The Passage of time

– lacks experimental evidence; all evidence is that at different times conditions differ, no evidence that earlier conditions become later conditions; all experiments to verify the nonexistence of other times end up verifying the reality of some present.
– lacks a theoretical model
– difficult to square with relativity
– squelches discussion of the arrows of time
– gives ontological pseudo-explanations of causal asymmetry (past events affect us because they're nonexistent and *past*; we can influence future events because they're nonexistent and *future*.
– obstructs the investigation of causal asymmetry at every turn

THE ENTROPIC ANALYSIS

Beginning with Hume nearly all attempts at characterizing causality have consisted of a list of time symmetric criteria to which is added an unconnected stipulation that cause precedes effect: these formulations treat cause and effect as the alike; cause is merely the one that happens to come first. In contrast the entropic analysis places causal asymmetry at the center of causal matters; principles are developed solely on the basis of their time asymmetries. The subject of causality can then be wholly built upon coarse-grained entropy and it increase.

Preliminary assumptions: Perfect isolation. Entropy increase. Mixing dynamics

(The last two can be justified when isolation is relaxed)

For simplicity we specialize to uniform distributions, then entropy is log (volume) for conditions and coarse-grained cells, and relative volume can be directly related to conditional probability.

Prediction goes from past/present to future.
Retrodiction goes from present/future to past.
Retro-inference is any means of learning about the past.

(Monochronic) Describable Conditions

- Description of finite length
- Refers to one time only
- Makes no distinction finer than the coarse graining

$\vec{A}$ is condition A under the action of the phase flow for Δt, $\overleftarrow{A}$ is A under the reverse flow for Δt. A*, the coarse completion of A, is the union of all coarse-grain cells that A intersects. $\mu^*(A) = \mu(A^*)$. For describable A, $A^* = A$.

Because of high dimensionality and chaotic divergence of trajectories in some directions, volume expansion of a describable condition is colossal. For A describable $\mu^*(\vec{A})$ and $\mu^*(\overleftarrow{A})$ are many orders of magnitude greater than $\mu^*(A) = \mu(A)$

Describable conditions are μ^* minima, i.e., coarse-grained entropy minima.

SOME ASYMMETRIC CAUSAL PRINCIPLES

A is a cause condition, B an effect condition

1. Cause as a lower entropy condition than effect.

For even a small fraction A to flow into B, $B\overrightarrow{K}$ must be orders of magnitude greater than AK, with background conditions K..

2. The plurality of possible causes.

$(\overleftarrow{B})*$ is inexhaustibly heterogeneous and disjunctive.

3. Entropy increase as a boon to forward action and prediction.

The rapid expansion of conditions make later or future conditions easier targets.

4. The futility of retrodiction.

Retrodiction requires locating a smaller earlier condition on the basis of a radically larger later condition.

5. The importance of necessary effects (i.e., causal necessity) vs. the triviality of necessary causes.

Necessary causes are either tautological (a mosquito's bite is necessary for a mosquito bite) or very general (something that results in moisture).

6. Retro-inference as founded on prediction

Inferences about earlier times are based not on retrodiction but on predictions from prior conditions and prior probabilities, which can be compared to current conditions.

7. The disjunctiveness principle.

Although the possible causes of an effect can be prolifically various, the heterogeneity of possible effects of a cause is severely limited.

8**. The impossibility of reverse causality.**

Possible reverse effects of a reverse cause would be uncontrollably various. Reverse causality conflicts not with logic or ontology but with rampant entropy increase.

CAUSALITY VS. INFLUENCE

Without the flow of time, there can be no flow of causality or influence. The latter find reinterpretation in the *constraint* that situations or conditions at one time place upon situations or conditions at another time.

	Coarse-Grained Causality	Fine-Grained Influence
1.	based on ensembles	based on individual situations
2.	unidirectional (in accordance with entropy increase)	bi-directional (in accordance with time reversibility)
3.	can be observed	operates beneath powers of observation
4.	depends on conditions/ properties	depends on situations/events
5.	facilitates prediction	prediction and retrodiction are symmetrically equal
6.	probabilistic	non probabilistic (except possibly for quantum probabilities)

The reconciliation of bi-directional influence with unidirectional causation then reduces to the classical resolution, propounded by the Ehrenfests, to the reversibility paradoxes.

