2. ARISTOTLE VS. DIODORUS: WHO WON THE FATALISM DEBATE?*

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ABSTRACT. We develop a modified system of standard logic, Augmented Standard Logic (ASL), and we employ ASL in an effort to show that, contrary to prevailing opinion, both Aristotle and Diodorus presented impressive arguments, having valid structures and highly plausible premisses, in their famous fatalism debate. We argue that ASL, which contains standard logic and a full system of modal and temporal logic emanating from a modicum of primitives, should not only enable one to appreciate the sophisticated philosophizing which characterized this ancient debate, but should prove to be quite useful in application to contemporary issues.

I.

Determinism is the theory that everything that happens at a given time was fixed at every earlier time. According to causal determinism, the antecedent fixity of events stems from the existence of prior sufficient conditions. According to fatalism, however, it is a necessary truth that whatever happens was fixed at every earlier time—the fixity results not from causation, but from essential characteristics of time, of truth and of necessity.¹ That Aristotle and Diodorus Cronus were involved in some sort of debate on the topic of fatalism is a reasonable conjecture.² But scholars have found it quite difficult to determine precisely what views regarding fatalism were espoused by these theorists, and what relationship the views had to each other. And many have characterized the views as muddled or even absurd.³ In this paper we utilize a modified system of modern logic to reconstruct and to evaluate the views of the two philosophers.⁴ We devise a system we call Augmented Standard Logic, ASL, and we employ ASL as a basis for interpreting the views and assessing their soundness. The strategy we pursue is to seek reconstructions which are in accord both with the relevant texts and with the presumption that the two theorists were astute logicians.⁵ Through careful analyses of the texts, we find in each case an argument which is deductively valid and contains highly plausible premisses. We feel that this development not only casts light on the ancient fatalism debate, but lends support to the idea that ASL would be useful in contemporary investigations of the many philosophical problems having modal and temporal dimensions.
II.

To construct ASL, we begin with what we shall call Standard Logic, SL, consisting of the second-order predicate calculus supplemented with quantifiers for propositional variables. Let us introduce variables 't1', 't2', etc., and constants 't1a', 't2b', etc., representing time periods (the term 'period' is used to refer indifferently to times ranging from "durationless" instants, through familiar intervals such as days and years, to "boundless" times). We permit atomic well-formed formulas to contain temporal variables or constants (e.g. 'fxt1', meaning 'x has f during t1', is well-formed), and we assume that SL is supplemented with quantifiers and standard quantification rules governing temporal variables. Let us now modify SL by replacing its primitive negation operator, 'it is not the case that p', with the time-relative negation operator 'it is not the case during t1 that p'. The ordinary negation operator is reintroduced by definition:

D1. It is not the case that p =\neg r for every t1, it is not the case during t1 that p.

The positive time-relative operator 'it is the case during t1 that p' is defined as follows:

D2. It is the case during t1 that p =\neg r it is not the case that it is not the case during t1 that p.

With the addition of three axioms and a rule of inference, the construction of ASL will be complete.

A1. It is the case during t1 that both p and q if and only if it is the case during t1 that p and it is the case during t1 that q.

A2. If it is the case during t1 that p and it is the case during t1 that if p then q, then it is the case during t1 that q.

A3. It is not the case during t1 that ft1 if and only if it is not the case that ft1.

The expression 'ft1' represents a well-formed formula containing 't1' as a free variable. Axiom A3 entails such statements as: "It is not the case during 1984 that a sea battle occurs during 1984 if and only if it is not the case that a sea battle occurs during 1984." Owing to its restricted character, the axiom does not entail such statements as: "It is not the case during 1983 that a sea battle occurs during 1984 if and only if it is not the case that a sea battle occurs during 1984." As we shall see, statements of this sort are precisely the kind Aristotle wished to reject. The rule of inference is:

RI. If 'p' is a thesis, then 'for every t1, it is the case during t1 that p' is a thesis.

Since ASL contains every axiom and rule of SL, it is an extension of SL rather than a competitor. But unlike SL, ASL can, with the introduction of suitable definitions, be turned into an interesting system of modal and temporal logic. Because modal and temporal operators can be
introduced into ASL without introduction of any additional primitives, the system can provide an analysis, as well as a logic, of modal and temporal notions. A propositional operator for necessity may be defined as follows:

**D3. It is necessary that p =⇒ for every t, it is the case during t that p.**

For example, it is necessary that a sea battle occurs during 1984 if and only if it is the case during every time that a sea battle occurs during 1984. This definition entails that necessity has such plausible properties as the following: if it is necessary that p, then p; if it is necessary that both p and q, then it is necessary that p and it is necessary that q; if it is necessary that p and it is necessary that if p then q, then it is necessary that q. Using the notion of necessity, one can introduce the other familiar modal notions: a proposition is impossible if and only if its negation is necessary; a proposition is possible if and only if it is not impossible; a proposition is contingent if and only if both it and its negation are possible. The modal structure of ASL is similar to that of the familiar modal system T. A proof of this fact and proofs of other facts about the system mentioned later are supplied in an appendix.

Introduction of definitions of key temporal notions will be facilitated if we first define the technical notion of temporal implicature. (We use 'of necessity' as a variant of 'it is necessary that'.)

**D4. t temporally implicates t if for every p, of necessity it is the case during t that p, then it is the case during t that p.**

**D5. t is simultaneous with t if t temporally implicates t and t temporally implicates t.**

**D6. t includes t for every p, of necessity it is the case during t that p, then it is the case during t that it is the case during t that p.**

**D7. t is earlier than t for every t included in t, t temporally implicates t and t does not temporally implicate t.**

**D8. t is later than t t is earlier than t.**

**D9. t is identical with t if t includes t and t includes t.**

**D10. t is an instant for every t included in t, t temporally implicates t.**

These definitions entail that simultaneity is equivalent to identity and is reflexive, symmetrical and transitive, and that temporal precedence and its converse are irreflexive, asymmetrical and transitive. If one adopts the postulates that every period is earlier than or later than any distinct, non-simultaneous period, that every period includes an instant, that there is a period between any two distinct instants, and that every instant is between two periods, one can capture the familiar conception of time as an infinitely divisible linear series of periods with no begin-
ning and no end. Thus unlike SL, ASL can easily be turned into a comprehensive system of modal and temporal logic.

Propositional operators for time-relative truth and falsity and for absolute truth and falsity may be defined as follows:

D11. It is true during \( t_1 \) that \( p =_s t \) it is the case during \( t_1 \) that \( p. \)

D12. It is false during \( t_1 \) that \( p =_s t \) it is true during \( t_1 \) that it is not the case that \( p. \)

D13. It is true that \( p =_s t \) for some \( t_1 \), it is true during \( t_1 \) that \( p. \)

D14. It is false that \( p =_s t \) for some \( t_1 \), it is false during \( t_1 \) that \( p. \)

ASL contains the familiar Excluded Middle Thesis: of necessity for every \( p \) either it is the case that \( p \) or it is not the case that \( p. \) It also contains the familiar Bivalence Thesis: of necessity every proposition is either true or false. Thus ASL is, like SL, a two-valued rather than a many-valued system. But ASL does not contain what we shall call the Unrestricted Temporal Bivalence Thesis: of necessity every proposition is either true during any time or false during that time. As we shall see, disproof of this thesis was Aristotle's main objective in Chapter 9 of *De Interpretatione*. ASL does, however, contain a closely related thesis which Aristotle accepted, the Restricted Temporal Bivalence Thesis: of necessity every proposition affirming the occurrence of an event is either true during any time or false during that time, provided the time is simultaneous with or later than that of the event's occurrence. Equipped with ASL, let us now turn to Chapter 9. A logical analysis of Aristotle's argument will be presented, to be followed by detailed examination of the text.

III.

Aristotle begins by accepting the thesis that of necessity every proposition affirming the occurrence of a present or past event is true or false. Since throughout the chapter he seems to be employing the notions of time-relative truth and falsity, we take the thesis to mean that every such proposition is now true or now false, i.e. true during the present time or false during the present time. Since there is nothing intrinsically special about the present time, the thesis is equivalent to the Restricted Temporal Bivalence Thesis, that of necessity if a proposition affirms that an event occurs during \( t_1 \), then for every simultaneous or later time \( t_2 \), the proposition is either true during \( t_2 \) or false during \( t_2 \). Aristotle claims that the situation is different with regard to propositions affirming the occurrence of future events, and he rejects the unrestricted thesis that of necessity every proposition is true or false. This thesis, which we construe as meaning that every proposition is now true or now false, is equivalent to the Unrestricted Temporal Bivalence Thesis, that of necessity every proposition is either true during any time or false during that time. Aristotle argues that acceptance of the unrestricted thesis would entail acceptance of the absurd idea that any proposition affirming the occurrence of an actual
event has always been true and is therefore necessary—in other words, that everything that happens happens necessarily, never as chance has it.\(^{21}\) He goes on to claim that an event cannot originate from deliberation and action unless it can be contingent, i.e. can be such that it is both possible that it occur and possible that it fail to occur. He argues that since this is so, and since there obviously are events which originate from deliberation and action, the unrestricted thesis is false.\(^{22}\)

Aristotle's argument can be stated in a direct form: It is highly plausible, if not obvious, that an event can originate from deliberation and action only if it is possible that the event is contingent, i.e. is such that it is both possible that it occur and possible that it fail to occur.\(^{23}\) And it is obvious that there is at least one event, call it \(E\), which originates from such a source. It follows that \(E\) can be contingent, and therefore that the proposition affirming the occurrence of \(E\), call it \(P\), is such that it can be both possible that \(P\) and possible that not-\(P\). Consequently, it can be the case that \(P\) is neither necessary nor impossible. This entails that it is not necessary that it is either true during every time that \(P\) or false during every time that \(P\), something which in turn entails that it is not necessary that it is either true during any time that \(P\) or false during that time that \(P\). Thus, according to Aristotle, by reflecting on more or less obvious facts about deliberation and action one can discover counterexamples to the unrestricted thesis. Aristotle's argument contains only highly plausible premises, and is, from the perspective of ASL, deductively valid.\(^{24}\)

In concluding his discussion, Aristotle distinguishes between absolute necessity, with which he has been concerned, and necessity relative to a time. He claims that while every actual event is such that its occurring is necessary relative to the time of its occurrence, its occurring need not be absolutely necessary.\(^{25}\) A time-relative necessity operator fitting Aristotle's conception can be defined as follows:

\[
\text{DI5. } \text{It is necessary relative to } t_1 \text{ that } p = df \text{ for every } t_2 \text{ simultaneous with or later than } t_1, \text{ it is the case during } t_2 \text{ that } p.
\]

Aristotle's thesis that relative necessity characterizes the occurrence of every actual event holds in ASL and entails the Restricted Temporal Bivalence Thesis, and his thesis that there can be actual events whose occurring is not absolutely necessary follows according to ASL from the falsity of the Unrestricted Temporal Bivalence Thesis.\(^{26}\) Thus Aristotle could block the inference that his rejection of the unrestricted thesis entails rejection of the commonsensical idea that, in some sense of 'necessary', whatever is actual is necessary. Any actual event \(E\) is such that, once \(E\) has happened, it is necessary then that \(E\) has happened, for it is true then and true ever after that \(E\) has happened.\(^{27}\) Aristotle goes on to point out that, while it is necessary for everything that either it will be or will not be the case, one cannot infer that for everything either it is necessary that it will be the case or it is necessary that it will not be the case. Similarly, even though it is necessary that, for any proposition, either it will be true or it will be false, it does not follow that, for any proposition, either it is necessary that it will be true or it is necessary that it will be false. Thus Aristotle in effect accepts the ordinary Excluded Middle and Bivalence theses, and notes that they have no objectionable consequences.
We can make use of Aristotle's notion of time-relative necessity to explicate the notion of fixity involved in the theory of determinism, and we can go on to provide precise characterizations of the varieties of determinism. We will then be in a position to assess the cogency of Aristotle's argument as a weapon against fatalism. An event is fixed relative to a time if and only if its occurrence is necessary relative to that time. Determinism is the theory that every actual event is such that its occurrence is necessary relative to every earlier time. Fatalism is the theory that it is necessarily rather than contingently the case that every actual event has a sufficient cause, or, more precisely, that the Universal Causation Thesis holds: for every \( t_1 \) and every \( t_2 \) earlier than \( t_1 \), every event occurring during \( t_1 \) is such that there is another event occurring during \( t_2 \) which is a sufficient condition of the event occurring during \( t_1 \). The notion of sufficient conditionship may be defined as follows:

D16. Its being the case that \( p \) is a sufficient condition of its being the case that \( q = \forall t \), of necessity if it is the case during \( t_1 \) that \( p \), then it is the case during \( t_1 \) that \( q \).

