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HOMAGE TO CLIO, OR, TOWARD AN HISTORICAL PHILOSOPHY FOR EVOLUTIONARY BIOLOGY

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Abstract.—Discussions of the theory and practice of systematics and evolutionary biology have heretofore revolved around the views of philosophers of science. I reexamine these issues from the different perspective of the philosophy of history. Just as philosophers of history distinguish between *chronicle* (non-interpretive or non-explanatory writing) and narrative *history* (interpretive or explanatory writing), I distinguish between *evolutionary chronicle* (cladograms, broadly construed) and narrative *evolutionary history*. Systematics is the discipline which *estimates the evolutionary chronicle*.

Explanations of the *events* described in the evolutionary chronicle are not of the covering-law type described by philosophers of science, but rather of the how-possibly, continuous series, and integrating types described by philosophers of history. Pre-evolutionary explanations of *states* (in contrast to chroniclar events) are still widespread in "evolutionary" biology, however, because evolutionary chronicles are in general poorly known. To the extent that chronicles are known, the narrative evolutionary histories based on them are structured like conventional historical narratives, in that they treat their central subjects as ontological individuals. This conventional treatment is incorrect. The central subjects of evolutionary narratives are clades, branched entities which have some of the properties of individuals and some of the properties of classes. Our unconscious treatment of the subjects of evolutionary narratives as individuals has been the cause of erroneous notions of progress in evolution, and of views that taxa "develop" ontogenetically in ways analogous to individual organisms. We must rewrite our narrative evolutionary histories so that they properly represent the branching nature of evolution, and we must reframe our evolutionary philosophies so that they properly reflect the historical nature of our subject. [Evolution; philosophy; systematics.]

Résumé.—Les discussions sur la théorie et la pratique de la systématique et la biologie de l'évolution ont jusqu'à présent réfléchi les opinions des philosophes de la science. J'examine ces idées de nouveau à partir du point de vue différent de la philosophie de l'histoire. Aussi bien que les philosophes de l'histoire discernent la *chronique* (un récit non-interprétatif ou non-explicatif) de l'*histoire narrée* (un récit interprétatif ou explicatif), je fais une distinction entre la *chronique évolutive* (des cladogrammes *sensu lato*) et l'*histoire évolutive narrée*. La systématique est la science qui *estime la chronique évolutive*.

Les explications des événements décrits par la chronique évolutive ne sont pas du type "lois de couverture" rendues par les philosophes de la science, mais au contraire du type "comment-possiblement", "série continue" et "intégrante", énoncées par les philosophes de l'histoire. Des explications pré-évolutives d'*états* (par contraste avec événements dont on a fait la chronique) sont pourtant encore communes dans la biologie "évolutive", car les chroniques évolutives sont en général peu connues. Autant que les chroniques sont connues en effet, les histoires évolutives narrées fondées sur eux sont construites comme des récits historiques conventionnels, en traitant leur sujets centraux comme des individus ontologiques. Ce traitement conventionel n'est pas correct. Les sujets centraux des récits évolutifs sont des clades, des entités produites par un événement de ramification qui possèdent tant des certaines proprietés des individus comme des certaines proprietés des classes. Notre traitement inconscient des sujets du récit évolutif comme des individus a été la cause d'idées erronées sur le progrès évolutionnaire, et de notions selon lesquelles les taxa se développent ontogénetiquement en façon analogue a des organismes individuels. Nous avons besoin de récrire le récit évolutif de façon qu'il répresente en effet la vraie nature ramifiée de l'évolution. Il faut aussi reconcevoir nos philosophies évolutionnaires de sorte qu'elles réfléchissent vraiment l'essence historique de notre sujet.

"How far more interesting" does our study become, "when we regard every production of nature as one which has had a history."

Darwin, 1859:485-486

It is a commonplace that evolutionary biology is an "historical science," concerned not only with laws of nature, but also with the unique and unrepeatable events of the natural past. Evolutionary biologists often emphasize the historical character of their subject (Mayr, 1982; Gould, 1986), and cite it as a feature which clearly distinguishes

evolutionary biology from the physical sciences, and from the "functional" life sciences (Mayr, 1961). My purpose in this paper is to examine in detail some of the historical aspects of evolutionary biology, and to interpret them in the light not of the philosophy of science, but of the philosophy of history.

A few earlier authors—biologists and philosophers—have investigated the historical character of evolutionary biology. Bock and von Wahlert (1963), Van Valen (1972), Hull (1975), Bock (1978), and Taylor (1987) have written on the subject, and I will discuss some of their views (particularly those of Hull) below. The most comprehensive treatment of the historical features of evolutionary biology to date is certainly *The Ascent of Life* by T. A. Goudge (1961). Goudge's book, which attempted to identify the differences between evolutionary biology and "science" as conventionally construed, provoked responses from a number of philosophers, including Ruse (1971, 1981), Hull (1974:97–100, 1981), Wilson (1981), and Williams (1981), all of whom more or less reasserted the primacy of the conventional construction of science. My analysis in this paper is in the spirit of Goudge's book, but rather than attempting to correct him where I think he was wrong, and to respond specifically to the criticisms leveled against him, I will instead present a new and positive position which is sufficiently distinct from his (and from those of other authors) to merit independent exposition.