RETRO-INFERENCE

All temporal inference is from cause to effect. Examples of useful reasoning from effect to cause always involve at least tacit use of prior conditions and probabilities; the cause to be inferred is surrounded by earlier and later conditions.

COARSE CONSTRAINT

In a coarse-grained sense, earlier conditions constrain later conditions much more than later conditions constrain earlier ones. The past constrains the present to a much greater extent than the future does, giving a sense of solidity to the constraining past and of emptiness to the non-constraining future. The present constrains the future to a much greater extent than it constrains the past, giving us a limited control of the constrainable future that we are unable to exercise with respect to the unconstrainable past.

FREE WILL AND AN OPEN FUTURE

Free will requires an open future

The open future implies passage of time

Passage of time implies no reverse causality, so the openness or any other disposition of the future has no effect on current freedom

Therefore, free will does not require an open future, nor does it require the passage of time.

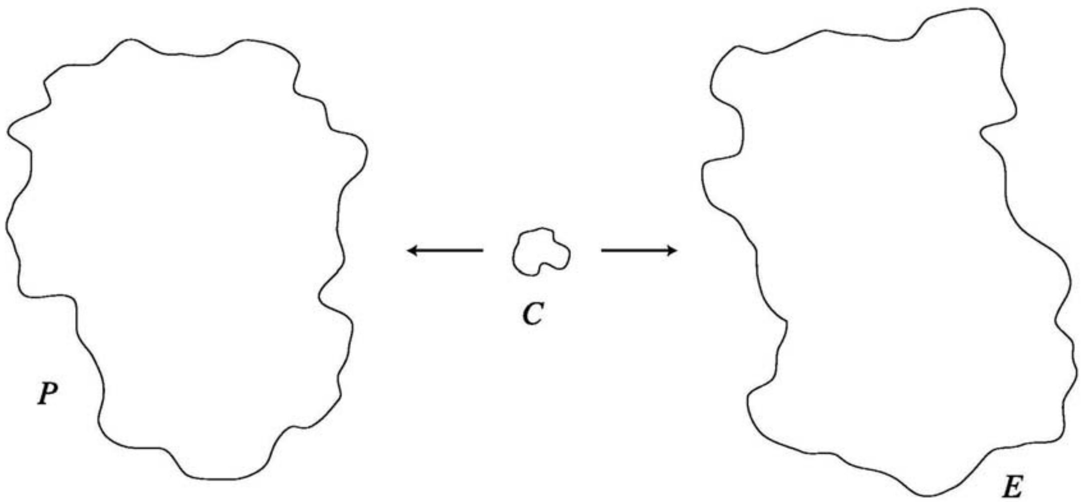
CAN WE REMEMBER

THE PAST?	THE FUTURE?
Yes. Memories need to be predictable consequences. of experiences. This requires that memories occur at higher entropy times, that is to say, later than the experience remembered. We have memories of the past because prediction is feasible	No. Memories of future experiences would have to be retrodictable prequences (temporally converse to predictable consequences) of those experiences. Natural selection is barred from setting up such a retrodictive memory by the nearly unlimited difficulties of retrodiction. We have no memories of the future because retrodiction is nearly impossible.

CAN WE ACT CAUSALLY UPON

THE PAST?	THE FUTURE?
No. To bring about a past event would require setting up a physical condition of which the past event was a retrodictable prequence. This cannot be accomplished locally since the precision required could be disrupted by influences as minute as gravitational perturbations from	Yes. To bring about a future event requires setting up a physical condition of which the future event is a predictable consequence. Coarse predictability renders it possible to accomplish this locally and approximately, yet to succeed.

distant cosmological objects.