Although fatalism and causal determinism are distinct theories, each entails determinism, and the latter in turn entails what may be called the Universal Necessitation Thesis: every actual event is such that its occurrence is absolutely necessary. Since there is nothing in Aristotle's argument which conflicts with causal determinism (except his suggestion that universal necessitation is in itself absurd), the causal determinist could accept the argument as sound. But the thesis the argument is directed against, the Unrestricted Temporal Bivalence Thesis, entails fatalism and appears to be the only source of the credibility of fatalism. Hence the fatalist would be practically forced to reject one of the premises of the argument. Since both premises seem true, the argument constitutes a formidable weapon against fatalism.

IV.

Aristotle's argument, as we have interpreted it, has highly plausible premises and a deductively valid structure. In view of Aristotle's stature as a logician, this constitutes evidence for the accuracy of the interpretation. Nevertheless, detailed examination of the text is called for before the interpretation can be considered valid. In developing the following translation and commentary, we were guided by two concerns—to provide as literal a translation as was feasible, and to clarify the logical role of each clause. We were surprised to find that these concerns were relatively easy to harmonize.

Aristotle begins by noting that in a number of cases it holds necessarily that propositions are either true or false at the present time. The cases are: (a) propositions about present and past events and states of affairs, (b) propositions about universals as universals (e.g. all Greeks are white) and (c) propositions about universals in relation to particulars (e.g., Socrates is white). Aristotle had earlier discussed cases (b) and (c) at De Int. 17a26-35. A minor exception, also previously discussed in the same place, occurs in the following case: (d) propositions about universals not as universals (e.g., a man is white). Since accord-
ing to Aristotle such a proposition can be both true and false at the same time, and since ‘or’ suggests ‘not both’, it should not be said without qualification to be true or false. The major exception, which is the focus of attention throughout the chapter, occurs in the following case: (e) propositions about future events and states of affairs. It is not that such propositions can be at present both true and false, but rather that when the relevant events and states of affairs are future contingencies, such propositions are at present neither true nor false.

18*28-33. Concerning things that are and things that have come to be, it is necessary that the affirmation or the denial be true or false; and concerning universals as universals [it is necessary that the one] is always true while [the other] is false; and concerning [universals] in relation to particulars, [it is] as has just been said; but concerning what is said of universals not as universals, [it is] not necessary, but [it is] as was said regarding these. But concerning what is going to be regarding particulars, it is not the same.

Aristotle argues that if one ignores this exception and holds that of necessity every proposition is at present either true or false, and if one holds also that of necessity any event or state of affairs a proposition is about either obtains or does not obtain, then since it follows that anyone making a prediction is making a statement which is of necessity either true or false at the time the statement is made, one must accept the consequence that everything that happens happens by necessity and not as chance has it.

18*34-37. For if [it is necessary that] every affirmation and denial be true or false, and it is necessary that everything be or not be, so that if someone will say that something will be but [another] will deny this same thing, it is clear that necessarily one or the other of them speaks truthfully, if all affirmations and denials are true or false (for both will not be [true] together concerning things of such a kind; [and] for if it is true to say that something is white or that it is not white, it was true to say or to deny, and if it is not, then it is false, and if it is false, it is not; so that it is necessary that either the [aforementioned] affirmation or the [aforementioned] denial be true or false), straightforwardly one thing either becomes or is by chance, nor the one of the two which happens [happens] by chance, not even [whether] it will be or will not be, but everything is by necessity and neither of the two chances to be.

To show that this consequence follows, Aristotle first restates the lemma he has deduced, i.e. of necessity any prediction is either true or false at the time it is made, and then provides three arguments linking it to the consequence that everything that happens happens by necessity and never by chance. The first two are indirect arguments: if something were to happen but not happen by necessity, it would have been possible that it should happen and possible that it should not happen, something which conflicts with the prediction’s having been already true; similarly, if something were to happen purely by chance, it would not have been more inclined to happen than not to happen, something which likewise clashes with the prediction’s having been already true. The
third argument, a direct and more elaborate one, utilizes the implicit
generality of the lemma by deducing the consequences of the corollary
that any past prediction was of necessity either true or false when it
was made.

1807-16. For either he who asserts or he who denies speaks
truthfully. In like manner: for [otherwise] it might be that
something became or did not become; for [otherwise] whichever
of the two happened, it neither held nor will hold more
in this way than not in this way. Moreover, if a thing is
white now, it was true to say earlier that it will be white,
so that it was always true to say of anything whatsoever
that has come to be that it is or will be. But if it was al-
ways true to say that it is or will be, how impossible that
this not be and will not be 34. When a thing cannot not
come to be, how impossible that it should not: Further, when
it is impossible that something not come to be, necessarily it
comes to be. Therefore everything which will be will come to
be necessarily. It follows that neither alternative chanced to
be nor will it come to be by chance, for if by chance, then
not by necessity.

Aristotle argues that one should not try to solve the problem by reject-
ing both of the assumptions which have yielded the troublesome conse-
quence, the assumption that of necessity every proposition is at present
true or false, and the assumption that of necessity any event or state
of affairs a proposition is about either obtains or does not obtain. Al-
though by rejecting the latter assumption one could reject the former,
the results would be disastrous.

18017-25. And yet it is not possible to say that neither of
the two is true for such [reason] as that something neither
will be nor will not be. For first the denial is not true
whose [corresponding] affirmation is false, and it happens
together with this that the affirmation is not true whose
[corresponding denial] is false. And for these [reasons also],
if it is true to say that something is white and large, it is
necessary that it be both. But if [it is true to say that] it
will be both tomorrow, [it is necessary that] it will be both
tomorrow. If [it is true to say that] it neither will nor will
not be tomorrow, then it is impossible that one of the two
chance to happen; for example, a sea battle, for it would be
necessary that the sea battle neither come to be tomorrow
nor not come to be.

Aristotle makes it clear that what is to be rejected is only the thesis
that of necessity every proposition is at present either true or false.
And he argues that the thesis is false not only because of the absurd
consequence that it rules out chance and contingency, but also because
of the absurd consequence that it rules out the efficacy of deliberation
and action. His argument can be expressed as follows: Suppose that we
will choose to bring something about and will work to bring it about,
and suppose that long ago someone predicted that the thing would come
about while someone else predicted that it would not. If the predictions
were of necessity either true or false when they were made, then what-
ever actually comes about will come about of necessity and hence cannot
have had an origin in our deliberation and action. And it does not mat-
ter whether or not the predictions were actually made, but only that if they had been made, they would have been of necessity either true or false at the time. Since it is obvious that many things do have an origin in deliberation and action, and hence are such that it is both possible that they occur and possible that they not occur, we must reject the thesis that of necessity every proposition is at present either true or false.

18b26-19a22. These absurd consequences and others like them follow if indeed of all affirmations and denials, either about universals being spoken of as universals or about particulars, it is necessary of these opposites that one is true and the other is false, and that neither alternative happens by chance among things coming to be, but everything is and becomes out of necessity, so that it would not be necessary to choose nor to work to bring something about, as if were we to do this, this will be, but if not this, then this will not be. For there is nothing to prevent someone's saying for ten thousand years that this will be, but another says not, so that out of necessity that one will come to be of whichever of the two of them truth was said then. Nor does it make any difference whether anyone asserted the contradictory or did not assert it, since clearly things are thus even if someone did not affirm it and another deny it. For it is not through affirming or denying that something will be or not be, nor for ten thousand years rather than for any other time, so that if in the whole of time it was thus to be true of one or the other, it was necessary for this to come to be, and each of the things coming to be in this manner, always such that it comes to be out of necessity. For what someone truly said will be is such that it cannot not come to be, and of that coming to be it was always truly said that it will be. For, seeing that these things are impossible, we see that there is an origin both in deliberation and in action of what will be, and that on the whole in things that are not always actual it is possible to be and, in like manner, not [to be], in which case both are possible, being and not being, and as a result becoming and not becoming. Clearly we have many things like this, such as that it is possible to cut up this cloak, and yet it will not be cut up, but may wear out earlier. But similarly, its not being cut up is also possible, for it would not be the case that it wore out earlier if its not being cut up were not possible. So that regarding the other things coming to be, it is the same as those which were spoken of in terms of possibility. Thus it is clear that not everything either is or becomes out of necessity. But of the two sorts, the ones [whose origin is in deliberation and action] happen and it is not the case that the affirmation is true rather than the denial, but the others for the most part [are such that] one [is] rather than the other, but it is not possible for the other to have become rather than the other [which is].

Having refuted the thesis that of necessity every proposition is at present either true or false, Aristotle concludes the discussion by distinguishing this thesis, together with its absurd consequences (i.e. that all that is, necessarily is; that all that is not, necessarily is not; that ev-
Everything necessarily is or necessarily is not; and that everything necessarily will be or necessarily will not be) from several related but acceptable theses (i.e. that all that is, necessarily is, relative to when it is; that all that is not, necessarily is not, relative to when it is not; that of necessity everything either is or is not; that of necessity everything either will be or will not be; and that of necessity every proposition is such that either it will eventually be true or it will eventually be false).

19\textsuperscript{23}-39. Accordingly, that which is, when it should be, necessarily is; and that which is not, when it should not be, necessarily is not. But assuredly neither all that is, necessarily is; nor all that is not, necessarily is not. For all that is, when it is, to be out of necessity, is not the same as [for all that is] to be out of necessity \textit{simpliciter}. And similarly concerning what is not. And concerning contradictories, the same account [as concerning things holds]—[first] everything necessarily is or is not, and will be or will not; certainly the divisions are not [such as] to say that one or the other is necessary (I say, for example, it is necessary that a sea battle will take place tomorrow or will not, but certainly it is not necessary that a sea battle come to be tomorrow, nor [necessary] that it not come to be, but it is necessary that it either come to be or not come to be); so [second] since statements are true just as they are like facts, it is clear that as long as it holds that whichever of the two [comes to be] happens although its contraries be possible, necessarily it holds in like manner for the contradictory. (This comes to pass regarding things which neither always are nor always are not.) For of these [statements], necessarily one or the other part of the contradictory is true or false, certainly not [necessarily] this one or [necessarily] that one but whichever of the two happened to be [true], and [necessarily] one [part] is true rather than the other, yet certainly not from this time true or false.

Aristotle ends with a brief summary, reiterating his rejection of the thesis that of necessity every proposition is at present either true or false.

19\textsuperscript{39}-b\textsuperscript{9}. It is, then, clearly not necessary that of all affirmations and their respective denials one be true and the other false. For what holds concerning things which are does not hold concerning things which are not but which may be or may not be; but [regarding these] it is as has just been said.

Careful examination of the text has shown that our interpretation of Aristotle's argument is in close accord with the structure of the chapter as a whole as well as with each part. This interpretation makes it possible to view the chapter as a tightly organized, cogently argued essay, free of fallacies and misstatements, exhibiting profound insight into the nature of time, truth, necessity and choice. Our view of this incredibly controversial chapter contrasts sharply with the majority of views down through the ages. As Richard Taylor has remarked, "The prevailing opinion . . . is and always has been, that Aristotle was muddled in these arguments and that his conclusion was false." Indeed,
our view stands diametrically opposed to that of many recent inter-
preters, such as Donald Williams, for whom Aristotle's reasoning is "so
swaggeringly invalid that the student can hardly believe he meant it," and his conclusion "as nearly incredible as any proposition could be."36
We feel that we have identified a cogent, philosophically profound argu-
ment, having intuitively sound premises and a deductively valid struc-
ture, which allows every clause of the essay to play an appropriate
logical role. It seems reasonable to conclude that this argument is none
other than Aristotle's argument.

