Time and Law

What did God have to do to create the universe? In other words, what exists? More specifically, what are the fundamental ontological items that constitute our universe? The job of physics- at least for realists like Boltzmann, Einstein, Schroedinger, Weinberg, Quine, Lewis, and Maudlin- is to inventory space-time and the contents of space-time. . So we should look to physics to begin to answer our question. Of course its not always easy to tell what physics is telling us about fundamental ontology. That is where philosophy comes in.

Of course, physics has not yet and may never complete its job. Current proposals for the fundamental physical contents of the universe include particles of various kinds, fields, strings, wave functions; proposals for fundamental properties and relations include mass, charge, EM field values, spin, wave functions, and so on. But even though we don't know the true and complete inventory of fundamental physical things and properties two very different answers can be discerned to our question of what God had to do to create the universe when it comes to creating the ontology that grounds temporal facts. That is facts concerning temporal order and duration. For example, that lightening is typically followed by thunder, that placing an ice-cube in warm water is typically followed by the cube's melting, that the meeting lasted an hour. Some philosophers (e.g. McTaggert and Prior- though they had very different views) have thought that the truth of statements like "the meeting begins now" – that is, statements containing tenses or indexicals- involve temporal relations that cannot be explained in terms of order and duration but require primitive tensed facts. I disagree but this issue will not be the focus of the following discussion.

Temporal order and duration are essential to the characterization of the motion

and change of physical quantities and the formulation of fundamental dynamical laws and special science laws. Temporal facts are intimately involved with notions of counterfactuals, causation, memory, decision, and experience. In particular all these involve temporal asymmetry- the distinction between past and future, Naturally then views about the ontology of time will have consequences for much else.

Ok; so what did God have to do to create our universe? One answer goes like this. What God did first, of course I don't mean "temporally first", since God acts outside of time- was to create Space/Time- the manifold in which physical events occur and equip it with topological and metrical structure. At this juncture whatever differences there are between the spatial and temporal dimensions is reflected in the topological and metrical structure. Second, God decided on the types of fundamental material ontology- particles, fields, strings, wave functions and their fundamental properties, quantities and relations- charge, charm, and so forth. Third God created the laws that govern the distribution of the fundamental ontology and quantities in space and time (or the chances of such distributions if God was so perverse as to play dice with the universe by decreeing indeterministic laws). Fourth, God selected a particular distribution of the fundamental ontology and properties to be the *initial condition* of the universe. Of course God had to make sure that the Space-time, the ontology, the laws, and the initial condition were all compatible; i.e. that He didn't select an initial condition ruled out by the laws that the laws are consistent with each other and with the space/time structure and so on. This is a very hard problem for physicists- thinks of making relativity and QM compatible- but we can suppose that God, being omniscient, had no trouble with it. And last, but not least, God created Time- or rather; since the space-time structure was already in place, He started Time going- or flowing. This last act of His was essential. Without it nothing would have happened. Without the flow of time the dynamical laws would do nothing since they specify how the distribution of fundamental ontology evolves with the flow of time. Given the flow of time the laws evolved the initial condition to produce the sequence of fundamental physical states on which the familiar macroscopic world -the stars, the weather, nations, and so forth- supervenes. The temporal directedness of familiar macroscopic process- and in particular those associated with increase of entropy-

the melting of ice, the passing of youth and so on- is due to this temporal flow.
I will call this "the M view"…M is for "mysterious", "more" or "Maudlin"- the first because the idea that time flows has struck many as mysterious, the second since we will soon contrast it with a view that makes do with less, and the third since I take it that something along these lines is Tim Maudlin's view.

The second answer to our question is comparatively parsimonious. It goes like this. As in the M-view God created a spatio-temporal manifold with its topological and metrical structure, and selected the fundamental ontology and quantities but He also completely distributed the fundamental things and properties in throughout all of space-time. He did this all at once so to speak (recall He is atemporal). So instead of selecting an initial condition- as he does on the M-view and letting the laws do the rest, God fixed the totality of physical events. What about the laws? According to this view if we could ask God He would say that the laws could be read off the totality of fundamental physical states. That is, the laws supervene on the totality of states and so don't require a separate act of creation. I will later discuss exactly how this supervenience might work. What about "the flow of time"? God would say that there is no flow or intrinsic direction to time. He would go on to add that the so-called "arrows of time" , - that entropy increases, that radiation propagates away not towards, from charged particles, that we can affect the future but not the past, can know more about the past then the future, and so on -also supervene on the total distribution of fundamental properties and quantities. He leaves it to us to figure out how.
I will call this the L-view…L for "Less" or for "Lewis" since something along these lines is David Lewis' view.
[Lewis also requires that the fundamental properties be instantiated at points and have no necessary connections to one another. This is part of a doctrine he calls "Humean Supervenience." I left this part out of my characterization of the L-view since although I think it is defensible it seems at odds with current physics (specifically with QM) and can be dropped without affecting the primary ontological issues that concern me.]
The L-view makes do with less than the M-view. According to it the laws, temporal direction, and the passing of time are not fundamental but supervene on the distribution of fundamental quantities while on the M view the laws and the flow of time (which

brings with it time's arrows) are primitive. The M view contains two kinds of primitive entities -M-laws and flowing time - more than the L-view.