My position is new for two reasons. First, while most of the philosophers who have written on evolutionary biology have approached the subject from the perspective of population biology and the modern synthesis, I approach it from the perspective of contemporary systematics, particularly cladistic systematics. As I will argue below, cladistic systematics has as its object the estimation of the evolutionary chronicle, not the elucidation of evolutionary mechanisms. My cladistic perspective has led me to be skeptical of some of the evolutionary explanations which philosophers of biology have in the past taken to be paradigmatic, so it is not surprising that my view of evolutionary explanation, for example, differs from that of earlier authors. I cannot impress too strongly upon readers outside of systematics how different the contemporary cladistic viewpoint is from older perspectives on systematics, and how inappropriate it would be to combine cladistic interpretations of systematics with those of any other school in a single analysis of how "systematics" is done.

My position in this paper is new, secondly, because I approach the philosophy of evolutionary biology from the perspective of the philosophy of history rather than from the perspective of the "received view" of the philosophy of science, as has heretofore been done. The term "philosophy of history" has two distinct senses today. In its older sense, a "philosophy of history" is a particular view of the nature and purpose of history itself, as for example when one speaks of Hegel's or Marx's or Toynbee's philosophy of history. This sense of philosophy of history is sometimes called the speculative or substantive philosophy of history, and is very similar to the "philosophies of evolution" propounded by Teilhard de Chardin, Hyatt, Osborn, and others.

The second and newer sense of the term "philosophy of history," the more common one today, refers to the discipline which studies not the past itself, but rather the way in which historians think and write about the past. This discipline is usually termed the critical or analytical philosophy of history, and the application of its concepts to the philosophy of evolutionary biology will be my primary concern. From among the several topics studied by analytical philosophers of history I have chosen the distinction between *chronicle* and *history*, the problem of *explanation*, and the nature of *narrative* to be foci of this paper, because they relate directly to current issues in systematics, and in evolutionary biology generally. Most of my conclusions have been reached from reading the works of Gardiner (1952), Dray (1957, 1960, 1964), White (1965), Walsh (1967), Gallie (1968), Hull (1975), Goldstein (1976), Atkinson

(1978), Olafson (1979), Garfinkel (1981), and Danto (1985). A quick survey of the literature cited in works on the philosophy of evolution will show that the ideas of these philosophers of history have figured little if at all in the debates over the nature of evolutionary biology.

CHRONICLE AND HISTORY

A distinction is made within the analytical philosophy of history between writing which is called *chronicle* and writing which is called *history*. The precise nature of this distinction has been the subject of debate (see Danto, 1985), but generally speaking a *chronicle* is a description of a series of events, arranged in chronological order but *not* accompanied by any causal statements, explanations, or interpretations. A chronicle says simply that *A* happened, and then *B* happened, and then *C* happened. A *history*, in contrast to a chronicle, contains statements about causal connections, explanations, or interpretations. It does not say simply that *A* happened before *B* and that *B* happened before *C*, but rather that *B* happened *because* of *A*, and *C* happened *because* of *B*.

Just as we can distinguish between a chronicle and a history of the human past, we can also distinguish between a chronicle and a history of the *evolutionary* past. *Phylogeny* is the *evolutionary chronicle*: the branched sequence of character change in organisms through time. *Systematics* is the discipline which *estimates the evolutionary chronicle*. Conventional characterizations of systematics relate it to the general field of classification, but all of these characterizations have their roots in the pre-evolutionary period when the classification of animals, plants, and minerals was of a piece, and when these three kingdoms of Linnaeus's *Systema Naturae* had a history of only a few thousand years. The many debates over classification per se in evolutionary biology (Gilmour, 1940; Bock, 1973, 1977; Sneath and Sokal, 1973; Ashlock, 1974; Nelson, 1974; Farris, 1977; and Mayr, 1981, to mention a very small sample) should today be irrelevant, because an *evolutionary* biology should be concerned not with constructing groups, but with reconstructing history. (I will have more to say about classification below.)

To get a clearer view of the distinction between history and chronicle we may follow the path cut by Arthur Danto (1985), who has investigated this distinction in considerable detail. To aid his investigation Danto created an imaginary document which he termed the Ideal Chronicle. The Ideal Chronicle is a complete and perfect description of everything which has ever happened, written down *as it was happening*. One might assume, says Danto, that if we had such a document there would be nothing left for historians to do, because everything that could be known about the past would already be included in that Ideal Chronicle. Such an assumption, however, would be false, because history, as distinct from chronicle, contains a class of statements called *narrative sentences*, and narrative sentences, which are essential to historical writing, will never appear in the Ideal Chronicle. A narrative sentence describes *an event*, taking place at a particular time, with reference to *another event* taking place at a *later* time. In Danto's words (1985), narrative sentences "give descriptions of events under which the events could not have been witnessed, since they make essential reference to events later in time than the events they are about. . . . 'The Thirty Years War began in 1618' could not have been known true in 1618, and in the main the descriptions of central historical importance are those which contemporaries and eyewitnesses could not have had."