Additional support for our interpretation will be forthcoming if we
can succeed in showing that it is compatible with a plausible recon-
struction of Diodorus' famous Master Argument, which apparently was
directed against Aristotle's position on fatalism.

V.

We noted above that Aristotle's argument, as we have construed it,
constitutes a formidable weapon against fatalism. It stands to reason
that anyone in the ancient world who succeeded in rebutting the argu-
ment would be apt to acquire widespread notoriety as a dialectician par
excellence. With his Master Argument, Diodorus may have accomplished
this seemingly impossible feat.

The following report from Epictetus is the most informative de-
scription of the Master Argument we possess:

The Master Argument seems to have been formulated with
some such starting points as these. There is an
incompatibility between the three following propositions,
"Everything that is past and true is necessary," "The
impossible does not follow from the possible," and "What
neither is nor will be is possible." Seeing this
incompatibility, Diodorus used the convincingness of the
first two propositions to establish the thesis that nothing is
possible which neither is nor will be true.37

We propose to construe the first two propositions and the conclusion
as follows:

Thesis A: Every proposition which was true in the past is
now necessary, i.e. is necessary relative to the
present time.

Thesis B: An impossible proposition does not follow from a
possible one.

Thesis C: No proposition is possible which neither is now
ture nor will be true.

The third proposition mentioned should be construed as the contradic-
tory of the conclusion, Thesis C. The fact that this proposition was men-
tioned along with Thesis B, which may be appropriately called the prin-
ciple of reductio ad absurdum proof, indicates that the argument had
the form of a reductio. Thesis A, which is closely related to Aristotle's
thesis that whatever has happened is necessary relative to the time of
its happening, is quite plausible and is provable in ASL. Thesis C would have been anathema to any orthodox Aristotelian, as it rules out the possibility of contingent events, and hence entails fatalism.

We hypothesize that the following highly plausible thesis was at least an implicit premise of the Master Argument:

**Thesis D:** If a proposition is not always true, its negation is sometimes true.

And we hypothesize that Diodorus argued more or less as follows:

We may take for granted the following two premises:

1. Every proposition which was true in the past is now necessary.
2. If a proposition is not always true, its negation is sometimes true.

Now let us assume the following:

3. Some proposition, say, that there will be a sea battle tomorrow (call it P), is neither now true nor will be true but is possible.

We may draw the following conclusions:

4. It is possible that P. [From (3)]
5. It is not necessary that not-P. [From (4)]
6. It is not always true that not-P. [From (5)]
7. It is sometimes true that P. [From (2) and (6)]
8. Either it was true, is now true or will be true that P. [From (7)]
9. It is not now true, nor will it be true, that P. [From (3)]
10. It was true that P. [From (8) and (9)]
11. It is now necessary that P. [From (1) and (10)]
12. It is now true that P. [From (11)]
13. It is not now true that P. [From (3)]

The assumption has led to an impossibility. We may therefore draw the following conclusion:

14. No proposition is possible which neither is now true nor will be true.
ARISTOTLE VS. DIODORUS: FATALISM DEBATE

If the Master Argument took this form, it would have been apt to produce shock and dismay among the Aristotelians. The premises are highly plausible, the argument is deductively valid from the perspective of ASL, which seems to codify the principles of reasoning employed by Aristotle in discussing such topics, and the conclusion entails the truth of fatalism.

The available evidence suggests that the Aristotelians were unable to devise any convincing rejoinder to the Master Argument. Indications are that Diodorus won the debate. If so, it was a shame, for he did not deserve victory. The second premise of his argument, that if a proposition is not always true, its negation is sometimes true, is a question-begging premise. To expose the flaw in the argument, let us formulate Step (6) in precise language, and let us make the move from (6) to (7) fully explicit by inserting an intermediate step, (6'):

(6) It is not the case that for every t, it is true during t that not-P.

(6') For some t, it is not the case that it is true during t that not-P.

(7) For some t, it is true during t that P.

From the perspective of ASL, the move from (6') to (7) would not be valid in the absence of the second premise. The thesis which, if true, would make the move legitimate and would verify the second premise is one we can appropriately call Diodorus' Thesis: of necessity if a proposition is not true during a time, then its negation is true during that time. This thesis is equivalent to the Unrestricted Temporal Bivalence Thesis. Thus Diodorus took for granted the very thesis which Aristotle had so effectively discredited in Chapter 9. Clearly, then, Diodorus was guilty of begging the question, and did not deserve his laurels.

VI.

We have sketched the construction of Augmented Standard Logic, or ASL, a system which seems to codify the principles of reasoning employed by Aristotle in his discussion of fatalism, and we have utilized the system in an effort to show that some sophisticated philosophizing characterized the ancient debate between Aristotle and Diodorus. We have shown that ASL enables one to find, in the perplexing text of Chapter 9 of De Interpretatione, a cogent, philosophically significant argument against fatalism, and to reconstruct, from a surviving sketch of the Master Argument, a clever, dialectically impressive counterattack. In closing we would like to suggest that ASL, which contains an interesting system of temporal and modal logic emanating from a modicum of primitives, might be quite useful in contemporary investigations of the numerous philosophical problems having temporal and modal dimensions.
APPENDIX

Proofs of the various facts about ASL mentioned in the text are provided in abbreviated form. The axioms, theorems and rules of SL, expanded to incorporate temporal variables, are presupposed. Conjunction 'p and q' is symbolized as 'p & q', disjunction 'p or q' as 'p v q', implication 'if p then q' as 'p => q', and complication 'p if and only if q' as 'p <-> q'. The primitive time-relative negation operator, 'it is not the case during ti that p', is symbolized as '¬-tip'. The expressions 'fti' and 'gti' represent well-formed formulas containing 'ti' as a free variable. The expressions 'f( )' and 'g( )' represent temporally incomplete "propositional" expressions, i.e. predicate expressions which resemble well-formed formulas except for containing gaps where temporal variables or constants could appear. The expression for universal quantification 'for all', is symbolized as '∀', while that for particular quantification, 'for some', is symbolized as '∃'. The symbol '/' in proofs indicates that the expression on the left side of the symbol is substituted for the expression on the right. Parentheses and brackets will normally be used only when needed to eliminate ambiguity. For convenience, the same symbols are employed as object-language symbols in axioms and theorems, and as metalanguage symbols in definitions and rules. The consistency of ASL follows from the fact that if Axiom A3 were strengthened by removing the restriction to formulas containing a free occurrence of the temporal variable (i.e., if A3 were replaced by '¬-tip = ¬p'), ASL would collapse into SL.

A. Definitions

D1. ¬p =⇒ ∀ti(¬-tip). It is not the case that p.
D2. tip =⇒ (¬-tip). It is the case during ti that p.
D3. Np =⇒ ∀ti(tip). It is necessary that p.
D3'. Nf( ) =⇒ ∀ti(f(t,ti)). It is de re necessary that f( ).
D4. tiT1t2 =⇒ ∀p[N(tip =⇒ tsp)]. ti temporally implicates t2.
D5. tiSIMt2 =⇒ tiT1t2 & t2T1t1. ti is simultaneous with t2.
D6. tiIt2 =⇒ ∀p[N(tap =⇒ tsp)]. ti includes t2.
D7. tiEt2 =⇒ ∀t3[t3It3 =⇒ (tiT1t3 & ←t3T1t3)]. ti is earlier than t2.
D8. tiLt2 =⇒ tiEt2. ti is later than t2.
D9. ti=t2 =⇒ tiIt2 & t2It1. ti is identical with t2.
D10. INSTt1 =⇒ ∀t2(t2It2 =⇒ tiT1t2). ti is an instant.
D11. Ttip =⇒ tip. It is true during ti that p.
D11'. Tt( ) =⇒ ti f( ). It is de re true during ti that f( ).
D12'. \( F_{t_1}f( ) =df T_{t_1}r_f( ). \) It is de re false during \( t_1 \) that \( f( ). \)

D13. \( T_p =def \exists t_1(T_{t_1}p). \) It is true that \( p. \)

D13'. \( Tr_f( ) =def \exists t_1(T_{t_1}f( )). \) It is de re true that \( f( ). \)

D14. \( F_p =def \exists t_1(F_{t_1}p). \) It is false that \( p. \)

D14'. \( Fr_f( ) =def \exists t_1(F_{t_1}f( )). \) It is de re false that \( f( ). \)

D15. \( N_{t_1}p =def \forall t_2[(t_2SIMt_1 \lor t_2Lt_1) \supset t_1p]. \) It is necessary relative to \( t_1 \) that \( p. \)

D16. \( pSCq =df \forall t_1[N(t_1p \supset t_1q)]. \) Its being the case that \( p \) is a sufficient condition of its being the case that \( q. \)

D17. \( \sim t_1Ot_2 =def \exists t_33[3(t_3Et_1 \& t_3It_2 \& t_3It_3 \& (t_3Et_2 \& t_3Lt_1) \lor (t_3Lt_2 \& t_3Et_1)]. \) \( t_1 \) overlaps \( t_2. \)

D18. \( \sim t_1Dt_2 =def \sim t_1It_2 \& \sim t_2It_1 \& \sim t_1Ot_2. \) \( t_1 \) is distinct from \( t_2. \)

D19. \( \sim t_1Ct_2 =def \sim t_1Dt_2. \) \( t_1 \) coincides (at least partially) with \( t_2. \)

D20. \( B_{t_1t_2} =def (t_2Et_1 \& t_1Et_2) \lor (t_1Et_2 \& t_1Et_1). \) \( t_1 \) is between \( t_2 \) and \( t_3. \)

B. Axioms

A1. \( t_1(p \lor q) = t_1p \& t_1q. \)

A2. \( (t_1p \& t_1(p \supset q)) \supset t_1q. \)

A3. \( \neg t_1ft_1 = \neg t_1t. \)

C. Primitive Rules

PR1. If 'p' is a thesis, then '\( \forall t_1(t_1p)' ' is a thesis.

D. Postulates

P1. \( (t_1Dt_2 \& \sim t_2SIMt_2) \supset (t_1Et_2 \lor t_2Et_1). \)

P2. \( \exists t_3(INSt_2 \& t_1It_2). \)

P3. \( (INSt_2 \& INSt_2 \& t_1Dt_2) \supset \exists t_3(Bt_1t_2t_3). \)

P4. \( INSt_1 \supset \exists t_33t_4(3t_4t_3t_4). \)
E. Theorems and Derived Rules

DR1. If 'p' is a thesis, then 'Np' is a thesis.
Proof: 1. 'p' is a thesis. (Premise)
2. \( \forall t (t p) \)' is a thesis. (1,R1)
3. 'Np' is a thesis. (2,D3)

T1. \(-t p \equiv \sim(t p)\).
Proof: 1. \( \sim p \equiv \sim p \). (Thesis of SL)
2. \( \sim(t p) \equiv \sim(t p) \). (1,D1)
3. \( \exists t (\sim(t p)) \equiv \sim(t p) \). (2,QE)
4. \( \exists t (T t p) \equiv p \). (3,D2)
5. \( \exists t (T t p) \equiv p \). (4,D11)
6. \( T p \equiv p \). (5,D13)

T2. \( T p \equiv p \).
Proof: 1. \( \sim(\sim p) \equiv p \). (Thesis of SL)
2. \( \sim(\forall t \sim(t p)) \equiv p \). (1,D1)
3. \( \exists t (\sim(t p)) \equiv p \). (2,QE)
4. \( \exists t (T t p) \equiv p \). (3,D2)
5. \( \exists t (T t p) \equiv p \). (4,D11)
6. \( T p \equiv p \). (5,D13)

T3. \( F p \equiv \sim p \).
Proof: 1. \( T p \equiv \sim p \). (T2, \( \sim p / p \))
2. \( \exists t (\sim(T t p)) \equiv p \). (1,D13)
3. \( \exists t (F t p) \equiv p \). (2,D12)
4. \( F p \equiv \sim p \). (3,D14)

T4. \( N p \supset p \).
Proof: 1. \( N p \). (Premise)
2. \( \forall t (t p) \). (1,D3)
3. \( t p \). (2,UI)
4. \( \exists t (t p) \). (3,EG)
5. \( \exists t (T t p) \). (4,D11)
6. \( T p \). (5,D13)
7. \( p \). (6,T2)

T5. \( N p \equiv \forall t (T t p) \).
Proof: 1. \( p \equiv p \). (Thesis of SL)
2. \( N p \equiv p \). (1,Np/p)
3. \( N p \equiv \forall t (T t p) \). (2,D3)
4. \( N p \equiv \forall t (T t p) \). (3,D11)

T6. \( [N p \supset N(p \supset q)] \supset N q \).
Proof: 1. \( N p \). (Premise)
2. \( N(p \supset q) \). (Premise)
3. \( \forall t (t p) \). (1,D3)
4. \( \forall t [t p \supset q) \}. (2,D3)
5. \( t p \). (3,UI)
6. \( t p \supset q \). (4,UI)
7. \( t q \). (5,6,A2)
8. \( \forall t q \). (7,UG)
9. \( N q \). (8,D3)

T7. \( N(p \supset q) \supset (N p \supset N q) \).
Proof: 1. \( [N p \supset N(p \supset q)] \supset N q \). (T6)
2. \( [N(p \supset q) \supset N p] \supset N q \). (1,Com)
3. \( N(p \supset q) \supset (N p \supset N q) \). (2,Exp)
T8. \( N(p \land q) = Np \land Nq \).