The M-view and the L-view don't exhaust the possibilities.

[An even sparser version of the L-view (a view that appealed to Leibniz and Mach) says that God made just the fundamental events and spatio-temporal relations among them. He thus would have avoided certain possibly embarrassing questions concerning exactly where to place the ontology in space-time. An even sparser version says that He didn't even need basic spatial relations but constructed them out of the temporal sequences of states or constructed the temporal sequence out of just a pile of states (this seems to be Barbour's view). There are also variant answers to our question that are closer to the M view. A more bloated relative of the M view (Tooley holds this) says that God also specified which events are *causally* responsible for which. The reason is that the laws he created (i.e. the plausible candidates for laws in our world) evolve the total state and leave that question unanswered. Tim wisely disavows this extra primitive since it is hard to see what work it can do (all the work already being done by the laws). Instead of adding primitive causation we could attempt to construct causal relations out of the laws and fundamental facts -perhaps along the lines of Lewis' counterfactual account -or do without this notion of causation. Some philosophers e.g. Armstrong have a view of laws like the M-views but don't take the flow of time as primitive or connect it to the operation of laws. This is a bit less ontologically demanding but, as we will see, it makes the operation of M-laws even more difficult to understand.**]**

Another possibility holds that the fundamental properties are individuated wholly or partially in terms of nomological or causal connections. On this view laws are necessary connections built right into the fundamental properties. So, for example, Newtonian inertial mass, is the property it is because it participates in Newtonian laws. Shoemaker, Ellis, Popper suggest a view of this sort. Initially this view has the attraction of reducing nomological to metaphysical necessity but on second thought it still requires some way of distinguishing which necessary connections are laws and as Kit Fine has recently pointed out also requires laws that are not metaphysically necessary to specify the properties that *can* be instantiated in our world. It is also obscure how this view connects with the two views of time that are our main concern. In any case, I will ignore these variants since I

want to focus on the M-view and the L-view as sketched above.

On the L-view laws and temporal facts- i.e. temporal order, duration and so on, supervene on the distribution of physical events and the geometry of the 4 (or however many) dimensional space-time manifold. The temporal dimension is just one of the 4 dimensions. It is distinguished from the spatial dimensions only in the way it is involved in laws and by the geometry. On the M-view neither the laws nor the direction of time supervenes on the physical events. The laws are entities in their own right. But what kind of entity are laws? They are not material contents of space/time or physical magnitudes. Newton speaks of space as a kind of entity- he calls it a "quasi-substance"- but it has some kind of reality but is a very different sort of thing than material particles. On the M view laws- I will them M-laws- are yet a another kind of fundamental entity; not material, not space, not time, but something ultimately distinct and basic which are either not located at any place in space time- or located everywhere- and have effects within space-time. M-Laws are entities that *govern* the evolution of events; the motions of particles, the propagation of radiation, and so forth. But what does this mean?
Also on the M view time flows but space doesn't. I am not sure what this comes to either. So we have two questions for the M-theorist. What is meant by laws *governing* events and what is meant by time flowing? Maudlin tries to illuminate both these ideas by connecting them. Time's flow really comes down to the claim that time has an intrinsic direction. But, as Maudlin remarks, ".. The passage of time connotes more than just an intrinsic asymmetry: not just any asymmetry would produce passing….the passage of time underwrites claims about one state "coming out of" or "being produced from" another, while a generic spatial (or temporal) asymmetry would not underwrite such locutions" Maudlin's idea is to connect the flow or passage of time with the "production of states from other states by means of the dynamical laws. Production is asymmetrical and the direction of time is the direction of production. By linking the governing role of laws with the flow of time Maudlin is hoping to illuminate both. The idea is that laws govern by directing what state is next as time flows; Or maybe we can think of the moments of time as including arrows that direct the evolution of events by the laws.

Maudlin remarks that the claim that time flows or passes usually elicits ridicule and

sometimes arguments designed to show that there is something basically wrong with it; either that it is logically. incoherent or that it is incompatible with what we know about the physics of our world. Although I disagree with Maudlin I will briefly mention a couple of these arguments since they help clarify his claim and since my objections to the M-view are different from these.