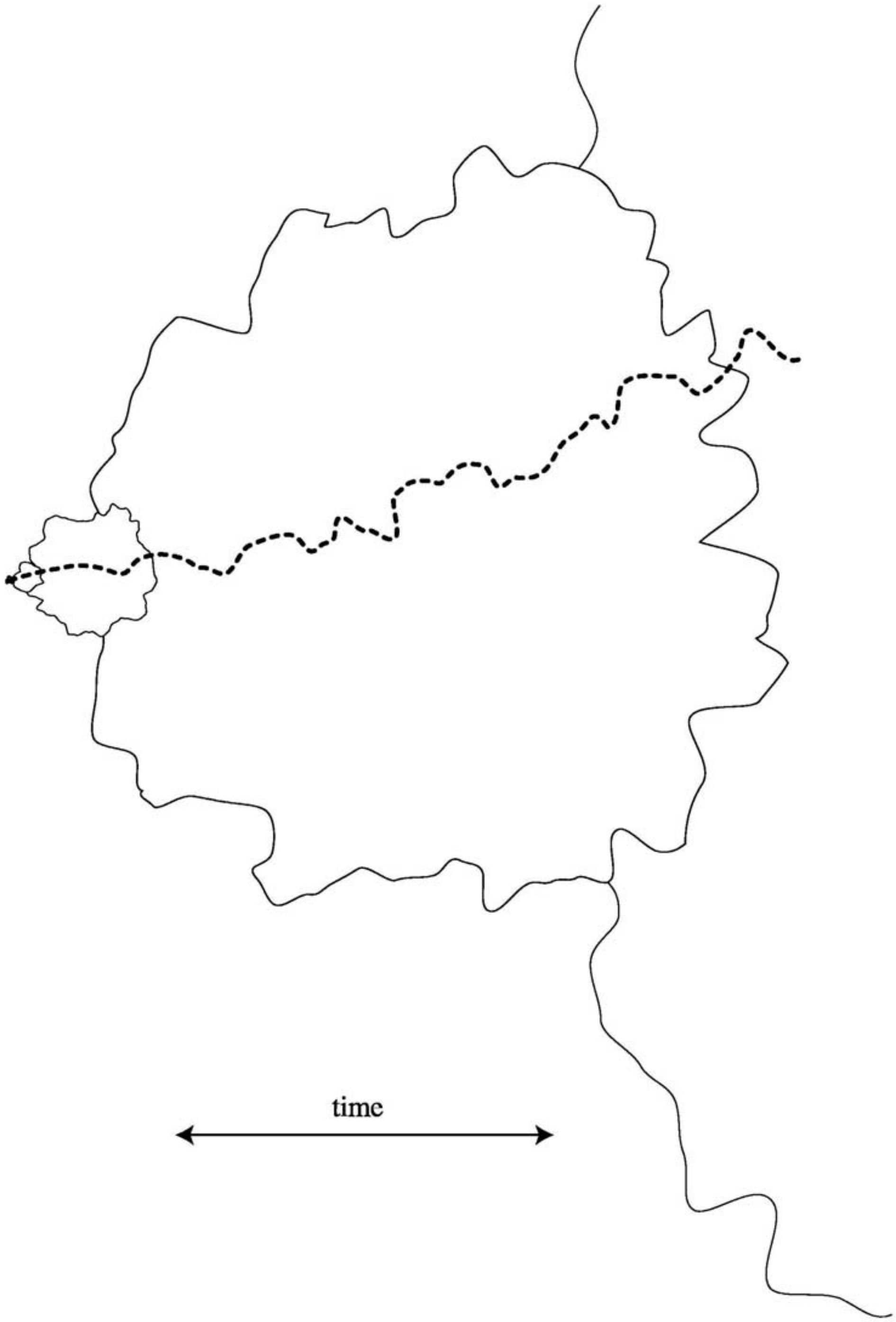
C is the condition of the rock's
being propelled toward the window

The part of P that goes to C represents the many ways the rock can come to be propelled toward the window. Only a small fraction of P can flow into the much smaller C; this reflects the fact that many subconditions of P have only a small probability of resulting in C.

The part of E that comes from C represents the possible effects of propelling the rock at the window.

