thesis against evolutionary theory. Unfortunately, however, there are serious problems with both of their structural analyses. Neither of the axiomatizations bears much resemblance to the sorts of laws, propositions, and descriptions found in the actual writings of contemporary evolutionary theorists. Moreover, there is more hand waving than substance behind the claim that all elements of the modern synthetic account can be validly deduced from a core set of partially defined primitive terms, first order predicate calculus, and evolutionary axioms – the deductions, for the most part, are not provided.

Moreover, whereas Ruse makes much of the centrality of population genetics in his account, Williams makes almost no use of the theories and laws of this field in her analysis. And both Ruse and Williams claim that their axiomatizations can be validly used to describe both the Darwinian and the modern synthetic accounts of evolutionary theory, a claim which seems most bothersome in light of the theoretical differences between these versions of the theory. Finally, the supposed benefits of showing the structure of evolutionary theory to be akin to the structure of legitimate theories in other disciplines, in terms of predictions, tests, and systematic power, pale somewhat in comparison to the content and frequency of predictions, disconfirmations, and tests to be found in actual, contemporary evolutionary accounts.

Surprisingly little has been written about the criteria to be used for assessing proposed axiomatizations of scientific theories. But it would seem that one minimal or necessary requirement is that the axiomatization generate a set of propositions and theorems that correspond very closely to the actual laws and theorems used by the empirical scientists themselves. Given this minimal requirement, neither Williams' or Ruses axiomatizations appear to be acceptable.

While it would certainly be worthwhile to refute the disreputability thesis by a careful structural and explanatory reconstruction of evolutionary theory, the resulting products appear to leave too large a gap between actual evolutionary theorizing and the axiomatic analytical products of Ruse and Williams. In trying to fit the modern synthetic theory into the received view of scientific theories, Ruse and Williams seem merely to emasculate the theory beyond recognition and to generate theoretical legitimacy at the cost of descriptive accuracy. Indeed it is doubtful whether the predictions, tests, and laws arrived at by such axiomatic efforts are likely to satisfy proponents or critics of the disreputability thesis.

VI

Let us suppose for the moment that the proponents of the disreputability thesis are correct, that evolutionary theory is hard to test, that it makes few predictions, that it is difficult to assess its systematic powers, that it does have an air of *ad hoc*ness about its explanations, and that it is worse off in all these respects than theories from other scientific fields. These facts may tell us something about the utility and worth of the modern synthetic theory, or they may instead tell us something about the utility and worth of the tenets of structural and explanatory uniformitarianism of the received view of scientific theories. It is the latter alternative that, I think, holds the key to refuting the disreputability thesis about evolution.

While there has been a good deal of critical attention directed at the component analysis of the received view of theories, little critical attention has been directed against the idea that all theories have the same systematic relationship among their axioms, laws, primitives and theorems[12] – that all theories must be, or at least be amenable to being organised as, hierarchical sets of nomological premises deducible from a single core of basic axioms. Since the argument underlying this structural claim would seem to be dependent upon the hope of maintaining explanatory uniformity among all scientific theories, an alternative structural model that could preserve this unity, but, offer an alternative view to the deductivist view of theory structure would obviate the need for empirically adequate axiomatizations of evolutionary theories, as well as, perhaps, shed some light on the reasons why the disreputability thesis seems to have some warrant against the modern synthetic theory of evolution.

A number of years ago Morton Beckner, in his book *The Biological Way of Thought*,[13] suggested that evolutionary theory might have a structure disparate from that found in theories in other domains of science. His idea was that the synthetic theory consisted, not of a deductively organized pyramid of axioms, theorems, laws, and lemmas, but, rather, of a loose set of laws, law sketches, models, and propositions that bore no deductive relationship to one another. While Beckner did not develop this interesting suggestion any further, he did note that some of the difficulties in testing evolutionary theory might be traceable to its particular structural character.

Beckner's insight as to the inadequacy of structural uniformitarianism for describing the modern synthetic theory of evolution is quite suggestive. Perhaps it is the case that what is needed to describe the structure of this theory is not an axiomatisation, but, a different model of theory structure in empirical science. If the deductivist requirement of hierarchical organization for all scientific theories is waived, it becomes possible to formulate an alternative model of theory structure that retains both compositional and explanatory uniformity and also accurately describes the modern synthetic theory as it is utilized by contemporary evolutionists.