The primary argument that the claim that time flows is logically incoherent is expressed by Price

> ....if it made sense to say that time flows then it would make sense to ask how fast it flows, which doesn't seem to be a sensible question. Some people reply that time flows at one second per second, but even if we could live with the lack of other possibilities, this answer misses the more basic aspect of the objection. A rate of seconds per second is not a rate at all in physical terms. It is a dimensionless quantity, rather than a rate of any sort. (We might just as well say that the ratio of the circumference of a circle to its diameter flows at π seconds per second!)

Maudlin replies that time does indeed pass at a rate of one second/second and that this is unobjectionable

On this basis, if we ask how fast time flows, i.e. how fast time passes, we must mean to ask how the temporal state of things will have changed after a certain period of time has passed. In one hour's time, for example, how will my temporal position have changed? Clearly, I will be one hour further into the future, one hour closer to my death and one hour farther from my birth. So time does indeed pass at the rate of one hour per hour, or one second per second, or 3,600 seconds per hour...

I am uncertain whether this is really an adequate reply but I think it is beside the point. Price seems to be taking the “searchlight metaphor” to seriously. Maudlin’s talk of time flowing or passing really shouldn’t be understood in terms of the metaphor of something- Time- changing with respect to something- Time. Rather, what it comes to is the idea that time – unlike space- comes with a directionality at each point that is connected to the direction in which the laws evolve the production of events. Talk of the rate at which this

occurs is confusing. Better just drop it.

Another objection is that the flow of time is incompatible with physics- specifically with special relativity. On the usual understanding of special relativity there is no frame independent relation of simultaneity. So if one thinks of time flowing as a wave that sweeps through space then indeed this wave will determine a simultaneity relation and the flow of time is incompatible with this understanding of SR. But special relativity is not incompatible with the claim at each point of space-time there is an intrinsic orientation that distinguishes past and future light cones at that point. SR doesn't itself make this distinction but it is not incompatible with it. Maudlin is supposes that the passage of time- whatever it is- determines which is the future light cone and which is the past and that events in the past are those that together with the laws produce the events that sit on the vertex. So no incompatibility with SR.

[Finally, it is often claimed that the fundamental laws of physics are "time reversal invariant" and it is supposed to follow from this there cannot be intrinsic direction of time. Time reversal invariance means, roughly, that the laws don't distinguish forward from backward light cones. I think Paul H argues along these lines. Maudlin's reply is a) it may be that there are fundamental laws that are not time reversal invariant- for example, CP violation seems to select a preferred temporal direction and certain indeterministic formulations of quantum mechanical laws certainly do so- and b) even if they are it doesn't follow that there is not an intrinsic temporal direction of the sort that Maudlin posits and which he thinks is required in order to account for the directionality of lawful processes.

[The treatment of this question is one of the most peculiar in the philosophical literature. The usual approach sets the problem as follows: the fundamental physical laws have a feature called "Time Reversal Invariance". If the laws are time-reversal invariant, then it is supposed to follow that physics itself recognizes no directionality of time: it does not distinguish, at the level of fundamental law, the future-direction from the past-direction, or future light-cones from past light-cones. Therefore, it is said, any such distinction must be grounded not in fundamental law, or in the intrinsic nature of the space-time itself, but

in contingent facts about how matter is distributed through space-time. The direction of time, we are told, is nothing but (e.g.) the direction in which entropy increases. The philosophical puzzle is then how to relate various other sorts of temporal asymmetry (the asymmetry of knowledge, or of causation, or of control) to the entropic asymmetry. (Paul Horwich's *Asymmetries in Time* (1988) provides an example of this form.)]]

So if Maudlin's claim that time flows comes to the claim that there is an intrinsic temporal direction that grounds the operations of laws then as far as I see this view- the M view- is logically coherent and compatible with current physics. The question of whether it is demanded by current physics is one to which I will return.

My objections to Maudlin's claim that time flows or posses an intrinsic direction lie elsewhere. First, I cannot bring myself to accept the M-view of laws to which it is wedded and second I think that the intrinsic arrow of time is, as far as physics is concerned, explanatorily unnecessary and explanatorily idle.

My main problem with M-laws is that I don't understand what kind of thing M-laws are and how the do their governing work. I don't see what it is about a particular M-law that makes it the law associated with a particular generalization or differential equation. Does the M-law in some way represent the equation? Does this mean that an M-law is itself some kind of representation? But how can a representation direct the evolution of events if not via some further laws? I especially have difficulty understanding how indeterministic M-laws could work. An indeterministic law can produce any of a number-vast number for say indeterministic QM-collection of alternative states with weights indicating the probability that a particular alternative is produced. On the M-view these weights are identified with chances. They are items distinct from actual frequencies but in some way are supposed to bring about frequencies – at least typically- or *probably* -that correspond to them. How do they succeed in doing that? And why should we set are degrees of belief by them? I find this baffling.