Just as narrative sentences distinguish history from chronicle, *evolutionary narrative sentences* distinguish evolutionary history from evolutionary chronicle. Prime examples of evolutionary narrative sentences may be found in discussions of "key innovations" in evolution:

> The history of life, like human history, has been marked by certain great developments rising above the general level of events that collectively make up the record. These outstanding evolutionary developments are in the nature of revolutions, affecting profoundly the phylogenetic trends that follow them, just as great historical revolutions,

> like the American Revolt against Britain or the French Revolution, have affected the subsequent histories of the peoples concerned with them. A better comparison might be with the peaceful revolutions in human arts and industries, such as those brought about by the development of the printing press or the application of steam power to machinery.
>
> One of the great events or revolutions in the history of vertebrates was the appearance of jaws. The importance of this evolutionary development can hardly be overestimated, for it opened to the vertebrates new lines of adaptation and new possibilities for evolutionary advancement that expanded immeasurably the potentialities of these animals. [Colbert, 1969:28]

The appearance of jaws in vertebrates, as related in this example, could not have been described as a "key innovation" by jawless eyewitnesses, of course, because those eyewitnesses could no more have predicted the evolutionary future in their day than we can predict it in ours. Statements about the "origins" of particular taxa are also evolutionary narrative sentences, because all that is implied by the name of the taxon as it is used in the present could not possibly have been known to witnesses to that taxon's origin; the witnesses would not necessarily have seen the "origin" of anything. To write the Ideal Chronicle, as Danto has observed (1985), one needs perfect knowledge of the past, but to write the Ideal History one needs perfect knowledge of the future. If we were miraculously to acquire knowledge of the Ideal Evolutionary Chronicle—the parametric phylogeny estimated by systematics—then the work of systematists would be over. The work of evolutionary historians, however, would remain to be done.

One of the values of the distinction made here between chronicle and history lies in the fact that the truth of a particular history, whether of a clade or a country, is dependent upon the truth of the particular chronicle underlying that history. As White has observed (1965:224), "If we say in a history of Germany that England declared war on Germany because Germany had invaded Poland, we imply that England declared war on Germany and that Germany had invaded Poland." Systematics, as the discipline which estimates the evolutionary chronicle, enables us to reject particular evolutionary *histories* by showing that they are based on false evolutionary *chronicles*. And even though every history—every causal and interpretive account—implies an associated chronicle, "an associated chronicle will not logically imply a [particular] history, since the true components of a causal statement do not imply the causal statement of which they are components. Neither 'England declared war on Germany' nor 'Germany had invaded Poland' nor their conjunction implies 'England declared war on Germany because Germany had invaded Poland'" (White, 1965). Thus no matter how thoroughly one may be able to establish a phylogeny—an evolutionary chronicle—one may still not be able to give a causal explanation of the events the phylogeny relates (compare Platnick [1977] and Wiley [1979]). This need not be particularly worrisome, however, because as we shall see below, a *causal* explanation may not always be the type of explanation which a questioner is seeking.

While I believe that the distinction between evolutionary chronicle and evolutionary history is clear in most cases, I recognize that there are difficulties with this distinction. Since we can never produce an Ideal Chronicle of evolution, the events we include in any particular chronicle may have been chosen for inclusion—consciously or unconsciously—because they lay the groundwork for some particular historical account. This issue is referred to by philosophers of history as the problem of the selection of evidence (Atkinson, 1978:69ff.). This seems to me to be a problem more for history proper than for systematics, however, because historians tend not to publish chronicles except as they are contained in histories, and the simple act of choosing to include certain events in a history and exclude others may have profound effects. In contrast to the historian, the systematist performing a cladistic analysis is trying to use all available evidence to estimate the positions of as many evolutionary events as possible; he is not trying to construct a narrative account of a se-

lected set of those events. The task of estimating the evolutionary chronicle itself is of such magnitude that it commands all of the researcher's attention, a fact not often appreciated. Sober (1984:13), for example, has remarked that "If scientists merely chronicled sequences of events, without trying to say what caused them, mistaken inferences from effects to causes might not occur." Unfortunately there is nothing "mere" about estimating the phylogeny of most taxa; Sober's field of population biology, rather than taking on this task, chooses to work across such a restricted time span that it is able to chronicle its subjects merely by keeping notes. Systematics has a far more difficult task; no long-term ecological research, no pure lines, no population cages in the Jurassic.