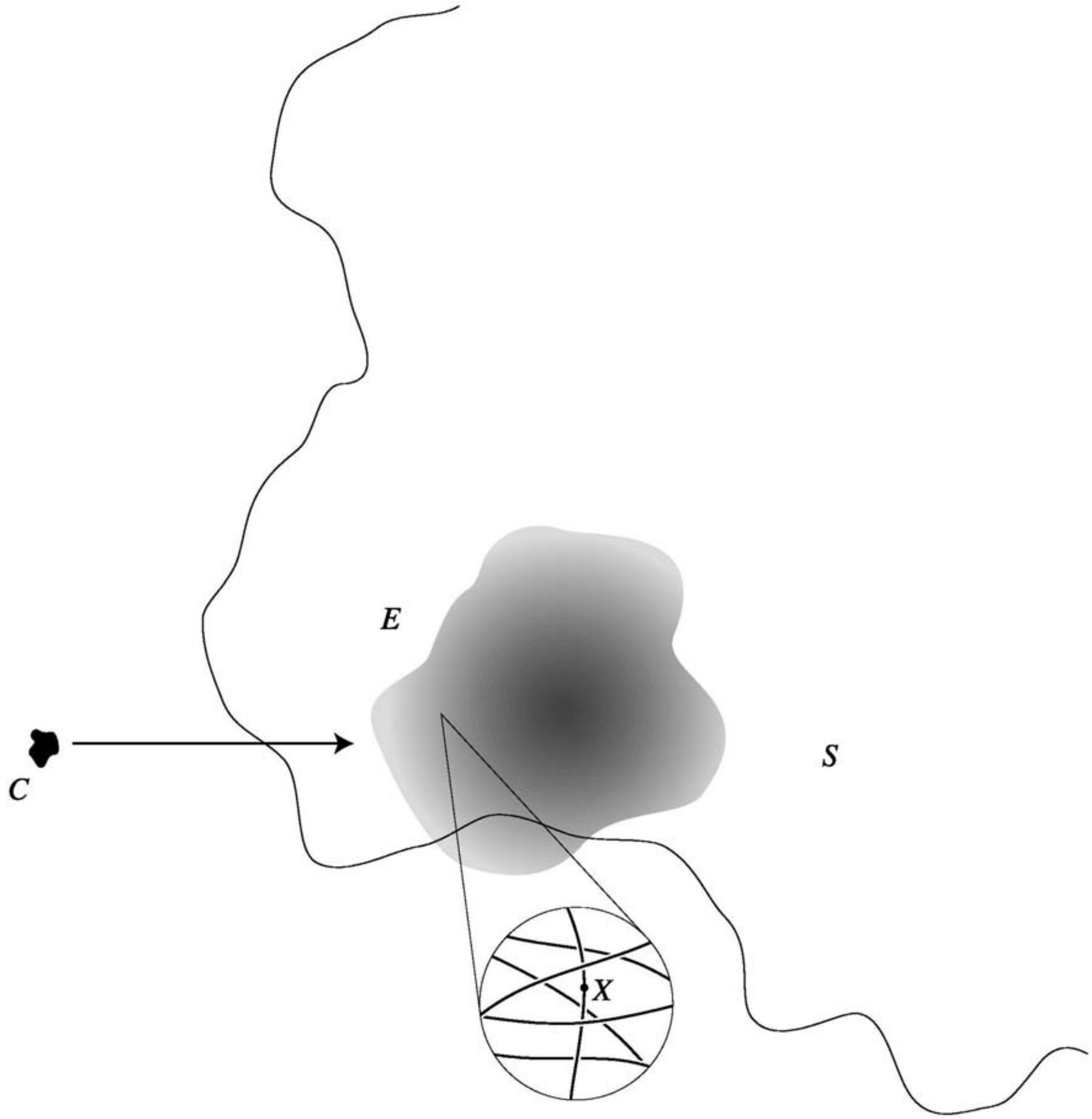
Expansion of condition C is time-symmetric.