Proof:
1. \( \forall t_i[tt(t_i(p \land q))] = \forall t_i[t_i(p \land q)] \). (Thesis of SL)
2. \( \forall t_i[tt(t_i(p \land q))] = \forall t_i[t_i(p) \land t_i(q)] \). (1,A1)
3. \( \forall t_i[tt(t_i(p \land q))] = \forall t_i[t_i(p) \land \forall t_i(t_iq)] \). (2,Dist)
4. \( N(p \land q) = Np \land Nq \). (3,D3)

T9. \( [N(p \Rightarrow q) \land N(q \Rightarrow r)] \Rightarrow N(p \Rightarrow r) \).

Proof:
1. \( [(p \Rightarrow q) \land (q \Rightarrow r)] \Rightarrow (p \Rightarrow r) \). (Thesis of SL)
2. \( N[[p \Rightarrow q) \land (q \Rightarrow r)] \Rightarrow (p \Rightarrow r)] \). (1,DRI)
3. \( N[(p \Rightarrow q) \land (q \Rightarrow r)] \Rightarrow N(p \Rightarrow r) \). (2,T7)
4. \( [N(p \Rightarrow q) \land N(q \Rightarrow r)] \Rightarrow N(p \Rightarrow r) \). (3,T8)

T10. \( (t_iTIt_2 \land t_2TIt_3) \Rightarrow t_iTIt_3 \).

Proof:
1. \( t_iTIt_2 \). (Premise)
2. \( t_2TIt_3 \). (Premise)
3. \( \forall p[tt(t_ip \Rightarrow t_2p)] \). (1,D4)
4. \( \forall p[N(t_2p \Rightarrow t_2p)] \). (2,D4)
5. \( N(t_ip \Rightarrow t_2p) \). (3,UI)
6. \( N(t_2p \Rightarrow t_2p) \). (4,UI)
7. \( N(t_ip \Rightarrow t_2p) \). (5,6,T9)
8. \( \forall p[N(t_2p \Rightarrow t_2p)] \). (7,UG)
9. \( t_iTIt_3 \). (8,D4)

T11. \( t_iSIt_1 \).

Proof:
1. \( t_1p \Rightarrow t_1p \). (Thesis of SL)
2. \( N(t_1p \Rightarrow t_1p) \). (2,DR1)
3. \( \forall p[N(t_1p \Rightarrow t_1p)] \). (2,UG)
4. \( t_iTIt_1 \). (3,D4)
5. \( t_iTIt_1 \land t_2TIt_1 \). (4,Taut)
6. \( t_iSIMt_1 \). (5,D5)

T12. \( t_2SIMt_2 \Rightarrow t_2SIMt_1 \).

Proof:
1. \( t_1SIMt_2 \). (Premise)
2. \( t_2TIt_2 \land t_iTIt_1 \). (1,D5)
3. \( t_2TIt_1 \land t_1TIt_2 \). (2,Com)
4. \( t_2SIMt_1 \). (3,D5)

T13. \( (t_2SIMt_2 \land t_2SIMt_3) \Rightarrow t_2SIMt_3 \).

Proof:
1. \( t_1SIMt_2 \land t_2SIMt_3 \). (Premise)
2. \( (t_1TIt_2 \land t_2TIt_2) \land (t_1TIt_3 \land t_2TIt_3) \). (1,D5)
3. \( t_1TIt_2 \land t_2TIt_2 \). (2,T10)
4. \( t_2SIMt_3 \). (3,D5)

T14. \( t_itp = t_ip \).

Proof:
1. \( \neg t_if t_1 = \neg t_1f t_1 \). (A3)
2. \( \neg t_i(t_ip) = \neg (t_ip) \). (1,t_1p/ft_1)
3. \( \neg t_i(t_ip) = \neg (t_ip) \). (2,Eq.)
4. \( t_i(t_ip) = t_ip \). (3,DN)
5. \( t_1t_ip = t_ip \). (4,D2)

T15. \( t_ip \Rightarrow p \).

Proof:
1. \( t_ip \). (Premise)
2. \( Tt_ip \). (1,D11)
3. \( \exists t_1(Tt_ip) \). (2,BG)
4. \( Tp \). (3,D13)
5. \( p \. (4,T2) \)
T16. \( t_1t_2 \Rightarrow t_2T_l t_1 \)
Proof:
1. \( t_1t_2 \). (Premise)
2. \( \forall p[N(t_2 \Rightarrow t_1t_1p)]. \) (1,D6)
3. \( N(t_2 \Rightarrow t_1t_1p) \). (2,UI)
4. \( N(t_1t_1p \Rightarrow t_1p) \). (T15,t_2/t_1,t_1p/p,DR1)
5. \( N(t_1p \Rightarrow t_1p) \). (3,4,T9)
6. \( \forall p[N(t_1p \Rightarrow t_1t_1p)]. \) (5,UG)
7. \( t_2T_l t_1 \). (6,D4)

T17. \( t_l t_1 \)
Proof:
1. \( t_l t_1p = t_1p \). (T14)
2. \( t_1p = t_l t_1p \). (1,Com)
3. \( t_1p \Rightarrow t_l t_1p \). (2,Simp)
4. \( N(t_1p \Rightarrow t_l t_1p) \). (3,DR1)
5. \( \forall p[N(t_1p \Rightarrow t_l t_1p)]. \) (4,UG)
6. \( t_l t_1 \). (5,D6)

T18. \( \sim t_1E t_1 \)
Proof:
1. \( t_1E t_1 \). (Assump)
2. \( \forall t_2[t_1t_2 \Rightarrow (t_2T_l t_2 \& \sim t_2T_l t_1)]. \) (1,D7)
3. \( t_1t_1 \Rightarrow (t_1T_l t_1 \& \sim t_1T_l t_1). \) (2,UI)
4. \( t_1t_1 \). (T17)
5. \( t_2T_l t_1 \& \sim t_2T_l t_1. \) (3,4,MP)
6. \( \sim t_1E t_1 \). (1-5,IP)

T19. \( t_1E t_2 \Rightarrow \sim t_2E t_1 \)
Proof:
1. \( t_1E t_2 \). (Premise)
2. \( \forall t_3[t_3t_3 \Rightarrow (t_3T_l t_3 \& \sim t_3T_l t_1)]. \) (1,D7)
3. \( t_3E t_2 \). (Assump)
4. \( \forall t_3[t_3t_3 \Rightarrow (t_3T_l t_3 \& \sim t_3T_l t_1)]. \) (3,DR1)
5. \( t_2t_2 \Rightarrow (t_2T_l t_2 \& \sim t_2T_l t_1). \) (2,UI)
6. \( t_2t_2 \). (T17,t_2/t_1)
7. \( t_2T_l t_2 \& \sim t_2T_l t_1. \) (5,6,MP)
8. \( t_1t_2 \Rightarrow (t_1T_l t_2 \& \sim t_1T_l t_2). \) (4,UI)
9. \( t_1t_2 \). (T17)
10. \( t_2T_l t_1 \& \sim t_2T_l t_2. \) (8,9,MP)
11. \( t_1T_l t_1 \& \sim t_1T_l t_2. \) (7,10,Conj)
12. \( \sim t_2E t_1. \) (3-11,IP)

T20. \( (t_1E t_2 \& t_3E t_3) \Rightarrow t_1E t_3 \)
Proof:
1. \( t_1E t_2 \). (Premise)
2. \( t_3E t_3 \). (Premise)
3. \( \forall t_4[t_4t_4 \Rightarrow (t_4T_l t_4 \& \sim t_4T_l t_2)]. \) (1,D7)
4. \( \forall t_4[t_4t_4 \Rightarrow (t_4T_l t_4 \& \sim t_4T_l t_2)]. \) (2,D7)
5. \( t_3t_3 \). (Assump)
6. \( t_3t_3 \Rightarrow (t_3T_l t_3 \& \sim t_3T_l t_2). \) (4,UI)
7. \( t_3T_l t_3 \& \sim t_3T_l t_2. \) (5,6,MP)
8. \( t_2t_2 \Rightarrow (t_2T_l t_2 \& \sim t_2T_l t_1). \) (3,UI)
9. \( t_2t_2 \). (T17,t_2/t_1)
10. \( t_2T_l t_2 \& \sim t_2T_l t_2. \) (8,9,MP)
11. \( t_3T_l t_3 \& \sim t_3T_l t_2. \) (7,10,Conj)
12. \( t_3T_l t_3 \). (11,T13)
13. \( t_4E t_3 \). (Assump)
14. \( t_4E t_3 \). (10,Simp)
15. \( t_4E t_3 \). (13,14,T12)
16. \( \sim t_4T_l t_2. \) (7,Simp)
17. \( \sim t_4T_l t_2. \) (13-16,IP)
ARISTOTLE VS. DIODORUS: FATALISM DEBATE

18. \(t_1Tl_t \& \sim t_4Tl_t\). (12,17,Conj)
19. \(t_1Tl_t \supset (t_1Tl_t \& \sim t_4Tl_t)\). (5-18,CP)
20. \(\forall t_4[t_1Tl_t \supset (t_1Tl_t \& \sim t_4Tl_t)]\). (19,UG)
21. \(t_1E_t\). (20,D7)

T21. \(~t_1E_t\).
Proof: 1. \(~t_1E_t\). (T18)
2. \(~t_1E_t\). (1,D8)

T22. \(t_1L_t \supset \sim t_1L_t\).
Proof: 1. \(t_1E_t \supset \sim t_1E_t\). (T19,t_2/t_1,t_1/t_2)
2. \(t_1L_t \supset \sim t_1L_t\). (1,D8)

T23. \((t_1L_t \& t_1L_t) \supset t_1L_t\).
Proof: 1. \((t_1E_t \& t_1E_t) \supset t_1E_t\). (T20,t_2/t_1,t_1/t_2,t_1/t_2)
2. \((t_1L_t \& t_1L_t) \supset t_1L_t\). (1,D8)

T24. \(N(p \lor \sim p)\).
Proof: 1. \(p \lor \sim p\). (Thesis of SL)
2. \(N(p \lor \sim p)\). (1,DR1)

T25. \(N(Tp \lor Fp)\).
Proof: 1. \(N(p \lor \sim p)\). (T24)
2. \(N(Tp \lor Fp)\). (1,T2,T3)

T26. \(t_1ft_1 = ft_1\).
Proof: 1. \(\sim(t_1ft_1) = \sim ft_1\). (A3)
2. \(\sim(t_1ft_1) = \sim(\sim ft_1)\). (1,Eq)
3. \(t_1ft_1 = \sim(\sim ft_1)\). (2,D2)
4. \(t_1ft_1 = ft_1\). (3,DN)

T27. \(t_1ft_1 \lor t_1 \sim ft_1\).
Proof: 1. \(t_1ft_1 = ft_1\). (T26)
2. \(t_1 \sim ft_1 = \sim ft_1\). (T26,\sim ft_1/ft_1)
3. \(ft_1 \lor \sim ft_1\). (Thesis of SL)
4. \(ft_1 \supset t_1ft_1\). (1,Simp)
5. \(\sim ft_1 \supset t_1 \sim ft_1\). (2,Simp)
6. \(t_1ft_1 \lor t_1 \sim ft_1\). (3,4,5,CD)

T28. \(t_1E_t \supset t_1Tl_t\).
Proof: 1. \(t_1E_t\). (Premise)
2. \(\forall t_3(t_1E_t \supset (t_1Tl_t \& \sim t_3Tl_t))\). (1,D7)
3. \(t_1E_t \supset (t_1Tl_t \& \sim t_3Tl_t)\). (2,UI)
4. \(t_1E_t\). (T17,t_2/t_1)
5. \(t_1Tl_t \& \sim t_3Tl_t\). (3,4,MP)
6. \(t_1Tl_t\). (5,Simp)

T29. \((t_1p \& t_1Tl_t) \supset t_1p\).
Proof: 1. \(t_1p\). (Premise)
2. \(t_1Tl_t\). (Premise)
3. \(\forall p[N(t_1p \supset t_2p)]\). (2,D4)
4. \(N(t_1p \supset t_2p)\). (3,UI)
5. \(t_1p\). (1,4,MP)
T30. \( t \in p \Rightarrow \neg \neg t \in p \).