While the selection of events for the purpose of constructing narratives does not pose a particular problem for cladistic systematists concerned only with estimating the evolutionary chronicle, it should be a concern for evolutionary systematists of the Mayr-Simpson school (Mayr, 1981). Just as an historian selects certain persons and events on which to base a history, and thereby makes the selected events "important," so also the evolutionary taxonomist of the Mayr-Simpson school *selects* certain characters on which to base his rankings, and thereby makes the selected characters *evolutionarily* important. Such selections are not only historical narrative constructions (in Danto's sense) because they are based on the future developments of the taxa in which the privileged characters appeared, but they are also selections made from the human point of view. Just as a British account of the revolution of 1776 might differ from an American account, even though both might be true, so too an evolutionary classification of animals made by Mayr and Simpson might differ significantly from one produced by those authors if they were crayfish, even though both classifications might be "true" in the sense that they would both be based on the same underlying chronicle. These classifications would differ only in that they privilege different sets of characters—they recognize different sets of events as evolutionarily important.

THE NATURE OF EVOLUTIONARY EXPLANATION

The events described in a chronicle are ordinarily the things for which *explanations* are sought.[1] The traditional account of *scientific* explanation has been the so-called covering-law model, most often associated with the writings of Karl Popper (1959) and Carl Hempel (collected in Hempel, 1965). Simply stated, the covering-law model says that an event, E, is explained by showing that it can be logically deduced from a set of boundary and initial conditions, $c_1, c_2, \ldots, c_n$, and one or more universal laws, $L_1, L_2, \ldots, L_n$. Hempel gives the following example:

> Let the event to be explained consist in the cracking of an automobile radiator during a cold night. [The initial conditions are:] The car was left in the street all night. Its radiator, which consists of iron, was completely filled with water, and the lid was screwed on tightly. The temperature during the night dropped from 39° F. in the evening to 25° F. in the morning; the air pressure was normal. The bursting pressure of the radiator material is so and so much. [The laws would be like the following:] Below 32° F., under normal atmospheric pressure, water freezes. Below 39.2° F., the pressure of a mass of water increases with decreasing temperature, if the volume remains constant or decreases; when the water freezes, the pressure again increases. . . .
>
> From statements of these two kinds, the conclusion that the radiator cracked during the night can be deduced by logical reasoning; an explanation of the considered event has been established. [Hempel, 1942; reprinted in Hempel, 1965:232]

The covering-law model of explanation has been so widely accepted by philosophers of science that Hull remarked (1975:273), with a touch of sarcasm, that "philosophers have been unable to discover the essence of beauty, goodness, horses, lemons, and

[1] The subject of explanation is a major one in the philosophy of history and science, and it is discussed in a very extensive literature. The references in Hempel's book *Aspects of Scientific Explanation* (Hempel, 1965) will introduce the reader to the literature of explanation in the physical sciences, and the bibliographies of the literature on the philosophy of history published as *Beihefte* to the journal *History and Theory* will do the same as regards studies of explanation made by philosophers of history.

games, but they have discovered the essence of scientific explanation, and it is subsumption under a scientific law."

In an influential paper published in 1942, Hempel attempted to extend the covering-law model to explanation in *history*. This attempt provoked a number of responses from philosophers of history, including Gardiner (1952) and Dray (1957), and the authors represented in the volume edited by Gardiner (1959). The applicability of the covering-law model to explanation in history has been one of the principal foci of research in the analytical philosophy of history since the mid-1940s.

The Pragmatics of Explanation

One of the most important realizations which emerged from these debates over the applicability of the covering-law model to history was that there is an important *pragmatic* aspect to explanation. When someone asks for an "explanation" of something what is desired in many cases is not a deductive statement about initial conditions and universal laws. In some cases a simple filling-in of intermediate stages (improving the chronicle) will suffice for understanding; this type of explanation has been called the continuous-series explanation (Dray, 1957:66). In other cases an explanation may be called for because a questioner has some a priori reason for believing that an event could *not* have occurred, and yet it has; the questioner is not seeking an explanation of why the event *necessarily* happened (as the covering-law model would provide) but simply an explanation of how the event could have *possibly* happened in the light of his own preconceptions. This type of explanation has been called the *how-possibly explanation* (Dray, 1957). A person asked to provide an explanation of some event needs, in Garfinkel's words (1981), to "dissect the question" being asked: to determine whether the questioner wants to know about the events preceding the one in question, or wants to have his preconception against the occurrence of the event removed, or wants to know if the puzzling event instantiates a class of events which follow a general law of change.

Explanation of State Before Evolution

Up to this point I have been speaking of explanations of *events*, and most philosophical discussions of explanation in both science and history are concerned with explanations of events: the freezing of a liquid, the start of a war, the denting of an automobile. The concept of an event is an important one, because an *event* is really a *change*.

> Indeed the existence of a change is often built into the language we employ to describe things: the description makes an implicit reference to a past state of the subject of change.... Simply to describe an automobile as *dented*, for example, is implicitly to refer to an earlier state of this automobile in which it was *not* dented; and to demand an explanation of the dent is accordingly to demand an explanation of the change. [Danto, 1985:233]

This observation, that explananda—the things for which explanations are sought—are actually changes, may seem trivial but it is not. It is not because in the pre-evolutionary period, and as I will argue in the evolutionary period to some extent as well, the things for which explanations were sought were not *changes* but rather *states*, and the transition from explanations of states to explanations of changes signals the introduction of true evolutionary thought to a discipline. In many cases this introduction has not yet been made.