If the M-view were the only way to make sense of physics and experience I suppose I would accept it. And if the M-view requires or is best developed with an intrinsic temporal direction I would accept that too. But, are M- laws and flowing time - as separate ontological posits- really needed to obtain our world or could God have done with less- made an L-world that looks to us- conscious beings within that world as physics and experience says our world looks- i.e. a world in which acorns grow into oaks in lawful ways and so on? Maudlin thinks that if God had created an L-world he would have made a world with no genuine laws, no passage of time, no genuine change, causation or explanation. He also thinks that conscious beings would be absent from an L-world. An L-world wouldn't appear like anything at all to us since there would be no us and no appearances. Let me bracket for now the issue of whether in an L world there would be any conscious beings. The question I want to ask is whether the L-account can "save the appearances.", supposing there are appearances in it; that is whether it can account for the fact that the past and the laws explain the present and not the reverse, that time appears to have an arrow- people grow old and die and never the reverse- and we experience the passage of time- I am aware- as no doubt you are as well- that I am a little closer to the end of my talk now then I was 10 minutes ago.

To make a case that our world might be an L-world the first thing we need to do is to say something about how the laws, L-laws that is, supervene on the totality of states. The best account I know of is Lewis'. He says that the laws are contingent generalizations entailed by the BEST THEORY of the world. The best theory is the true theory that best combines scientific virtues…in particular the virtues of simplicity and informativeness. Lewis' idea is that the BEST THEORY best summarizes the totality of fundamental physical facts. Indeterministic laws come into the story by adding probability as an undefined term to the best theory and then characterizing a sense of informativeness or degree of fit on which indeterministic theories may differ in degrees of fit. This not only makes objective probabilities un mysterious but also connects them, as surely they are, to rational degrees of belief. That is, it provides an explanation for why our degrees of belief should be guided by objective probabilities (or our beliefs about objective probabilities.) [This is a bit of a story that we can get into during discussion]

A BEST THEORY for a world- for our world-; i.e. one that is very simple and informative- plausibly delivers laws that select one of the dimensions for special treatment. since these are enormously informative for beings like us. This of course, is what the dynamical laws of classical mechanics, electromagnetism, quantum mechanics etc. do. In fact one could say that what distinguishes the temporal dimension from the spatial ones is that it is the dimension picked out by the BEST THEORY for special treatment; in other words the distribution of fundamental properties is laid out in the space-time manifold in such a way that the theory that best combines simplicity and informativeness picks one of these dimensions for writing down equations that informatively describe that distribution. This remark needs more development and defense -especially in view of relativistic conceptions of space-time- then I will get into here but it is suggestive of the constructive potential of Lewis' conception of laws.

OK so on the L-view of God's creation God has made the laws once he makes He distributes fundamental physical fields etc. throughout space-time. But how does one get the direction of time on the L-view? As we mentioned earlier most of the candidates for fundamental dynamical laws that have been proposed by physicists are time reversal invariant- that is they don't pick a preferred temporal direction. They are temporally symmetric- at least in this sense- for any temporal sequence of positions of particles (particle position may itself may not be a fundamental matter but supervenient on fields or something else more fundamental but it is plausible that macroscopic properties that interest us supervene on sequences of particle positions) that the theory allows the temporally reversed sequence is also equally permitted; or are equally likely.

However in our world temporally directed processes- lawful processes- are ubiquitous. Ice in war water melts, cream mixes with coffee, youth passes, galaxy's form, decisions affect the future not the past and so on. Within physics this mismatch between the fundamental and the macroscopic came up specifically in understanding how thermodynamic phenomena are related to more fundamental mechanical phenomena. Thermodynamics concerns how certain macro features of matter (gasses, liquids, solids) including volume, temperature, pressure, heat, work, entropy and so on are related to one another and how they evolve in certain systems. One of the central ideas of thermodynamics is that an isolated system is in *equilibrium* when there are certain relations among these quantities (e.g. for a gas PV=kT) and that systems not in equilibrium will evolve toward equilibrium. Most famous of these is the so-called second

law that says, in one of its forms, that the entropy of an isolated system never decreases. The dynamical laws of thermodynamics are thus temporally asymmetric.

When physicists began to take seriously the idea that macroscopic systems are composed of molecules that satisfy classical mechanics the question obvious arose and became urgent of how the asymmetric laws can emerge from temporally symmetric fundamental laws. So, for example, the trajectories of particles that begin with an ice cube in warm water and end in the ice cube melted and the water at a uniform cooler temperature is compatible with classical mechanics. But then so is the trajectories of particles which begin with water at a uniform temperature and end with an ice cube in slightly warmer water. But the second evolution violates the second law. The puzzle that confronted physics when the hypothesis that gasses and so on are constituted by particles obeying classical mechanics was how it can be that, on the one hand, the fundamental dynamical laws are complete and temporally symmetric while there are laws of thermodynamics which take the form of dynamical laws governing macroscopic states and are temporally asymmetric?