fig. 1



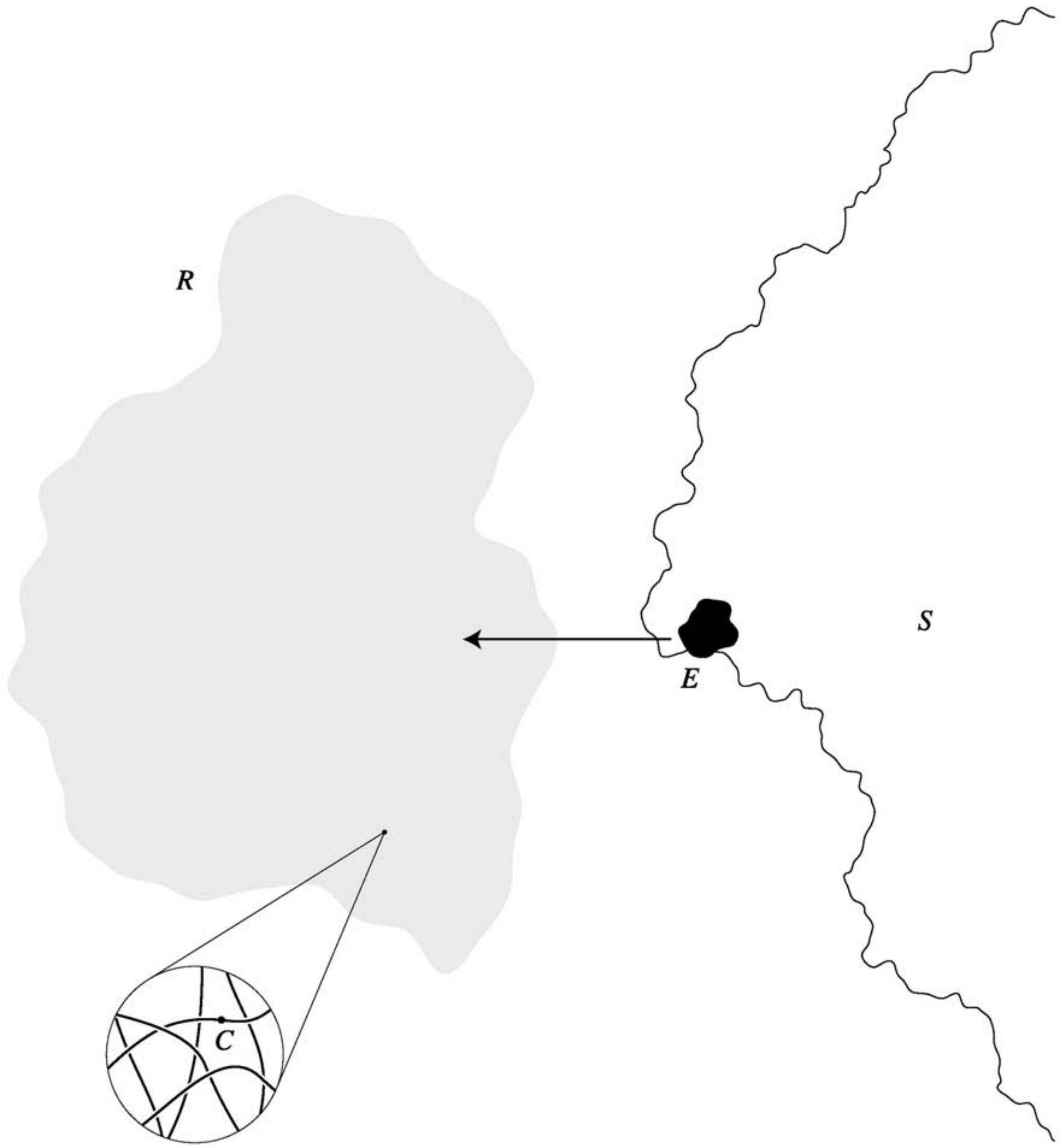
Expansion of the coarse-grained cells
surrounding the trajectory of a single
system is time asymmetric; in the
reverse direction there's contraction.

fig. 2



C is all ways the rock can fly at the window. E, the coarse-completion of $\vec{C}$, is the effects of C plus all situations indistinguishable from these effects. A subregion of E that lies in $\vec{C}$, such as X has to be exceedingly narrow.

fig. 3



R, the coarse completion of $\overleftarrow{E}$, is all situations that lead to E or are indistinguishable from situations that lead to E. C is a describable condition that leads to E and hence is an exceedingly narrow subregion of R that lies in $\overleftarrow{E}$.

fig. 4