To understand the notion of an explanation of a state, consider the following dialogue:

> *Pupil.* Which are our principal grains?
> *Tutor.* Wheat, rye, barley, oats, Indian-corn, &c.
> *Pupil.* Of what use are the long stalks?
> *Tutor.* That the ears may not easily be beat upon the moist ground. They furnish the husbandman, also, with straw, for various purposes.
> *Pupil.* For what purpose are the stalks so smooth?
> *Tutor.* That the rain may easily run off and not rot them.
> *Pupil.* Why have the stalks knots and shoots, or blades?
> *Tutor.* That they may not be broken in the open fields, by the violence of the winds.
> *Pupil.* Why are they thus pointed and flexible, or waving?
> *Tutor.* The birds would otherwise sit upon them at

> their ease, and pick out the grain, and that too, before it was ripe. [Martinet, 1790:100]

The explanations provided in this passage are examples of explanations of *states*, and they are made with reference to the *purpose* of the states, the rational design behind their structures. There is no implied chronicle behind these explanations, because there are no *events* to be explained: there was never an earlier time when the stalks of rye and barley were not smooth; their smoothness was an integral part of their original design. State-explanations such as these cannot be part of a history. The task of the author of this dialogue—the task of every pre-evolutionary naturalist—was, in Milton's words, to assert eternal Providence, and justify the ways of God to man; to show that things are the way they are in the timeless world because that is the way they ought to be. Very nearly the same task is faced by functional biologists today.

Miltonian explanations of state existed in the physical sciences as well as in natural history, but they were abandoned there early. They were abandoned partly because of the success of the covering-law model, but more importantly because of the realization that "the real problem" with explanations of state "lies in the very idea that this is the kind of thing that can be explained at all. After all, suppose that [astronomers discover] there are nine planets. Why is this so? . . . Modern science rejects the idea of explaining that sort of thing, except by the trivial statement that that is how many there turned out to be" (Garfinkel, 1981:7).

Explanation of Change After Evolution

The modern science of evolutionary biology, at its inception, might have been expected to reject explanations of state, and introduce a previously non-existent class of explanations: explanations of evolutionary *events*. The very idea of evolution requires all sorts of events to have occurred: dispersals to islands, changes in structure, splittings of lineages, and on and on. But recall that an event is a change, and that to properly explain a change one must know not only the final state, but also the initial state; in other words, one needs to know phylogeny—the evolutionary chronicle. After 1859, explanations of evolutionary events flourished most in those disciplines where initial states could be postulated, such as comparative anatomy and paleontology, while explanations of states persisted in other disciplines, such as ecology and physiology, where initial conditions were more obscure. The persistence of state-explanations will be considered below, but let us examine first the nature of the event-explanations given in evolutionary biology, and the reasons we sometimes find some of them unsatisfying.

The explanations of evolutionary events given by biologists are generally of the *how-possibly* type described above. Rather than explaining why necessarily a particular evolutionary event occurred, as a covering-law explanation might, a how-possibly explanation merely removes the objections the questioner has to the event's occurrence. Darwin uses the very phrase "remove difficulties" several times in the *Origin*; indeed the whole book can be considered one long how-possibly argument for evolution. This is not unexpected inasmuch as he was presenting his minority view to a large audience who already held opinions leading them to believe evolution could not have taken place. How possibly could evolution have occurred, since species are invariant? Darwin removes the objection by showing that there is variation in nature. How possibly could evolution have occurred, since there is no force to drive change? Darwin removes the objection with the introduction of natural selection. How possibly could evolution have happened in so short a time? Darwin tells us that the earth is older than we thought. How possibly could evolution have taken place if we don't see all the intermediate stages? Darwin tells us about extinction and the imperfection of the fossil record. How possibly could species isolated on islands be descended from other species? Darwin tells us about the powers of dispersal. Darwin rarely argues that evolution necessarily *had* to take place, he rather shows that

it is perfectly *reasonable* to believe that it *did* take place, because the objections *against* its having taken place are unfounded. In discussing the origin of bird flight, for example, Darwin answers those who might have said that a transition from terrestrial or aquatic to aerial locomotion could not possibly have been made by reminding his readers of birds which use their wings "solely as flappers, like the logger-headed duck (Micropterus of Eyton); as fins in the water and front legs on the land, like the penguin; as sails, like the ostrich; and functionally for no purpose, like the Apteryx." But he cautions his readers as well:

> It must not be inferred from these remarks that any of the grades of wing-structure here alluded to, which perhaps may all have resulted from disuse, indicate the natural steps by which birds have acquired their perfect power of flight; but they serve, at least, to show what diversified means of transition are possible. [Darwin, 1859:182]

Even Darwin's celebrated experiments were not what would now be called critical experiments—experiments designed to test the validity of some natural law. They were rather, to coin a new expression, *how-possibly experiments*, designed to show that seeds *could* live in salt water, and so could possibly disperse by floating across the ocean to islands, or some such thing. A how-possibly experiment performed by Philip Darlington and Thomas Barbour at the Museum of Comparative Zoology has become legendary. Darlington and Barbour were disputing the possibility of frogs being dispersed in the West Indies by hurricanes. Darlington, who believed such dispersal was possible, took a bucket of live frogs up to the roof of the Museum, and, with Barbour standing on the lawn below, proceeded to throw the frogs to the ground, one by one. As each one hit the ground, Barbour examined it and called up "That one's dead," "So's that one," and so on. But after a few minutes, much to Barbour's disappointment, the frogs all revived and started to hop away. Darlington had thus shown that hurricane dispersal was *possible*, or at least had removed one of Barbour's objections to it, namely that it would be too rough on the frogs.