The problem of reconciling the existence of temporally asymmetric laws of thermodynamics with temporally symmetric fundamental dynamical laws was partly solved by Boltzmann who observed that "most" of the micro-states (where the state is characterized by the positions and momenta of molecules of liquid water and ice) corresponding to an ice cube in warm water evolve towards the future into states in which the ice is melted and the water slightly colder. Most here means that relative to a very natural measure on micro-states the measure of the states exhibiting the melting of the ice is very nearly 1. Boltzmann concluded that the *probability* that an ice cube in warm water will melt is very nearly 1. This is only part of a solution since, as Boltzmann soon realized, most of the micro-states corresponding to an ice cube in warm water when evolved toward the past are ones in which there is a *smaller* ice cube and eventually water at a uniform temperature. Of course, we don't believe for a moment that the ice cube we now see in the glass of water spontaneously formed out of water at a uniform temperature. There are various ways of responding to this paradox. One is to think of the Boltzmann providing rules for prediction but not retrodiction.1 But this *instrumentalistic* understanding of the probabilities leaves one wondering why this recipe works so well. A different idea is suggested by Boltzmann and has become one of the standard ways of thinking about statistical mechanics (e.g. Feynman, Lebowitz, Goldstein). It has recently been given an explicit and elegant formulation by David Albert. The idea is that there is a law about the initial conditions of the universe that specifies that the initial condition was one of very low entropy and highly symmetrical with respect to thermodynamic conditions e.g. matter is evenly distributed and the temperature is uniform. Albert calls this claim "The Past Hypothesis"(PH) and considers it to be a *fundamental* law. He also posits a probabilistic law that assigns a uniform probability distribution over the micro-states that realize the low entropy initial condition. The reason that PH and the uniform probability distribution are *laws* about the initial condition is that they together with the dynamical laws they ground other laws and

1 This is Steven Leeds suggestion in (Leeds 2003)

counterfactuals; e.g. if the ice had been in the water for the last 10 minutes it would have melted.2

Albert argues that the dynamical laws together with the PH and uniform probability distribution- call this "the fundamental package"- entail the thermodynamical laws and probabilities (e.g. a probabilistic version of the second law). In fact the fundamental package entails a great deal more. It entails a probability for every physically possible micro history and every physically possible macro-history of the world. Like the fundamental dynamical laws these probabilities apply independently of the material constitution of a system. The probability distribution applies to the matter and radiation alike. In quantum mechanics it applies to the initial wave functions of the universe compatible with the past hypothesis.

Assuming that the dynamical laws are deterministic the account of fundamental physics can be pictured as follows:

The thin lines represent micro histories and the red line represents the actual micro history. The red circle represents the special low entropy macro condition postulated by PH. Of course it occupies only a tiny portion of the space of nomologically possible initial conditions. The cylinders represent macro histories and the blue cylinder represents the actual macro history. All the micro histories satisfy the low entropy initial condition and almost all evolve towards a state of maximum entropy. Although the evolution of micro histories are governed by deterministic laws the macro histories appear to evolve indeterministically. The macro state at t doesn't determine a unique evolution but the probability distribution specifies the probabilities of the histories that realize that macro state.[3] Suppose we know the complete macro state M at a time t[4]. Then the probability

2 On Lewis' account of laws it is very natural to think of PH and the initial probability distribution as lawful since they are part of a highly informative and simple package. I argue for this in Loewer (2001) and (2004). Also the PH plays the role of a law in similarity accounts of counterfactuals like Lewis'. See Elga (2000) and Albert and Loewer (2004)

[3]The probability assignment over initial conditions together with the deterministic laws and the supervenience principles connecting macro to microstates determines a probability distribution over propositions characterizing macro states. So for example, it assigns a probability to the proposition that a particular ice cube in warm water will melt in the next hour.

distribution specifies the likelihood of the various rather different macro histories that branch from M. So, for example, the macro state of the world right now is compatible with and micro states that lead to rather different weather conditions a few days from now and with various macro weather conditions having substantial chance of coming about. It is also a feature of this structure- and a very important one for our purposes- that very small differences in the micro condition can give rise to very different macro states at later times. This contrasts with pasts of histories compatible with M. Since all these histories must eventually end up (or have started) in the low entropy state characterized by PH they are very constrained. If we knew the complete macro state at t we would basically know the whole of the macro past. But even if we know only a part of the current macro state we will be in a position to have reliable information about the macro past. This, of course, is what underlies the possibility of records of the past. Notice also that small differences in the current microstate make for (or are almost certainly to) almost no difference in the macro past.