Proof:
1. \( t \in p \). (Premise)
2. \( t_{2SIM} \lor t_{2Lt} \). (Assump)
3. \( t_{2SIM} \). (Assump)
4. \( t_{1Tlt} \). (3, D5, Simp)
5. \( t_{2SIM} \Rightarrow t_{1Tlt} \). (3-4, CP)
6. \( t_{2Lt} \). (Assump)
7. \( t_{1Et} \). (6, D8)
8. \( t_{1Tlt} \). (7, T28)
9. \( t_{2Lt} \Rightarrow t_{1Tlt} \). (6, 8, CP)
10. \( t_{1Tlt} \). (2, 5, 9, CD)
11. \( t \in p \). (1, 10, T29)
12. \( (t_{2SIM} \lor t_{2Lt}) \Rightarrow t \in p \). (2-11, CP)
13. \( \forall t_{2}(t_{2SIM} \lor t_{2Lt}) \Rightarrow t \in p \). (12, UG)
14. \( \neg \neg t \in p \). (13, D15)

T31. \( \neg \neg t \in p \Rightarrow t \in p \).

Proof:
1. \( \neg \neg t \in p \). (Premise)
2. \( \forall t_{2}(t_{2SIM} \lor t_{2Lt}) \Rightarrow t \in p \). (1, D15)
3. \( (t_{1St} \lor t_{1Lt}) \Rightarrow t \in p \). (2, UI)
4. \( t_{1SIM} \). (T11)
5. \( t \in p \). (3, 4, MP)

T32. \( t \in p \Leftrightarrow \neg \neg t \in p \).

Proof:
1. \( t \in p \Rightarrow \neg \neg t \in p \). (T30)
2. \( \neg \neg t \in p \Rightarrow t \in p \). (T31)
3. \( t \in p \Rightarrow \neg \neg t \in p \). (1, 2, Conj)

T33. \( (t \in p \& t \in Et) \Rightarrow \neg \neg t \in p \).

Proof:
1. \( t \in p \). (Premise)
2. \( t \in Et \). (Premise)
3. \( t_{1Tlt} \). (2, T28)
4. \( t \in p \). (1, 3, T29)
5. \( \neg \neg t \in p \). (4, T32)

T34. \( t_{1} \equiv \neg \neg t_{1} \).

Proof:
1. \( t_{1} \equiv t_{1} \). (T26)
2. \( t_{1} \equiv \neg \neg t_{1} \). (T32, t_{1} / p)
3. \( t_{1} \equiv \neg \neg t_{1} \). (1, 2, Eq)

T35. \( \neg \neg t_{1} \lor \neg t_{1} \Rightarrow t_{1} \).

Proof:
1. \( t_{1} t_{1} \equiv t_{1} \). (T27)
2. \( t_{1} \equiv \neg \neg t_{1} \). (1, T26)
3. \( \neg \neg t_{1} \lor \neg t_{1} \equiv \neg t_{1} \). (2, T34)

T36. \( (t_{2SIM} \lor t_{2Lt}) \Rightarrow (t_{1} t_{1} \lor F t_{1} t_{1}) \).

Proof:
1. \( t_{2SIM} \lor t_{2Lt} \). (Premise)
2. \( t_{2SIM} \). (Assump)
3. \( t_{1Tlt} \). (2, D5, Simp)
4. \( t_{2SIM} \Rightarrow t_{1Tlt} \). (2-3, CP)
5. \( t_{2Lt} \). (Assump)
6. \( t_{1Et} \). (5, D8)
7. \( t_{1Tlt} \). (6, T28)
8. \( t_{2Lt} \Rightarrow t_{1Tlt} \). (5-7, CP)
9. \( t_{1Tlt} \). (1, 4, 8, CD)
10. \( t_{1} t_{1} \lor \neg t_{1} \). (T27)
11. \( t_2Etl \lor t_1Ct_2 \) \( \cdot \cdot \cdot \cdot \cdot (10,9,T29) \\
12. \( Tt_2ft_1 \lor Tt_1-fr_1 \) \( (11,D11) \\
13. \( Tt_2ft_1 \lor Ft_2ft_1 \) \( (12,D12) \\

T37. \( (t_2Etl \lor t_1Ct_2) \Rightarrow (t_2Tft_1 \lor t_1Tf_2t_1) \)

Proof:
1. \( t_2Etl \lor t_1Ct_2 \) (Premise)
2. \( t_2Etl \) (Assump)
3. \( t_2Tft_1 \) \( (2,T28) \\
4. \( t_2Etl \Rightarrow t_2Tft_1 \) \( (2,3, CP) \\
5. \( t_1Ct_2 \) (Assump)
6. \( \sim(t_2It_2 \land \sim t_1It_1 \land \sim t_1Ot_2) \) \( (5,D18,D19) \\
7. \( t_2It_2 \lor t_1It_1 \lor t_1It_2 \) \( (6,DeM) \\
8. \( t_2It_2 \Rightarrow t_2Tft_1 \) \( (T16) \\
9. \( t_2It_2 \Rightarrow t_2Tft_1 \) \( (T16,t_2/t_1,t_1/t_2) \\
10. \( t_1Ot_2 \) (Assump)
11. \( \exists t_3 \exists t_3 \exists t_5 \{ t_1It_2 \land t_2It_3 \land t_3It_4 \land t_4It_5 \land [(t_4Etl \land t_5Lt_1) \lor (t_4Lt_2 \land t_5Et_1)] \} \) \( (10,D17) \\
12. \( t_1It_4 \land t_2It_5 \land [(t_4Etl \land t_5Lt_1) \lor (t_4Lt_2 \land t_5Et_1)] \) \( (11,Et,Simp) \\
13. \( t_4Etl \land t_5Lt_1 \) (Assump)
14. \( t_4Lts \) \( (12,Simp) \\
15. \( t_5Tft_1 \) \( (14,T16) \\
16. \( t_5Lt_1 \) \( (13,Simp) \\
17. \( t_5Et_1 \) \( (16,D8) \\
18. \( t_2Tft_2 \) \( (17,T28) \\
19. \( t_2Tft_2 \) \( (15,18, T10) \\
20. \( (t_2Etl \land t_1Lts) \Rightarrow t_2Tft_1 \) \( (13-19,CP) \\
21. \( t_4Lts \land t_5Et_1 \) (Assump)
22. \( t_2Tft_2 \) \( (12,Simp) \\
23. \( t_4Tft_1 \) \( (22,T16) \\
24. \( t_4Lt_2 \) \( (21,Simp) \\
25. \( t_5Et_1 \) \( (24,D8) \\
26. \( t_4Tft_2 \) \( (25,T28) \\
27. \( t_2Tft_1 \) \( (23,26, T10) \\
28. \( (t_1Lts \land t_5Et_1) \Rightarrow t_2Tft_1 \) \( (21-27,CP) \\
29. \( t_2Tft_1 \land t_1Tft_2 \) \( (12,20,28,CD) \\
30. \( t_1Ot_2 \Rightarrow (t_2Tft_1 \land t_2Tft_1) \) \( (10-29,CP) \\
31. \( t_1Tft_1 \land t_2Tft_1 \) \( (7,8,9,30,CD) \\
32. \( t_2Ct_2 \Rightarrow (t_1Tft_2 \land t_2Tft_2) \) \( (5-31,CP) \\
33. \( t_2Ct_2 \Rightarrow t_2Tft_1 \) \( (1,4,32,CD) \\

T38. \( [f_1 \land \forall t_2(t_2q \land t_2q)] \Rightarrow \forall t_3[(t_3Etl \land t_4Ct_3) \Rightarrow Tt_3f_3]. \)

Proof:
1. \( f_1 \) (Premise)
2. \( \forall t_2 (t_2q \land t_2q) \) (Premise)
3. \( t_2Etl \land t_1Ct_2 \) (Assump)
4. \( t_2Tft_1 \land t_2Tft_1 \) \( (3,T37) \\
5. \( t_2Tft_1 \) (Assump)
6. \( \sim Tt_3f_3 \) (Assump)
7. \( Tt_3f_3 \land Tt_3f_1 \) \( (2,UI) \\
8. \( Tt_3f_3 \) \( (6,7,DS) \\
9. \( Tt_3f_3-f_3 \) \( (8,D12) \\
10. \( Tt_3f_3 \) \( (9,D11) \\
11. \( Tt_3f_3 \) \( (5,10,T29) \\
12. \( \sim f_3 \) \( (11,T26) \\
13. \( f_3 \land \sim f_3 \) \( (1,12, Conj) \\
14. \( Tt_3f_3 \) \( (6-13, IP) \\
15. \( Tt_3f_3 \Rightarrow Tt_3f_3 \) \( (5-14, CP) \\

ARISTOTLE VS. Diodorus: Fatalism Debate 61
16. \( t_1T_1t_2 \) (Assump)
17. \( t_1t_2t_1 \) (1,T26)
18. \( t_2t_1t_2 \) (16,17,T29)
19. \( T_3t_2t_1 \) (18,D11)
20. \( t_1T_1t_2 \Rightarrow T_2t_1t_2 \) (16-19,CP)
21. \( T_3t_1t_2 \) (4,15,20,CD)
22. \( (t_2E_1 \vee t_1C_2) \Rightarrow T_3t_2t_1 \) (3-21,CP)
23. \( \forall t_1[(t_2E_1 \vee t_1C_2) \Rightarrow T_3t_1t_2] \) (22,UG)

("*" in following theorems indicates dependence upon P1.)