Evolutionary event-explanations may also be of the continuous-series type (Dray, 1957). When we ask a question like "How did birds evolve?", the desired explanation may not be a statement of selective forces or supposed agents of macroevolutionary change, but rather a statement of the intermediate evolutionary steps. Thus Huxley, in an early evolutionary classic (1868), "explained" the evolution of birds simply by showing that there are taxa which could possibly have been intermediates; he narrowed the gap in the chronicle between the two groups. (This is similar to the encyclopedism of White [1965:225].)

Dissatisfaction with How-Possibly Explanations

There is often an uneasiness surrounding the how-possibly event-explanations which are given in evolutionary biology. How-possibly explanations, as we have seen, do not demonstrate why events or changes should necessarily have taken place, but rather remove objections to the belief that they could have taken place. The success of a particular how-possibly explanation, then, depends upon how well it answers or removes the objections a reader has thought of to the event's having occurred, and this is one of the sources of the uneasiness mentioned above. The provider of an explanation is not likely to foresee all of the objections which may occur to all readers. The conscientious explanation provider will, of course, try to do his best to cover all the bases, and present all the objections he can think of as thoroughly as possible so that those who accept his conclusion will be as satisfied as possible. As Darwin said (1859:459): "That many and grave objections may be advanced against the theory of descent with modification through natural selection, I do not deny. I have endeavoured to give them their full force." But against objections which were raised later, of course, Darwin could do nothing.

Dissatisfaction with how-possibly explanations may also arise because what the questioner really wants to know is not how a change *may* have taken place, but how it

did take place—not how-*possibly*, but how-*actually*. Such a questioner typically accepts that the change occurred and needs no further convincing of this. He wants to go a step further and be told the actual sequence or cause of the change. But how-possibly explanations do not follow the covering-law model, and can't do this; how-possibly explanations provide plausible answers in the face of apparent implausibility; they do not provide deductive answers based on laws.

How-possibly explanations may also be unsatisfying because there may be a very large number of acceptable ones for any given question. How do we choose among them? The strongest position to take in this matter would be that if alternative how-possibly explanations are not based on different underlying chronicles then it is not possible to choose among them. This position reemphasizes the great importance of knowledge of the chronicle to all evolutionary studies; knowledge of the chronicle constrains the universe of acceptable explanations. But how-possibly explanations are explanations of change, and I believe it is far less of a problem in biology today to choose among possible explanations of change than it is to find appropriately phrased questions of change in the first place. This is because pre-evolutionary state-questions and state-explanations are still so widespread.

The Persistence of Explanations of State, and the Need for "Tree Thinking"

The urine of the lynx, we are told by Pliny, hardens into a precious stone, and the lynx "envies us the possession of its urine and therefore buries it in the earth" (Ley, 1968:52).

> To this John Bostok, M.D., one of the translators, added the footnote: "It is not unusual for animals to cover their excrements with earth, probably from the fact of their being annoyed by its unpleasant odor." A neat Victorian sentiment, unfortunately marred by the fact that it misses the mark by about a mile; the reason some animals cover up their excrements is that they are trying to avoid giving their presence away to predators. [Ley, 1968:52]

Why does the lynx bury its excrement? Any evolutionary biologist can think of dozens of questions of this form which have been put to him. "Why are flamingos pink?" an historian asked me not long ago. But what exactly is the form of these questions? They appear to be questions of state; structurally they are identical to "Why are the stalks of rye and barley smooth?", or "Why are there nine planets?", which latter question we have been told science today neither asks nor answers. But questions of this form are asked and answered every day by biologists and biological texts. The lynx buries its excrement because it envies us its possession, or because it is annoyed by its odor, or because it does not wish to give away its presence to predators; flamingos are pink because of their particular diets, or because pink promotes coloniality, or some such thing. An evolutionary biologist, however, remembering how interesting his discipline becomes when he regards every production of nature as one which has had a history, might attempt to translate "Why does the lynx bury its excrement?" and "Why are flamingos pink?" from questions of state into questions of change; change is after all what evolution is all about. But what is required to transform a question of state into a question of change? What must one know to give, for example, a causal explanation of a change as opposed to a functional, rational, or purposive explanation of a state? Trivial as it may sound, before giving an explanation of a change from A to B one ordinarily needs to know A. Why are flamingos pink? Why does the lynx bury its excrement? Well, are we certain that there was a time when *flamingos* were not pink, or when *lynxes* did not bury their excrement? There are in fact flamingos today which have very little pink in their plumage; should we ask instead why certain flamingos are, or have become, pink? Or should we instead ask why certain flamingos are not, or are no longer, pink, for this is a very different question, based on an entirely different evolutionary chronicle. To ask why certain species have a particular attribute is to suggest that that attribute is a derived character uniting them in