This statistical mechanical probability distribution induces a probability distribution over all propositions including those in the vocabularies of the special sciences since these supervene on micro histories and fundamental laws. One can speculate- Albert and I do- that all the probabilities that occur in meteorology, evolutionary theory, learning theory, economics, regularities involving gambling situations and so on, *in so far as* these are genuine objective probabilities are ultimately grounded in these statistical mechanical probabilities. We have no "proof" of this claim. We consider it a bold conjecture. But it is supported by the fact that these special science processes invariably involve thermodynamic processes. To the extent that the hypothesis has been tested it has passed the tests. Epistemologically, it is in the same boat as the dynamical laws.5

On this account the thermodynamic arrow of time derives from a law that applies to a

---

[4]Of course this is much more than anyone could ever know. It also may be a little bit less in that we might know something about the microstate over and above its probability given that it realizes the macro state. E.g. we might know the precise position of a particular particle

5 Another approach to the statistical mechanical probabilities grounds them in the indeterministic dynamical laws of a particular version of quantum theory GRW.

state at one end of the temporal dimension. It is an interesting feature of Lewis' account of laws- and one that I think recommends it- that it makes sense of what we could mean by there being such a law and also of a probability distribution over possible initial conditions. Adding PH and PROB to the dynamical laws results in a great increase in informativeness at a small cost in simplicity. On the M-theory these kinds of laws and probabilities are very puzzling since M-laws are essentially dynamical.

It might be thought that the M-view can explain the entropic arrow in terms of the passage of time without the Past Hypothesis. But intrinsic time direction by itself won't explain the increase in entropy, the passing of youth, and so on. There are worlds with the same dynamical M-laws as ours in which the second law and the rest fail. The M theorist has to agree with the L-view that at one end of the universe the state satisfies the Past Hypothesis and probability distribution. Once he does that it is the past hypothesis that grounds the second law. This makes it look like the flow of time is irrelevant to the explanation of temporally directed processes. But Maudlin will say that what qualifies that end as the *initial* end. He will add that that this initial condition occurs at the time when time began to flow where the L-theorist will say that what makes it "initial" is just its being the end at which the Past Hypothesis applies.

Although the two accounts may agree on what laws there are- though not what laws are- as we are seeing -they have very different views of time's arrows. On the M-view the entropic and other arrows are ultimately grounded in the flow or intrinsic of time. But the L- view grounds the entropic arrow only in the past hypothesis. The program for the L-theorist is then to ground all temporal directness in the entropic one. That is a tall order. But some Progress in this program has been made by Boltzmann, Reichenbach, Lewis, Albert, among others.

Here is a sketch of how the explanation might go.
The main asymmetries are those of counterfactuals, causation, decision, records, and our subjective experience of time passing. Explaining the asymmetry of counterfactuals in terms of the statistical mechanical probability distribution is a start. Lewis' well known

account of counterfactuals in “Time’s Arrow” is I think basically on the right track. His account there depends on the idea that a very tiny local difference in state at a time t can make for very large differences in the future but is compatible with the actual past. Lewis remarks that he “..does not know how to connect the asymmetry of counterfactuals ...and the famous asymmetry of entropy.” But we can see that the probabilistic structure induced by PH and PROB has the consequence that small differences in micro state can lead to big differences in macro state in one direction- what we call the future- but not in the other direction- what we call the past. . So it will be true, for example, that if Nixon had pushed the button the subsequent history would have been very different from what it actually has been but the past would have been pretty much the same- and macroscopically exactly the same as it was prior to the button pushing. The asymmetry of counterfactuals underwrites the fact that we can affect the future but not the past. And given the connection between causation and counterfactuals it also grounds the fact that (local) causes typically precede their effects.

An aside: Paul Horwich commenting on Lewis’ account of counterfactuals says

> “Now these criteria of similarity may well engender the right result in each case. However, it seems to me problematic that they have no pre-theoretical plausibility and are derived solely from the need to make certain conditionals come out true and others false. For it is quite mysterious why we should have evolved such a baroque notion of counterfactual dependence. Why did we not, for example, base our concept of counterfactual dependence on our ordinary notion of overall similarity? As long as we lack answers to these questions, it will seem extraordinary that we should have any use for the idea of counterfactual dependence, given Lewis’ description of it; and so that account of our conception of the counterfactual conditional must seem psychologically unrealistic.”

ANSWER: The information expressed by counterfactuals (as we have proposed they be evaluated) is important for us because it tracks the statistical mechanical probability distribution. Knowledge or partial knowledge of this distribution is relevant to successful decision-making. People whose degrees of belief approximate the statistical mechanical probability distribution are objectively more likely to succeed in satisfying their desires (assuming they are otherwise rational) than people whose degrees of belief diverge from this distribution. So if I know that if I were to strike the match now it likely

light then I know that P(light/strike&M(now)) is close to 1. If I want to start a fire this knowledge is very useful.