Suppose Beckner's view is modified to state that the modern synthetic theory is not a set of models, statements, and laws, but, instead, is a set of sub-theories, theories, and theory-sketches, which themselves can be deductively organised. Explanations and predictions can be deductively or inductively generated from component theories, but, the overall theory does not have this sort of systematic organization. On this 'ordered-set' conception of theory structure in science some theories must be described as amalgams or collections of sub-theories, theory-sketches, quasi-theories, and full-blown theories which are collectively utilized by empirical scientists under the rubric of a single theory.

Disciplines such as population genetics, demography, mathematical ecology, and behavioural biology do not seem to be deductively related. Williams and Ruse are only able to make evolutionary theory appear to be deductively related by emasculating the contents of their axiomatizations into caricatures of the modern synthetic theory. Biologists can, and historically have, done a good job of explaining genetic events within populations by means of population genetic theory by itself without making use of or having access to the findings of systematics, demography, paleoecology, behavioural biology, and the rest of the subspecialties of the modern synthetic theory. And the same is obviously true of practitioners in other areas of evolutionary biology.

The question then becomes one of asking why a particular set of theories, disciplines, or fields, that may themselves be hierarchically organized and utilize standard models of explanation and the like, should be referred to as a theory. In part the answer is a semantic one – such sets of disciplines could be referred to as supratheories or compositional theories, but, such labels would not correlate well with scientific usage or biological description. Moreover, what Beckner failed to notice was that evolutionary theory is not simply a set of random elements lumped together under a convenient rubric, but, rather is an ordered, unified set of disciplines. The order or unity is provided in five ways:

First, there is a causal etiology concerning the entities of biological evolution that describes various levels of biological organization and interrelation. The familiar causal litany runs thus; genes produce enzymes which make proteins, which develop and produce traits, which produce behaviours and reproductive strategies. The environment interacts with observable traits and behaviours to eliminate some and favour others who get their genes into the next generation and start the cycle again. This causal etiology unifies the synthetic theory by showing which component disciplines are instantiated or appropriate to the level of biological organization or interaction under investigation. Developmental biology and classical genetics are relevant to a discussion of gene-trait production, while population genetics and ecology are appropriate for environment/population interactions.

Second, the set of evolutionary disciplines and theories which constitute the synthetic theory are unified by their common concern with a particular set of biological phenomena and events. Psychoanalysis or hydraulics could not be included in the set of theoretical elements constituting the modern synthetic theory since the empirical domains of these theories do not overlap with those of genetics, paleontology, and population ecology. It is the commonness of problems and interests that lends theoretical unity and systematic power to the modern synthetic theory.

Third, there is a large mass of observations, empirical facts, measurements, and scientific descriptions that all of the component theories and fields of the set have in common. While it may be the case that all observations in science are 'theory-laden' to some degree, not all observations or facts are bound or relative with respect to the same theories. Thus, the population geneticist, the systematist, the functional morphologist, and the ecologist can all make use of facts and findings from cytology, natural history, geology, biochemistry, biophysics, and field observations. These factual statements and observations that form the empirical foundation of evolutionary science are held in common by all the disciplines of the modern synthetic theory and serve to unify the independent theory elements into a single theory.

Fourth, for some component theoretical elements of the set of theories and theory-sketches that constitute the modern synthetic theory theoretical unity and ordering arises from the fact that certain derived predictive or explanatory descriptions or statements from one sub-theory constitute the descriptions and statements for the initial conditions and boundary conditions of another sub-theory. For instance, when the bio-geographer shows that it follows from certain laws of bio-geographical theory pertaining to dispersal rates and population distribution that a high level of migration is necessary to maintain successful reproduction, such conclusions frequently form some of the assumptions utilized by the population geneticist and the ecologist in understanding gene flow and reproductive strategies in their disciplines.