T39.* \( t_1E_1t_2 \vee t_2L_1t_2 \vee t_3S_1t_2 \vee t_3C_1t_2. \)
Proof: 1. \( (t_1D_1t_2 \& \sim t_3S_1t_2) \Rightarrow (t_1E_1t_2 \vee t_2L_1t_2). \) (P1)
2. \( (t_1D_1t_2 \& \sim t_3S_1t_2) \Rightarrow (t_1E_1t_2 \vee t_2L_1t_2). \) (1,D8)
3. \( \sim(t_1D_1t_2 \& \sim t_3S_1t_2) \vee (t_1E_1t_2 \vee t_2L_1t_2). \) (2,Imp)
4. \( \sim t_1D_1t_2 \vee t_3S_1t_2 \vee t_1E_1t_2 \vee t_2L_1t_2. \) (3,DeM)
5. \( t_1C_2 \vee t_1E_1t_2 \vee t_1L_1t_2 \vee t_3S_1t_2. \) (4,D19)
6. \( t_1E_1t_2 \vee t_1L_1t_2 \vee t_3S_1t_2 \vee t_3C_1t_2. \) (5,Com)

T40.* \( [t_1p \& \forall t_2((t_2E_1 \vee t_1C_2) \Rightarrow t_2p)] \Rightarrow Np. \)
Proof: 1. \( t_1p. \) (Premise)
2. \( \forall t_2[(t_2E_1 \vee t_1C_2) \Rightarrow t_2p]. \) (Premise)
3. \( \sim Np. \) (Assump)
4. \( \sim \forall t_2(t_2p). \) (3,DeM)
5. \( \exists t_2(\sim t_2p). \) (4,QE)
6. \( \sim t_2p. \) (5, EI)
7. \( (t_2E_1 \vee t_1C_2) \Rightarrow t_2p. \) (2,UI)
8. \( \sim(t_2E_1 \vee t_1C_2). \) (6,MT)
9. \( \sim t_2E_1 \& \sim t_1C_2. \) (8,DeM)
10. \( t_2E_1 \vee t_2L_1t_2 \vee t_3S_1t_2 \vee t_3C_1t_2. \) (T39, t/t/1,t1/t2)
11. \( t_2L_1t_2 \vee t_3S_1t_2. \) (9,10,DS)
12. \( t_2L_1t_2. \) (Assump)
13. \( t_2E_1. \) (12,D8)
14. \( t_2T_1t_2. \) (13,T28)
15. \( t_2L_1 \Rightarrow t_1T_1t_2. \) (12-14,CP)
16. \( t_3S_1t_2. \) (Assump)
17. \( t_1T_1t_2. \) (16, D5, Simp)
18. \( t_3S_1t_2 \Rightarrow t_1T_1t_2. \) (16-17,CP)
19. \( t_1T_1t_2. \) (11,15,18,CD)
20. \( t_2p. \) (1,19,T29)
21. \( t_2p \& \sim t_2p. \) (20,6, Conj)
22. \( Np. \) (3-21, IP)

T41.* \( [f_1 \& \forall t_2((t_2E_1 \vee t_1C_2) \Rightarrow T_3t_2t_1)] \Rightarrow Nf_1. \)
Proof: 1. \( [t_1f_1 \& \forall t_2((t_2E_1 \vee t_1C_2) \Rightarrow t_2f_1)] \Rightarrow Nf_1. \) (T40, f/t1/p)
2. \( [f_1 \& \forall t_2((t_2E_1 \vee t_1C_2) \Rightarrow t_3f_1)] \Rightarrow Nf_1. \) (1,T26)
3. \( [f_1 \& \forall t_2((t_2E_1 \vee t_1C_2) \Rightarrow T_3t_2t_1)] \Rightarrow Nf_1. \) (2,D11)

T42.* \( [f_1 \& \forall q \forall t_2(T_3q \vee F_3t_2)] \Rightarrow Nf_1. \)
Proof: 1. \( f_1. \) (Premise)
2. \( \forall q \forall t_2(T_3q \vee F_2q). \) (Premise)
3. \( \forall t_2((t_2E_1 \vee t_1C_2) \Rightarrow T_3t_2t_1). \) (1,2,T38)
4. \( Nf_1. \) (1,3,T41)
ARISTOTLE VS. DIODORUS: FATALISM DEBATE

T43.* \[ \forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow \neg (N f_{t_1} \lor N \neg f_{t_1}). \]

Proof:
1. \( f_{t_1} \lor \neg f_{t_1}. \) (Thesis of SL)
2. \([f_{t_1} \land \forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N f_{t_1}. \) (T42)
3. \([\neg f_{t_1} \land \forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N \neg f_{t_1}. \) (T42, \( f_{t_1} / f_{t_1} \))
4. \( f_{t_1} \Rightarrow [\forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N f_{t_1}. \) (2, Exp)
5. \( \neg f_{t_1} \Rightarrow [\forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N \neg f_{t_1}. \) (3, Exp)
6. \([\forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N f_{t_1}. \land [\forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N \neg f_{t_1}. \Rightarrow N f_{t_1} \lor N \neg f_{t_1}. \) (1,4,5, CD)
7. \( \forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q). \) (Assump)
8. \( N f_{t_1} \lor N \neg f_{t_1}. \) (6,7, CD)
9. \( \forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow (N f_{t_1} \lor N \neg f_{t_1}). \) (7-8, CP)
10. \( N \forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N f_{t_1} \lor N \neg f_{t_1}. \) (9, DR1)
11. \( N \forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N (N f_{t_1} \lor N \neg f_{t_1}). \) (10, T7)

The following theses will be cited by name in the sequel:

Universal Causation: \( \forall t_1 \forall t_2 \forall f ([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \exists g [g t_2 \land (g t_2 S C_{t_1})]). \)

Determinism: \( \forall t_1 \forall t_2 \forall f ([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \neg f_{t_1}). \)

Fatalism: \( \neg [\forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q) \Rightarrow N f_{t_1}]. \)

Universal Necessitation: \( \forall t_1 \forall f ([f_{t_1} \Rightarrow N f_{t_1}]). \)

Unrestricted Temporal Bivalence: \( \neg [\forall q \forall t_2 (T_{t_2} q \lor F_{t_2} q)]. \)

T44. Universal Causation entails Determinism.

Proof: 1. \( \forall t_1 \forall t_2 \forall f ([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \exists g [g t_2 \land (g t_2 S C_{t_1})]). \) (Premise)
2. \( f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2}). \) (Assump)
3. \([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \exists g [g t_2 \land (g t_2 S C_{t_1})]. \) (1, UI)
4. \( \exists g [g t_2 \land (g t_2 S C_{t_1})]. \) (2, 3, MP)
5. \( g t_2 \land (g t_2 S C_{t_1}). \) (4, EI)
6. \( g t_2. \) (5, Simp)
7. \( g t_2 S C_{t_1}. \) (5, Simp)
8. \( \forall t_2 \forall [N (t_2 g t_2 \Rightarrow t_2 f_{t_1})]. \) (7, D16)
9. \( N (t_2 g t_2 \Rightarrow t_2 f_{t_1}). \) (8, UI)
10. \( t_2 f_{t_1}. \) (6, T26)
11. \( t_2 f_{t_1}. \) (9, 10, MP)
12. \( \neg f_{t_1}. \) (11, T32)
13. \([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \neg f_{t_1}. \) (3-12, CP)
14. \( \forall t_1 \forall t_2 \forall f ([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \neg f_{t_1}). \) (13, UG)

T45. Fatalism entails Determinism.

Proof: 1. \( N [\forall t_1 \forall t_2 \forall f ([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \neg f_{t_1}). \) (Premise)
2. \( \forall t_1 \forall t_2 \forall f ([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \neg f_{t_1}). \) (1, T4)

T46.* Determinism entails Universal Necessitation.

Proof: 1. \( \forall t_1 \forall t_2 \forall f ([f_{t_1} \land (t_2 E_{t_1} \lor t_1 C_{t_2})] \Rightarrow \neg f_{t_1}). \) (Premise)
2. \( f_{t_1}. \) (Assump)
3. \( t_1 f_{t_1}. \) (2, T26)
T47. Unrestricted Temporal Bivalence entails Fatalism.
Proof: 1. $[f_t & \forall t2[(t2E_t \vee t1C_t) \Rightarrow t2f_t]] \Rightarrow Nf_t$. (T40, ft1/p)
2. $\forall t1[f_t \Rightarrow Nf_t]$. (1, Exp)
3. $\forall t1[f_t \Rightarrow Nf_t]$. (Assump)
4. $f_t \Rightarrow Nf_t$. (5, UI)
5. $Nf_t$. (6, MP)

T48. $\forall t1(\forall t2(Tt2q \vee Ft2q)) \Rightarrow Nf_t$. (T41)

T49. $\forall t1(\forall t2(Tt2q \vee Ft2q)) \Rightarrow Nf_t$. (T41)

T50. $\forall t1(\forall t2(Tt2q \vee Ft2q)) \Rightarrow Nf_t$. (T41)
ARISTOTLE VS. DIODORUS: FATALISM DEBATE

5. \( t_1 \sim f_1 \equiv \sim f_1 \). (T26, \( \sim f_1 / f_1 \))
6. \( \sim v_1(TrT_{f1}( )) \equiv \exists t_1(t_1 \sim f_1) \). (4,5,Eq)
7. \( \sim v_1(TrT_{f1}( )) \equiv \exists t_1(TrT_{f1} \sim f( )) \). (6,D11')

T51. \( t_1SIMt_2 \supset t_1=t_2 \).

Proof: 1. \( t_1SIMt_2 \). (Premise)
   2. \( t_1Tt_2 \& t_2TT_{t1} \). (1,D5)
   3. \( \forall p[N(t_1p \supset t_2p)] \& \forall p[N(t_2p \supset t_1p)] \). (2,D4)
   4. \( \forall p[N(t_1p \supset t_2p) \& N(t_2p \supset t_1p)] \). (3,Dist)
   5. \( \forall p[N(t_1p \supset t_2p) \& (t_2p \supset t_1p)] \). (4,T8)
   6. \( \forall p[N(t_1p = t_2p)] \). (5,Eq)
   7. \( N(t_1p = t_2p) \). (6,UI)
   8. \( N(t_1t_2p = t_2t_2p) \). (6,UI)
   9. \( N(t_1t_1p = t_2t_1p) \). (6,UI)
   10. \( N(t_1p = t_2p) \). (7,T14)
   11. \( N(t_1t_2p = t_1t_2p) \). (8,Com)
   12. \( N(t_1p \supset t_2t_2p) \). (10,Simp)
   13. \( N(t_1t_2p = t_1t_2p) \). (11,Simp)
   14. \( N(t_1p \supset t_1t_2p) \). (12,13,T9)
   15. \( N(t_1p = t_2p) \). (7,Com)
   16. \( N(t_1p = t_2t_2p) \). (15,T14)
   17. \( N(t_1p = t_1t_1p) \). (16,Simp)
   18. \( N(t_1p = t_2t_2p) \). (9,Simp)
   19. \( N(t_1p = t_2t_2p) \). (17,18,T9)
   20. \( N(t_1p = t_2p) \& N(t_2p = t_1t_2p) \). (14,19,Conj)
   21. \( \forall p[N(t_1p = t_2t_2p)] \& \forall p[N(t_2p = t_1t_2p)] \). (20,UG)
   22. \( t_1t_2 \& t_2t_1 \). (21,D6)
   23. \( t_1=t_2 \). (22,D9)

T52. \( t_1=t_2 \supset t_1SIMt_2 \).

Proof: 1. \( t_1=t_2 \). (Premise)
   2. \( t_1t_2 \& t_2TT_{t1} \). (1,D9)
   3. \( t_2TT_{t1} \& t_1TT_{t2} \). (2,T16)
   4. \( t_1SIMt_2 \). (3,D5)

T53. \( t_1SIMt_2 = t_1=t_2 \).

Proof: 1. \( t_1SIMt_2 \supset t_1=t_2 \). (T51)
   2. \( t_1=t_2 \supset t_1SIMt_2 \). (T52)
   3. \( t_1SIMt_2 = t_1=t_2 \). (1,2,Conj)

ENDNOTES

* An earlier version of this paper was presented at the 1984 meeting of the American Philosophical Association, Western Division.

1 As we are defining determinism, the theory entails neither the truth nor the falsity of the thesis that time had a beginning; it merely entails that for every actual event there is no time during which the event's occurrence is not fixed. We use the term 'event' to cover both happenings and states of affairs (i.e. changes and non-changes) regardless of whether they involve single individuals or entire groups of individuals. A particular event consists in something's being or becoming the case during a certain time. Thus to say of something that it is the case during a certain time, as opposed to saying that it is the case during some time or other, or that it is the case during every time, is to affirm the occurrence of an event. One event is identical with another if and
only if any proposition affirming the occurrence of the one is the same proposition as any proposition affirming the occurrence of the other. We would not wish to claim that this extremely broad conception of eventhood accords with the or an ordinary conception, but only that it is useful for present purposes. Explications of the notions of fixity and of sufficient conditionship, and more precise characterizations of the various kinds of determinism, are provided in Section 3. In this essay we are concerned only with what may be called generic necessity; its two species, logical necessity and non-logical (or natural) necessity, were not clearly distinguished by Aristotle and his contemporaries.