Following the 4 dimensional worm associated with a person we will see memories accumulate in one direction (the same direction as that of the entropic arrow) and decisions have consequences in the same direction and so on It is not implausible that our sense of time's passage derives, at least in part, from these asymmetries in action and knowledge. All this is programmatic but I think it suggests how the temporal asymmetries may be recovered from the statistical mechanical probability distribution over the PH initial state without assuming an intrinsic direction or flow to time. In fact, as we observed adding an intrinsic direction seems neither necessary nor sufficient to obtain the temporal asymmetries that we have been discussing.

"STOP!", I can hear, Maudlin- I have HEARD Maudlin- scream. It may be that merely adding an intrinsic direction of time can't explain why ice melts- the past hypothesis and the probability distribution is needed for that- but what the temporal direction is needed for is to ground the direction of explanation. Without it and without M-laws there are no explanations at all L-laws are not genuine laws. They are mere regularities. And if the L-laws are not genuine laws then neither are the probabilities, causes, counterfactuals, explanation, temporal direction, and so forth constructed from them genuine.

This charge is familiar to Humeans. If the claim is that they are not genuine since they are not M-laws; that is, items that exist independently of the states and govern their evolution then- not to put to fine a point on it- the objection is totally question begging. An argument that shows that L-laws are not genuine laws needs to be one which shows that they are incapable of doing something that laws are supposed to do without presupposing the truth of the M-theorist's ontology. There are arguments proposed by some M-theorists that purport to do just this but are only a little less obviously question begging. For example, Armstrong argues that L-laws don't support counterfactuals. His reason is that since L-laws are mere actually true generalizations there is no reason to

suppose that they continue to hold at non-actual worlds where the counterfactual antecedent holds. But if counterfactuals are evaluated along the lines Lewis (Bennett, Albert, Loewer and other) proposes on which the similarity relation depends in part on what laws- what L-laws obtain at the actual world- then there is reason to suppose that they continue to hold at most similar counterfactual worlds; at least for typical counterfactuals.

Armstrong argues that L-laws are incapable of sustaining explanations. A devastating charge, if true. But of course if explanation involves the derivation of the explanandum from the laws and propositions describing initial conditions then L-laws are suited for that. It is an L-law that p logically implies p. Laws also enter into causal explanations e.g. the striking of the match caused and explained the lighting of the match. The L-theorist can account for the role of laws in this case in terms of the role of laws in counterfactuals and the connections between counterfactuals and causation. There is a close connection (though perhaps not so simple as Lewis' original counterfactual analysis of causation) between the causal claim and the counterfactual if the match had not been struck it would not have lit.

The M-theorist is likely not to be assuaged by the forgoing remarks. Their point can be put like this. Think of a pattern of pixel firings on a screen. Let T be a theory that best describes the pattern of firings; i.e. it is by far the BEST in combining simplicity and informativeness. Does this qualify it to *explain* the firings? Of course not. The Humean is that in this toy example the Best Theory of the pixel firings is not explanatory because while it is a best summary of the pixel firings there is much more going on in the world including events in the device that produces the pixel firings that is left our of this theory. But suppose now that the pixel firings were the totality of events in the world. Would then elevate the Theory into the status of a law-giver and make the contingent generalizations it entails explanatory? The anti-Humean finds this absurd. Why should the non-existence of anything else suddenly turn a merely accidental generalization into a law? Well the Humean is committed to this in part because he thinks that a contingent generalizations being a law is not logically independent of the facts. It is this feature that the M theorist thinks makes them inept for explanation. In contrast the M-laws are

logically independent of the facts they explain. But what we have here is not so much an argument against Humeanism and for the M-view but rather a dilemma. If the laws are logically independent of the facts as the M-theorist thinks is required for explanation then how can they entail the facts?

There are two that I think he may be sympathetic with. First, there are certain thought experiments that have been claimed to show that laws- as we usually understand them- fail to supervene on the totality of states. It seems that we can easily imagine worlds which are identical in their sequences of states but which differ in their laws. For example we can imagine a world in which there is a single particle moving in absolute space with uniform velocity. This world is compatible with the Newtonian laws and with many laws incompatible with Newton's and each other. We have to distinguish between the worlds being compatible with the regularities associated with laws from being compatible with the regularities being laws. The claim is that this simple world is compatible with all of these regularities being laws. If so then supervenience on the state fails. Lewis' own view entails the L-law for the simple world is that there is a single particle moving with uniform velocity (this being very simple and informative about this world.). But surely, the objection goes the Newtonian ones. A related point is that, since the L-laws supervene on the totality of spatio-temporal facts it will inevitably turn out that not every initial condition compatible with the regularities characterized by a given set of L-laws will when evolved by those laws lead to a world in whose laws are those L-laws. Similarly, and even more obviously, indeterministic L-laws assign positive chance to worlds in which they fail to hold (and in which there may be very different chances.) Some philosophers are persuaded- or I would say taken in- by these thought experiments. But I don't think that they show that our world is not an L-world. They do show that there is a mismatch between our concept of law- or the intuitions generated by the concept- and L-laws. But it is not surprising that we would have these intuitions since a something like the M-theorist quote s account is a component of our concept of laws. That aspect is bequeathed to us from the 17th century idea that the natural laws are God's commands. This way of thinking of laws played an important role in separating scientific from theological explanation. God chooses the laws and the initial conditions and science