a clade, and that the appearance of the character is the thing for which an explanation is sought. To ask why certain species do not have the attribute is to suggest that the presence of the attribute is primitive and that those species lacking it have lost it secondarily; here the loss of the character is the thing for which an explanation is sought. Are lynxes the only mammals which bury their excrement? Obviously not; is this behavior restricted to felids, or carnivores, or is it present in all mammals? How many times has it evolved independently within the Mammalia? Such questions can only be answered in the context of an established phylogeny; they cannot be answered in the context of a classification (except in the trivial case where classification mirrors phylogeny).

The ability to analyze evolutionary "why" questions in this way comes from what I call "tree thinking" (after Mayr's "population thinking"). Tree thinking is absolutely necessary for answering almost all evolutionary "why" questions. A pre-evolutionary perspective on diversity results in what may be called "group thinking," and state questions arise out of group thinking; it is tree thinking that allows one to convert a question of state into an evolutionary question of change. Anyone who has internalized tree thinking will recognize that attempting to answer a question like "Why are flamingos pink?" without significant knowledge of the evolutionary chronicle of flamingos (and probably a number of other clades of birds as well) is as foolish as attempting to explain why England declared war on Germany without knowing whether Germany invaded Poland or Poland invaded Germany. One needs to know the chronicle of events in a situation before causation can be inferred with any confidence; in evolutionary terms, one needs to know phylogeny. Questions of state, like "Why are flamingos pink?" and "Why do some mammals bury their excrement?", persist in evolutionary biology because relatively few non-systematists think in tree terms, and because tree thinking, as well as a certain degree of knowledge of the chronicle (which is almost always lacking), is necessary for proper conversion of a state question into a change question.

CENTRAL SUBJECTS AND EVOLUTIONARY NARRATIVES

If we take the events of a chronicle, describe them with reference to later events, weave these descriptions together with explanations, sprinkle in a few anecdotes, and give the whole a preface and a conclusion, we produce an historical narrative. The structure and function of narrative has rarely been a concern of philosophers of science, but it has long been a concern of philosophers of both history and literature. It is a widely held view among philosophers of history, for example, that narratives are by their very nature "explanatory" works. Proponents of the covering-law model of explanation have argued in contrast that narratives are explanatory only to the extent that they contain implicit laws, and that since the laws present in narrative are poorly articulated, narratives provide only "explanation sketches" of sequences of events, rather than fully-fledged explanations (Hempel, 1965). Students of narrative, in maintaining their position, have tried to identify the specific ways in which narratives exert their explanatory force. For the purposes of this paper the most important study of the explanatory structure of narrative is Hull's philosophy of history paper entitled "Central subjects and historical narratives" (1975).

Hull's paper may be viewed as an extension of the debate over the ontological status of species, begun by Ghiselin (1966, 1974, 1987), and continued by many others (Hull, 1974, 1976, 1978; Kitts and Kitts, 1979; Caplan, 1981; Bernier, 1984; Mayr, 1987; etc.). This debate addresses the question of whether species should be considered individuals or classes, in an ontological sense. Ghiselin, who considers species to be individuals, describes the distinction between these terms as follows:

> *Individuals* are single things, including compound objects made up of parts—such as ourselves, and also every cell and atom in our bodies. Such parts

> need not be physically connected—a baseball team is an individual made up of players. Individuals each have a definite location in space and time. In general they are designated by proper names—such as "Ernst Mayr" or "Canada." *Classes*, on the other hand, are spatially and temporally unrestricted, and their names may designate any number of objects—including none at all. The only thing the members of a class have to share is the criteria of membership—usually what are called the "defining properties." Both classes and individuals have "elements" or "subunits," but the relationships are not the same. Individuals are "parts" of larger individuals. (John is part of his family.) They are "members" of classes. (John is male.) Classes are not parts of anything, though they can be included in larger classes. (The sexes include male and female.) In general one can tell if a thing is a part of an individual or a member of a class by virtue of the fact that parts are not "instances." For example, we do not say "This thumb is a Michael Ghiselin," or "Ontario" is a "Canada." To some people it is not obvious that it is equally wrong to say "Trigger is an *Equus cabalus*." [Ghiselin, 1987:128]

In "Central subjects and historical narratives" Hull argues that historical narratives are accounts of the chronological development of ontological *individuals*, in Ghiselin's sense, and he terms these individuals *central subjects*. Narratives acquire their explanatory power, Hull argues, by *integrating* these central subjects—by making them wholes (see also Hull, 1981).