2 See, e.g., Kneale and Kneale (1962), p. 122 and p. 133, and Sedley (1977), p. 96. The hypothesis that Diodorus directed his Master Argument against Aristotle's views on fatalism is not incompatible with the hypothesis that it was used, or even designed, to justify his equating a possible proposition with one which is or will be true. The argument, as we reconstruct it, is quite capable of serving both functions; indeed, the two functions are closely related, as the equation leads immediately to fatalism (see Notes 39 and 40). For presentations of the latter hypothesis, see, e.g., Mates (1952), p. 37ff., and Hintikka (1973), Ch. IX. It should be noted, however, that Mates interprets the relevant notion of possibility as one which we shall be calling de re possibility, while Hintikka construes it as involving temporally indefinite "propositions," i.e. sentences which explicitly or implicitly contain token-reflexive temporal expressions, such as 'now.' In this regard, see Notes 9, 11, 38, 39, and 40.

3 Bochenski (1961), Kneale and Kneale (1962), Gale (1967), Hintikka (1973) and Sorabji (1980) can be used as helpful guides to the vast literature on the views. Richard Taylor, who is somewhat favorably disposed towards Aristotle's view, discusses the wide range of assessments of the view in Taylor (1957), and indicates that the prevailing opinion has always been negative. For an unfavorable assessment of Diodorus' view, see Kneale and Kneale (1962), Ch. 3; for a more favorable one, see Sedley (1977).

4 Corcoran (1974) contains some spirited, well-argued advocacy of the use of modern logic in reconstructing ancient views. Our interpretation of Aristotle's view, which is somewhat similar to that of Taylor (1957) and to that of Von Wright (1979), accords more closely with the second of the two interpretative approaches discussed in Ackrill (1963), pp. 132 ff. Our interpretation of Diodorus' view resembles that of Sedley (1977) and that of Rescher and Urquhart (1971), Ch XVII.

5 While Aristotle's great stature as a logician is universally recognized, the impressive accomplishments and legacy of Diodorus have only recently become thoroughly documented; see Sedley (1977).

6 By letting the temporal variables and constants stand for periods rather than just for instants, we make the calculus accord more closely with ordinary discourse. While the term 'interval' suggests precise boundaries, the term 'period' is not intended to carry such connotations. The expression 'during tₐ,' which is used in the sense of 'at or in the course of tₐ,' rather than in the narrower sense of 'in the course of tₐ,' means 'sometime during tₐ' rather than 'all during tₐ.' For example, 'a sea battle will occur (during) tomorrow' means 'a sea battle will occur sometime during tomorrow' rather than 'a sea battle will occur all during
tomorrow'. Note that since 'a sea battle will not occur (during) tomorrow', means 'it is not the case that a sea battle will occur (during) tomorrow, it means 'a sea battle will occur during no time tomorrow' rather than 'a sea battle will not occur during some time tomorrow'. The latter should not be confused with 'a sea battle will not occur sometime during tomorrow', which is equivalent to the former. For convenience we use the same symbols, 't₁', 'p', etc., as object-language symbols in axioms and theorems, and as meta-language symbols in definitions and rules.

As theorem T₁ shows, 'it is not the case during t₁ that p' and 'it is not the case that it is the case during t₁ that p' are equivalent. But 'it is the case during t₁ that p' entails but is not equivalent to 'it is not the case during t₁ that it is not the case that p'. (See the Appendix for the theorem.)

The substitution instances of 'ft₁' which involve temporal constants rather than temporal variables constitute what may be called event-expressions, as they are expressions which may be used to affirm the occurrence of events.

The verbs in these statements should be construed as tenseless (e.g. 'occurs' means 'either occurs now, occurred, or will occur'). We will sometimes, however, follow Aristotle's example in using sentences containing token-reflexive temporal expressions (e.g. 'will be', 'tomorrow') instead of sentences containing tenseless verbs and dates. But just as SL is not designed to codify the rules for the use of such token-reflexive expressions as 'this thing' or 'you', so also ASL is not designed to reflect the rules for token-reflexive temporal features of language. Thus ASL is a temporal logic, i.e. a logic of temporal structures, but not a tense logic. We treat such token-reflexive expressions as 'will be', 'tomorrow', 'now', 'the past' as linguistic devices employed in systematic ways to facilitate expression of the particular proposition under consideration, the proposition itself, unlike the sentence (type) used to express it, being of necessity either true or false and not both. With regard to time-relative truth and falsity, a proposition is of necessity either true during some time or other or false during some time or other, and not both. It can happen that a proposition is neither true during a certain time nor false during that time, but it must eventually either become and remain true or become and remain false. As we are using the term 'proposition', a proposition is to be distinguished from a temporally incomplete "proposition", i.e. a designatum of a temporally incomplete "propositional" expression, and from a temporally indefinite "proposition", i.e. a sentence (type) explicitly or implicitly containing a token-reflexive temporal expression. Unlike a genuine proposition, a temporally incomplete "proposition" can be de re true during a time and de re false during another time, and a temporally indefinite "proposition" can express a true proposition at one time and a false proposition at another. Truth-value changes in temporally incomplete "propositions" reflect changes in the world, whereas such changes in temporally indefinite "propositions" reflect only changes in the designation relationship, and hence can occur when the world remains unchanged (in relevant respects), and can fail to occur when the world changes. For example, the temporally indefinite "proposition" 'I am now alive' always expresses a true proposition when assertively uttered, but never expresses a proposition which is always true (unless uttered by a necessary being), and never expresses a temporally incomplete "prop-
For a discussion of the various conceptions of "proposition" employed by Aristotle and his contemporaries, see, e.g., Hintikka (1973). For a discussion of the relationships between temporal logic and tense logic, see Van Benthem (1983), Part II.

For a history of explications of modal notions in terms of time, and of contrasting explications in terms of "possible worlds", see Knuuttila (1981).

This type of necessity, which may be termed *de dicto* necessity, should be distinguished from what may be called *de re* necessity, definable as follows:

\[
D3' \quad \text{It is } \text{de re} \text{ necessary that } f(t) = df \text{ for every } t, \text{ it is the case during } t \text{ that } f(t).
\]

The expression \(f(t)\) represents a special kind of predicate—a temporally incomplete "propositional" expression. For example, it is *de re* necessary that a sea-battle occurs if and only if for every \(t\), it is the case during \(t\) that a sea-battle occurs during \(t\). (In other words, if and only if a sea-battle always was, is now and always will be constantly occurring). The definition of \(D3'\) is equivalent to "for every \(t\), \(f(t)\)" (see T26); the more complex form, however, highlights the structural similarity between \(D3\) and \(D3'\). In ordinary discourse the term 'invariably' is often used to express *de re* necessities. For example, the statement "A sea battle invariably occurs when both opposing navies are confident of victory" can be formulated as "For every \(t\), a sea battle occurs during or after \(t\) if both opposing navies are confident of victory during \(t\)". Although Aristotle employed the notion of *de re* necessity in discussing everlasting things and processes, he indicated in his discussion of fatalism that the issue did not concern such matters. Instances of Aristotle's employment of the notion of *de re* necessity may be found in, e.g., *De Gen.* et *Corr.* II 11 and *De Caelo* I 12. His indication that the fatalism issue does not concern everlasting things and processes occurs in *De Int.* 9, 19*7*-13 and 32-34. The much discussed Principle of Plenitude, that possibility entails sometime-actuality, holds in ASL for *de re* possibility but not for *de dicto* possibility (see T48). (Indeed, *de re* possibility is equivalent to *de re* truth, as T49 shows.) If the Principle of Plenitude is adopted for *de dicto* modalities, all such modalities reduce to two (see Note 40). Questions can certainly be raised regarding whether *de re* modality is a "genuine" type of modality, or only seems to be because of confusion with *de dicto* modality. For example, it is doubtful that an ordinary statement such as "It is possible for this cloak to be cut up" (De Int. 19*12*) would ever involve affirmation of a proposition which entails that there is, was or will be a time during which the cloak is cut up (or that there would be such a time if the cloak did not suffer some other form of destruction first). Hence instead of interpreting the statement as "It is *de re* possible that the cloak is cut up", we should probably interpret it as "It is (*de dicto*) possible that there is a time during which the cloak is cut up". For extended discussions of the Principle of Plenitude and for arguments that Aristotle accepted some form of it, see Hintikka (1973) and Knuuttila (1981). It should be noted that in these discussions the authors do not exploit the distinctions between temporally incomplete "propositional" expressions and propositional expressions containing token-reflexive temporal expressions, and between (what we are calling) *de re* and *de*
dicto modalities. It seems likely that such distinctions were never clearly formulated by Aristotle and his contemporaries.

12 That the modal structure of ASL is at least as strong as that of System T follows from the presence in ASL of T4, T7 and DRI. We conjecture that the characteristic S4 thesis that necessary p entails necessary necessary p is not provable in ASL. For a presentation of T and S4, see, e.g., Hughes and Cresswell (1968). Since no technique for establishing non-provability in ASL has yet been devised, all non-provability claims we make about ASL should be construed as no more than educated guesses.


14 Definitions of distinctness and of betweenness, and precise formulations of these postulates, are provided in the Appendix. We presuppose that time as conceived by Aristotle is linear; unlike the other postulates, the first postulate, which expresses the linearity of time, will be employed in proving certain theorems (see T39–T43 and T46).

15 For in-depth treatments of temporal logic and of tense logic, see, e.g., Prior (1967), Reicher and Urquhart (1971), Lucas (1973), Van Benthem (1983), Gabbay (1976) and Chapman (1982). Development of ASL was influenced by the first four works listed.

16 The conception of time-relative truth embodied in ASL is somewhat similar to that developed in McCall (1966), Reicher (1966a), Reicher (1967) and Escher and Urquhart (1971), Ch. XVII. To justify our approaching truth and falsity in terms of propositional operators rather than in terms of predicates of the sentences used to express the relevant propositions, we would cite Aristotle's employment of what appears to be a "redundancy" conception of truth (see De Int. 18a 34–b5), and his claim that its being true that something is so depends only on whether it is so, and not on someone's saying that is is so (see 18b 26–19a 6). Thus truth and falsity appear for Aristotle to be independent of the existence of sentences and speech acts. For a discussion of "redundancy" theories of truth, see Haack (1978), Chs. 6, 7, and 8. The expression 'it is the case that p', which in our usage is equivalent to 'p', could be formally introduced by definition as meaning 'for some t1, it is the case during t1 that p'. With regard to D14, consider the following propositions: (1) For some t1, it is false during t1 that p, (2) For some t1, it is the case during t1 that it is not the case that p, and (3) For some t1, it is not the case during t1 that p. (1) is equivalent to (2), and (1) entails (3); but (3) does not entail (1). While (1) is equivalent to 'It is not the case that p', (3) is equivalent to 'It is possible that it is not the case that p'.

17 See T24 and T25.

18 See T36. (The modal version of this theorem follows immediately by DRI.) It should be noted that while the unrestricted thesis 'Ttp v Ft1p' and its equivalent 't1p v t1~p' are not provable, the more restricted thesis 't1ft1 v t1~t1f1' is provable (T27), as is its equivalent 'Tt1ft1 v Ft1ft1'. It should also be noted that the thesis 't1p v ~t1p', which is simply a special case of 'p v ~p', and hence is provable, is not equivalent to 't1p v t1~p'.
The chapter opens with the statement: "With regard to what is and what has been it is necessary for the affirmation or the negation to be true or false" (18*28-29, Tr. Ackrill (1963)). The present infinitive appears in the Greek text. That Aristotle is employing notions of time-relative truth and falsity is indicated in the following places: 18*9-13, 19-25, 30-19*7, and 19*37-39.

See 18*34-36. The clearest statement of the thesis Aristotle is attacking can be found in his summary remarks: "Clearly, then, it is not necessary that of every affirmation and opposite negation one should be true and the other false." (19*39 Tr. Ackrill (1963)). See also 18*b 26-29.

18*34-18*b 16. At 18*b 26 he characterizes this consequence as absurd. The validity of the first step of his argument is shown by T38, the second by T41, and the third by T42. The latter two steps depend for their validity on P1, the postulate that time is linear.

19*7-22. His argument is validated by T43—since the consequent of T43, together with his first premise, entails that there can be no events originating from deliberation and action, it is contradicted by his second premise; hence the antecedent of T43, which is the unrestricted thesis, must be false.