Fifth, even though the component elements of the modern synthetic theory are not deductively related, the laws, generalizations, and assumptions of the component theories must be internally consistent with one another. Paleontologists cannot assume some sort of Lamarckian inheritance to have been at work in the past given the concurrent assumptions and laws of population genetics and behavioural biology. While these disciplines are not deductively related they do impose constraints upon the theoretical postulations that are admissible for any evolutionary explanation or prediction.

Component theories on the ordered-set view are also unified as a consequence of inter-theoretical consistency as well as intra-theoretical consistency. It will hardly do for geologists to maintain a catastrophic theory of geological change while modern synthetic theorists assume some sort of geological gradualism. Similarly sociology, anthropology, psychology, economics, and chemistry limit the degree to which evolutionists can make assumptions and postulations. Limits on what goes into the set of members of evolutionary theory are determined both by internal and external requirements. The same limitations would seem to be true for the ordering and relationship of component elements to each other.

If this view of the structure of the synthetic theory is accepted, a number of interesting consequences follow immediately. Such a structural view of theories affords the preservation of explanatory uniformitarianism, since each discipline or sub-theory may be hierarchically and deductively organized, thereby generating the standard sorts of explanations found in other sciences, while accounting for some of the problems underlying the disreputability thesis given the structural properties of the synthetic account. Secondly, it broadens philosophical understanding of how scientific theories are testable since it can be seen that theoretical inconsistency vis à vis component theories can serve just as well as empirical cases to test theoretical validity. Theoretical incompatibilities of a reductionistic sort, say between molecular biology and a Lamarckian theory of genetics, or a cross-disciplinary sort, say between ecological catastrophism and the gradualism of population genetics, may jeopardize the validity of the synthetic account.

Thirdly and, most importantly, the ordered set view of theory structure admits the validity of some of the tenets of the disreputability thesis and succeeds in both pinpointing their source in the structure of the theory, and, in defusing much of the challenge of the thesis by both pinpointing ways in which the theory can be tested, and, by broadening philosophical conceptions of what scientific theories are like. Once the structure of the synthetic theory is clearly understood, its systematic and synthetic power becomes evident. The absence of predictions from contemporary evolutionary accounts can be partially understood as a function of the large number of initial conditions, boundary conditions, and law-like statements from a large number of fields that have to be supplied in order to arrive at a specific empirical consequence. Conversely, some of the *ad hoc*ness of synthetic theorizing can be seen to reside, not in the flexibility or weakness of the theory, but, in the large number of disciplines and conditions that must be utilized and instantiated in attempting a large number of evolutionary explanations. Finally, given the ordered set conception of evolutionary theory, it becomes easy to understand why the theory is so difficult to test since significant sub-portions or component elements of the theory could be rejected without jeopardizing the theory as a whole. Indeed, it becomes possible to understand why a number of theoretical developments in current evolutionary theorizing have provoked so much controversy. Sociobiological models of genotype selection, group selection models, vicariance theories of speciation, and catastrophic theories of paleontological change, are all models which challenge the adequacy of the causal etiology or ordering that has been suggested as constituting the unifying link for the synthetic theory.

Finally, an alternative model of theory structure such as the ordered set conception may prove helpful in understanding theories in other disciplines which are plagued by analogous versions of the disreputability thesis. Theories in sociology, developmental psychology, molecular biology and psychoanalysis, which have been traditionally accused of being difficult to test and lacking in predictive and systematic power, may be analyzable in terms of this model of theory structure, and, thus, be viewed in a more favourable light.[14]

VII

Whether or not one accepts the suggestion that attempts to counter the disreputability thesis concerning evolutionary theory by forcing the theory into an axiomatic structure be abandoned in favour of loosening the structural uniformitarianism of the received view of theories, a few issues emerge from this discussion that seem to demand further philosophical inquiry. It is not evident that a commitment to the unity of scientific method demands a commitment to structural uniformitarianism about scientific theories. Nor does explanatory uniformitarianism presuppose the validity of such a view. Nor does it seem fair to demand high philosophical standards of testability, systematic power, and predictability of scientific theories that seem to adequately serve the explanatory needs of empirical scientists for purely logical or philosophical reasons. The logical analyses of philosophers of science, which were undertaken as purely descriptively adequate enterprises, may have grown prescriptively unwieldy. Finally, the visible amusement of many evolutionary biologists at the logical fretting of philosophers and non-biological scientists concerning the status of the modern synthetic theory of evolution should give philosophers pause as to whether their analyses of theories are meant to illuminate what empirical scientists do, or, whether the work of empirical science is undertaken solely to confirm the philosophical analyses of philosophers of science.[15]