This far I agree with Hull, and find his analysis very insightful. The process he describes of integrating the central subject of an historical narrative is similar to what students of literary narrative call providing *closure* (Kermode, 1967; Smith, 1968; White, 1981). Closure is what gives a literary work cohesiveness and conclusiveness; it provides readers with "the sense of an ending"—the sense that the story has not just broken off, but has concluded. The difficulty in applying these analyses of literary and historical narratives to evolutionary narratives, however, lies in the fact that the central subjects of *evolutionary* narratives are not individuals in the conventional sense, but rather *clades*: branched pieces of the evolutionary tree. Although they have spatially and temporally restricted beginnings, they have unrestricted endings; although their branches are continuous back through time, at any *given* time they are not continuous. In a narrative history of England we start with England and close with something called England again at the end. In a narrative history of the vertebrates, however, we start with a lamprey-like ancestor, and have bats, elephants, penguins, turtles, hummingbirds, goldfish, and burrowing snakes at the end, and these endpoints no longer exhibit any continuity among one another; they remain part of the same "individual" only by virtue of their ancient evolutionary history. The writers and readers of narratives, however, are accustomed to having narrative central subjects behave like individuals, and narrative individuals not only have distinct beginnings but also distinct endings—they have closure. Closure may be inherent in the central subject itself (as it is in a human individual, whose life story concludes with death), or it may be imposed upon the central subject by the narrative. Sometimes closure imposed by narrative becomes indistinguishable from closure inherent in the subject. Artificial closure is imposed upon evolutionary narratives in a number of ways. It is imposed when such narratives trace only one thread through a branched tree, or when they label one of a pair of coordinate sister taxa as "a side branch," or as "off the main line," like a footnote to the text. The recognition of paraphyletic groups assists this practice: paraphyletic groups allow narrators to minimize the cladistic aspect of evolution and maximize the linear aspect (or rather create an imaginary linear aspect), and so increase the closure and cohesiveness of their narratives. The narrative closure and cohesiveness made possible by paraphyletic groups is often coupled with vaguely ontogenetic or teleological views of evolution. "Just as T. H. Huxley begot Leonard Huxley, and Leonard Huxley begot Aldous and Julian Huxley, the ostracoderms gave rise to the placoderms and the placoderms gave rise to the sharks and bony fishes" (Hull, 1975:269). Evolutionary "ontogenies" such as this are deeply ingrained in our thought: try to imagine the story of vertebrate evolution without thinking of the fish, the amphibian, the reptilian, and

the mammalian stages. But the elements of these evolutionary ontogenies are not stages in the life of a phylogenetic individual, the way infancy, childhood, adolescence, and adulthood are stages in the life of a human individual, because in phylogeny there is no "individual" in the same sense: there is only an open clade. We feel as though we ought to be able to tell the "story" of anything that changes over time—like America, or the vertebrates. But the things about which we can tell stories must either possess individuality, or they must be prepared to have individuality and all it entails—like ontogeny and closure—imposed upon them by the force of narrative.

Biologists must free themselves from the ontogenetic view of evolution, and from linear evolutionary narratives. The evolutionary narratives of the future must branch and take their readers down any chosen thread of the evolutionary tree. To borrow a term from computer science, they must be "hypertexts," beginning with a tree which diagrams the structure of the entire story. Precedents for tree-like (or at least irregularly structured) narratives exist in a number of novels, such as *Hopscotch* (Cortázar, 1966). But while in literature non-linear narratives are curiosities, in evolutionary biology they should be necessities, because the chronicle on which evolutionary narratives are based is not linear, but branched. When we rewrite our evolutionary histories in branched form the absurdity of notions of evolutionary progress and of the "ontogeny" of taxa will be self-evident. Both of these false concepts arise out of our expectation that the central subject of an evolutionary history is a linear individual, instead of a branched tree.

CONCLUSION

I have tried in this paper to frame a new philosophy for evolutionary biology, a philosophy which reflects the discipline's historical nature. The problems this philosophy addresses—narrative structure, forms of explanation, the distinction between chronicle and history—will be new to most evolutionary philosophers, who have heretofore concerned themselves with classification, falsification, and law. These new problems are quite simply the problems of history; as we become over time more of an historical science these problems will occupy more and more of our attention, for "the understanding of the past is not so easy as it is sometimes made to appear" (Butterfield, 1931:132).

In what is surely one of the most remarkable understatements in English literature Darwin observes near the end of his great work of 1859 that "when the views entertained in this volume on the origin of species, or when analogous views are generally admitted, we can dimly foresee that there will be a considerable revolution in natural history." In the hundred or more years since Darwin's revolution began it has extended far beyond natural history, touching nearly every division of science and art. But the muse of history says here that when the future looks back through the lens of narrative, not only on Darwin's age but also on our own, it will see that the revolution of 1859 did not come to a close even within natural history until it came to a close with us at the end of the Twentieth Century. It was not until the end of the Twentieth Century that the inertia of pre-evolutionary thought—of state questions and group thinking—was at last overcome by force of history—of change questions and tree thinking—and Clio came down from the rafters of our museums, shook off the dust, and took her rightful place in the director's chair. A happy outcome of this, they will say, was the resurrection of the old term natural history: when the Darwinian revolution came to a close at the end of the Twentieth Century, natural *history* became a discipline once again.

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