can figure out the rest. But one can also find in 17 and 18th century physicists something more like Lewis' conception of laws as axioms of a simple and informative axiom system. In any case, it is obviously mistaken to argue from the fact that our concept to be applicable the world must be such and such to the world must be such and such. The issue is whether those who find the first component unpalatable can excise it from their concept of law while preserving the work that laws can reasonably asked by science to do. If the mismatch between our concept of law and L-laws was so great as to make L-laws incapable of supporting counterfactuals or of sustaining explanations then there would be merit to the argument that the laws science speaks of are not L-laws. But I have argued that arguments purport to show this are question begging.

It may be worth remarking that while the L-view may seem to allow for too few possibilities the M-view seems to permit too many. On the M-theory there are two possible worlds that agree exactly in their sequence of states but one without any laws and the other with a law that determines the sequence in all details. There is a world just like ours wrt the sequence of states but whose sole law determines the motions of the moon- And there are two worlds that agree in their sequences of states but in which time flows in opposite directions. Even someone who has no verificationist instincts may find this an embarrassment of possibilities.

The objection to the L-view that I think Tim finds most compelling is that it is incompatible with consciousness and with our phenomenal experience of time's passage. If this were so there would be no question of saving the appearances. But merely asserting that consciousness requires the primitive passage of time is just foot stamping. Why should one think this is so? One reason is that mental states and processes- beliefs, thinking, experiencing and so forth- are functional states and so are individuated in terms of causal and counterfactual connections among themselves and other events. If in an L-world there are no genuine causal and counterfactual connections then there are no functional states and so no mental states either. If this is the argument then we have already dealt with it. A deeper claim is that in experience we are directly aware of the passage of time and that this awareness is essential to conscious experience. In perception, thinking, deliberation and so forth we are aware of both the passage of time and something that might well be described as the production of one event from out of

another. Further these awarenesses are intimately connected. It is not implausible that they are essential to consciousness; that is, without being aware of the temporal flow of experience I am not aware of anything. There is clearly something to these claims. It is because of these reflections that the M-view can strike one as obviously right. The M-view locates the source of our awareness of temporal flow in primitive relations of production and passage. But does the primitive flow of time really account for this awareness any better than the L-theorist can. It is not obvious to me that it does. The L-theorist explains the appearance of the passage of time in terms of the feelings associated with the laying down of memories, the visual experiences of the motions of objects, the experience of deciding to move ones hand and experience of moving it and so forth. If these feelings, experiences, etc. can occur in an L-world then that is sufficient explanation for our awareness of time's passage. Similarly it is sufficient to explain our awareness of time's passage in an M-world. The primitive "flow of time" would be irrelevant to the explanation. If the M-theorist protests that the L-account of awareness is insufficient he needs to explain how our awareness is directly of the flow of time; how our states of awareness can get reliably hooked onto the flow. Or he can simply claim that there is no awareness (or experiences) of any sort or explanation at all without the passage of time. But then we are back to foot stomping.

So where does this leave us? As far as I can see and as far as I understand the two views both the M-world and the L-world are possible and both our compatible with the appearances. Metaphysically and epistemologically speaking God could have made either actual. But if this is where we are then I think the situation favors the L-view. If our world could be an L-world (even if it is an M-world) then it is hard to see why we would have reason to believe that it contains the extra ontology demanded by the M-theory even if we thought we could understand what that ontology involves. The M-views additional ontology would be idle wheels that may make us feel better by validating the feeling that the flow of time is basic but they do no work. In particular, the primitive passage does no work in explaining time's arrows except in so far as it is required to underwrite the operation of M-laws. The M-theorist's account of the arrows of time will (except for the mysterious direct awareness of time's flow) go via the entropic arrows. So if the M-theorist is to be convincing it looks like he will have to show- without begging the

question- that our world could not be an L-world because L-laws cannot sustain genuine explanations and so on. If this can't be shown then the L-view is preferable on Occamist grounds to the M-theory. And even if one has no brief for Occamism the M-theorist has no argument to rationally persuade the L-theorist to come over to his side.

(Draft)

Barry Loewer
Rutgers University

October 21, 2004