NOTES

[1] See for example A. R. Manser, 'The Concept of Evolution', Philosophy, Vol. XL, 1963, pp. 18-34. Also A. D. Barker, 'An Approach to the Theory of Natural Selection', Philosophy, Vol. XLIV, 1969, pp. 271-290, and, R. H. Peters, 'Tautology in Evolution and Ecology', The American Naturalist, Vol. 110, No. 971, January-February, 1976, pp. 1-12.

[2] See for example, M. Scriven, 'Explanation and Prediction in Evolutionary Theory', Science, Vol. 130, 1959, pp. 477-482. See also Chapter 3 of D. Hull, Philosophy of Biological Science, Englewood Cliffs: Prentice-Hall, Inc., 1974 for a discussion of these claims.

[3] A. L. Caplan, 'Tautology, Circularity, and Biological Theory', The American Naturalist, Vol. 101, March-April 1977, pp. 390-393.

[4] For an interesting account of this synthesis see W. B. Provine, The Origins Of Theoretical Population Genetics, Chicago, University Press, 1971.

[5] Representative texts for the modern synthetic theory are T. Dobzhansky, Genetics *of the* Evolutionary Process, New York: Columbia University Press, 1970 and Ernst Mayr, Animal Species and Evolution, Cambridge: Harvard University Press, 1963.

[6] R. Rudner, Philosophy of Social Science, Englewood Cliffs: Prentice-Hall, Inc., 1966, p. 10.

[7] R. Rudner, Philosophy of Social Science, Englewood Cliffs: Prentice-Hall, Inc., 1966, p. 10.

[8] For a discussion of the received view see F. Suppe, 'The Search for Philosophic Understanding of Scientific Theories' in F. Suppe, (ed.), The Structure of Scientific Theories, Urbana: University of Illinois Press, 1974, pp. 16-62.

[9] P. Suppes, 'The Desirability of Formalization in Science', Journal of Philosophy, Vol. 65, 1968, pp. 651-664, and C. G. Hempel, 'On the "Standard Conception" of Scientific Theories', in M. Padner and S. Winokur eds., Minnesota Studios in the Philosophy of Science, Vol. IV, Minneapolis: University of Minnesota Press, 1970, pp, 142-163.

[10] M. H. Williams, 'Deducing the consequences of evolution: a rnathematical model', Journal of Theoretical Biology, Vol. 29,1970, pp. 343-385, and M. H. Williams, 'The Logical Status of the Theory of Natural Selection and other Evolutionary Controversies: Resolution by Axiomatization', in M. Hunge, ed., The Methodological Unity of Science, Dordrecht: D. Reidel, 1973, pp. 84-102.

[11] M. Ruse, The Philosophy of Biology, London: Hutchinson, 1973, chapter 4.

[12] One exception to this lack of attention is A. Kaplan, The Conduct of Inquiry, San Francisco: Chandler, 1964, chapter 8. In his discussion of types of theories Kaplan distinguishes what he terms concatenated theories from hierarchical theories. However, he does not push the distinction very far.

[13] M. Beckner, The Biological Way of Thought, Berkeley: University of California Press, 1968, pp. 159-160.

[14] The ordered-set model of theories might be viewed as a way of depicting scientific theories in the process of change and reformulation rather than as an ideal or goal toward which scientists in ail fields ought to strive. It seems to me whether one counts this as a benefit will depend upon one's view of the role of philosophical analysis of scientific theories as being prescriptive or descriptive. I would not want to argue that the modern synthetic theory in some future version will never be axiomatizable. My claim is the weaker one that at present it seems implausible and that the ordered-set view provides a more accurate account of the structure of the actual theory.

[15] An earlier draft of this paper was presented at the Pacific Division meeting of the American Philosophical Association in Berkeley, California, March 25, 1976. I am greatly indebted to my commentator, Morton Beckner, for the comments and suggestions he made at that meeting.