We cannot tell from the text whether this premise should be given the comparatively weak reading: "An event can originate from deliberation and action only if it is possible that the event is contingent," or the stronger reading: "An event can originate from deliberation and action only if the event is contingent." We have chosen the former reading since (owing to its comparative weakness) it is a more plausible claim, and is nonetheless sufficient to make Aristotle's argument deductively valid. As we indicate in discussing causal determinism below, the causal determinist could accept the weak version; he could not, however, accept the stronger. (In this regard, see Notes 28 and 31.)

See Notes 21 and 22.

19*23-38.

See T34.

In several works Aristotle alludes to the "necessity" of past and present happenings; see, e.g., Rhet. III 17.1481*3-5, Eth. Nic. VI 2.1139*b5-10, De Caelo I 12, 383*b 13 ff.

We have chosen the phrasing 'for every t1 and every t2 earlier than t1...,' instead of the weaker, more common phrasing 'for every t1 there is some t2 earlier than t1 such that...,' in order to make the principle capture what seems to be the standard conception of universal causation. In its weaker form, the principle would not, for example, entail that the future is fixed relative to the present. Let t1 be the present and t2 some future time. Assuming the infinite divisibility of time (P3), there is an infinite number of times between t1 and t2. Hence it could happen that an event occurring during t2 is an "effect" of an infinite series of sufficient "causes" occurring between t1 and t2 without being an "effect" of any sufficient "cause" occurring during t1. This argument is adapted from Lukasiewicz (1970), p.118 ff. (His
argument, however, has a different purpose.) A more precise formulation of the Universal Causation Thesis is provided in the Appendix.

29 It should be noted that we are explicating sufficient conditionship in terms of the propositional operator 'its being the case that ___ is a sufficient condition of its being the case that ___', rather than in terms of the relational predicate '___ is a sufficient condition of ___' (the blanks in the latter must be filled by names of sentences). Sufficient conditionship, as we define it, may be said to transmit time-relative necessity from "cause" to "effect"--the occurrence of an event is necessary relative to the time any sufficient condition of it occurs. In several places in the Metaphysics Aristotle seems to employ such an idea in arguing for indeterminism (see VI 3 and XI 8). This suggests that he may have intended the argument in Chapter 9 of De Int. as a refutation of causal determinism as well as of fatalism, in which case the "stronger reading" mentioned in Note 23 would be appropriate. Correspondingly, a weaker reading of the unrestricted thesis, \( \forall p (T_{t_1} p \lor F_{t_1} p) \) instead of \( \exists \neg (\forall p (T_{t_1} p \lor F_{t_1} p)) \), would turn the argument into a deductively valid argument against determinism per se. A distinct problem with this interpretation of the argument is the fact that the modal term 'necessary' appears both in Aristotle's statement of the thesis he accepts (18.328-29) and in his clearest statements of the more general thesis he rejects (18.326-29 and 19.39-40).

30 See T44–T46.

31 As we remarked in Notes 23 and 28, Aristotle may have intended his first premise to be given the "stronger reading," in which case the causal determinist could not accept it. There is evidence that Aristotle would reject causal determinism as well as fatalism. He seems to hold that the (efficient) causes of deliberate action (which for him include such things as choice, desire, reasoning, belief and knowledge) are completely within the agent; see, e.g., Eth. Nic. VI 2.1139 b 32–b 5 and 111 b 14-21. Moreover, in Met. VI he seems to reject causal determinism to allow for the efficacy of choice. But there would be difficulties associated with construing his argument in De Int. as an argument against determinism per se; see Note 23. The issue of the compatibility of determinism and "free choice" is beyond the scope of this paper.

32 See T47. Another source of credibility for fatalism is at least conceivable—if one could establish that universal causation holds of necessity, one could prove the truth of what can be termed causal fatalism. Judging from his introduction of the notion of condestinate events, i.e. events which are predetermined in connection with earlier events, Chrysippus may have held such a view. (See Kneale and Kneale (1962), p. 123 ff.) His view may, however, have been equivalent to ordinary causal determinism.

33 Our translation is based on the Bekker text as printed in the Loeb edition. Ackrill's and Cooke's translations were consulted constantly, and our debt to these translations is great indeed. Material enclosed in brackets is supplied to help clarify elliptical constructions and ambiguous references. Parentheses have been introduced wherever required by the sense to separate explanatory asides from the main body of an argument. Since it is known that the original Aristotelian manuscript would have lacked punctuation, and since the demands of English
grammar are different than those of the Greek, we have modified traditional punctuation where necessary to clarify the flow of argument.

34 We follow the Loeb translation by Harold Cooke in translating "οὐχ οἷόν τε" and "μὴ οἷόν τε" on the next line as "how impossible...!" See Cooke (1938).


38 See T33. If Thesis A were modified in such a way that the "necessity" is construed as absolute necessity, the thesis would not have been plausible for orthodox Aristotelians, and if the "necessity" were construed as de re necessity, the thesis would have been obviously false; it would entail, for example, that whatever has existed will always exist.

(Mates notes that his "de re" construal of Diodorean modality does not accord with Diodorus' use of modal terms in the Master Argument; see Mates (1952), p. 37 ff.) It is possible that Diodorus started with something equivalent not to Thesis A, but to Thesis A': every true proposition about the past is now necessary. But A' entails A. (Let p be a proposition true in the past, i.e. true during some past time t. Let q be the proposition that it was true during t, that p. q is a true proposition about the past, for q is about the fact that p was true during t. Hence, by A', q is now necessary, i.e. it is now necessary that it was true during t, that p. But this entails that it was true during t, that p, which in turn entails that it is now necessary that p. So any proposition which was true in the past is now necessary.) Since A' entails A, substitution of A' for A in our reconstruction of the Master Argument would not affect its validity.

39 That Thesis C rules out the possibility of contingent events can be shown as follows. Assume that a sea battle's occurring during 1984 is a contingent event, and let P be the proposition that a sea battle occurs during 1984. It follows that it is both possible that P and possible that not-P. Assume further that P. It follows that there is no time, past, present or future, during which it is true that not-P. But according to C, since it is possible that not-P, either it is now true that not-P or it will be true that not-P, something which contradicts our previous conclusion. Thus if C holds, there can be no such thing as a contingent event. If C were modified in such a way that the "possibility" is construed as possibility relative to the present time, the thesis would follow but would be too weak to contradict anything in Aristotle's argument (assuming that the "strong reading" mentioned in Note 23 is not adopted). This version of C would only rule out the possibility of events which are contingent relative to a given time. If the "possibility" were construed as de re possibility, the thesis would be unquestionably true (see T48), but would not contradict anything in Aristotle's argument; furthermore, Thesis A would apparently be irrelevant to its derivation.

40 It is an immediate consequence of D3 and D11 that a proposition is necessary if and only if it is always true (see T5). Hence, (5) obviously entails (6). It seems likely that Diodorus conceived of absolute necessity
ARISTOTLE VS. DIODORUS: FATALISM DEBATE

as that which is always true. For one thing, he seems to employ the companion conception of absolute impossibility (as that which is never true) in discussing conditionals; see, e.g., Mates (1953) p. 44 ff. [Note, however, that Mates construes the relevant modal notions as (what we are calling) de re ones.] In addition, the conceptions of modal notions attributed to Diodorus by Boethius, ["Diodorus defined the possible as that which either is or will be [true], . . . the necessary as that which, being true, will not be false . . ."] (Commentarii in Librum Aristotelis Secunda Edito, ed. Meiser, p. 234) appear to be conceptions of relative modalities, the definition of necessity being equivalent to that we attributed to Aristotle (see D15). Such conceptions would go hand-in-hand with the above mentioned conceptions of absolute modalities. The conclusion of the Master Argument, as we are interpreting it, in effect "proves" that absolute possibility is equivalent to relative possibility. This interpretation would accord with Alexander's statement: "And for the establishment of this [notion of possibility], the 'Master' argument was put forth by Diodorus" (In An. Pr., ed. Wallies, p. 184.) An argument, not a definition would be needed to establish such an equivalence. The equating of these two modalities would ultimately lead to a reduction of all of the modalities to two: (a) absolute possibility, relative possibility, absolute truth, relative truth, absolute necessity and relative necessity, vs. (b) absolute possible-falsity, relative possible-falsity, absolute falsity, relative falsity, absolute impossibility, and relative impossibility. Such wholesale collapse of modalities is precisely what the fatalist desires. It should be noted that these equivalences would not be logical equivalences, unless Diodorus' Thesis (see below) were adopted as a logical truth. It should also be noted that, in the absence of this thesis or its equivalent, Diodorus' conception of relative possibility is not equivalent to the conception we have attributed to Aristotle, despite the equivalence of the corresponding conceptions of relative necessity. Diodorus' and Aristotle's conceptions of de re possibility would appear to coincide, as the Principle of Plenitude holds for such possibility (see Note 11).

41 Diodorus' views on determinism, and his closely related views on motion and modality, seem to have rather quickly eclipsed Aristotle's views; see Sedley (1977), esp. pp. 96 ff. and p. 104.

42 The relevance of this thesis to the Master Argument has been emphasized in Rescher (1966b), Rescher (1967), Guerry (1967), Rescher and Urquhart (1971) and Sedley (1977). Rescher, however, hypothesizes that Diodorus assumed as a premise that a proposition could not be possible relative to a time and impossible relative to a later time; since this thesis is so clearly contrary to Aristotle's view, it is unlikely that the Aristotelians would have found it plausible. Sedley's conjecture that the missing premise of the argument was "If it were or were going to be true [that something is so], then it would already in the past have been the case that it would be true" (p. 97) is not, we feel, as credible as our conjecture that the premise was Thesis D. It is doubtful that anyone but the already-converted would have found the former premise plausible. In contrast, D is not only plausible in itself, but could easily have been confused with the following thesis about temporally incomplete "propositions": Thesis D': If a "proposition" is not always de re true, its negation is sometime de re true. D' is unquestionably true and is provable in ASL (see T50). If, as seems likely, the Aristotelians did not distinguish clearly between de re and de dicto modalities, failure to distinguish between D and D' could have made the former seem unassaila-
ble. (For an example of a passage in which Aristotle appears to employ the notion of time-relative de re truth, See Cat. 5, 423b23-424b2.)

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If 'p' is a well-formed formula, then so is '¬t_ip'. Instead of employing time-relative negation '¬t_ip' together with ordinary conjunction 'p & q' as primitive propositional operators, one could employ time-relative alternative denial, 'it is not during t_i both the case that p and the case that q', symbolized '/t_ipq', with '¬t_ip' being defined as '/t_ipp', ordinary alternative denial 'it is not both the case that p and the case that q', symbolized 'p:q', being defined as '/t_tpq', ordinary negation, symbolized '..... p', being defined as '/t_t(-t_ip)', and finally 'p & q' being defined as '(p:q)'.

Instead of adopting D7, one could adopt the weaker definition: D7': t_iEt_2 ≡ [t_4T_1t_2 & ϕ(t_2t_3 & ¬t_3T_1t_4)], unless one considered the extra content of D7, i.e. [t_iEt_2 ≡ ϕ(t_2t_3 & t_4T_1t_4)] (which is entailed by P1 and D7') to be an essential feature of temporal precedence, and one at the same time considered the linearity of time to be a non-essential feature of time.

In view of T53, P1 could be simplified to: P1. t_iDt_2 ≡ (t_iEt_2 v t_2Et_1).

The more general thesis, (1) [t_i & φ(t_2t_1 & t_3p)] ⇒ Np, is not provable. If it were provable, then (2) p ⇒ Np would be provable. Assume p. It follows that for some t_3, t_3p. Let t_i be a time such that t_i includes t_3 and includes every time earlier than t_3. It follows that t_3p. Since there is no time earlier than t_i, it also follows that φ(t_2t_1 & t_3p). Given (1), it would follow that Np.

For reasons cited in Note 48, T4I is slightly less general than a completely literal reading of Aristotle's thesis would require. "If an actual event has always been true, then it is necessary," taken literally, would yield: (1) [ϕt_i & φ(t_2t_1 & T_3f_1)] ⇒ Nf_1t_i. It is obvious that Aristotle would have argued for T4I instead of (1) if he had been apprised of the distinction between them.

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