Title: Time as Organization â€“ Downward Caustation, Structure and Complexity II

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Abstract:

The passage of time and emergent levels:

Top down and bottom up cascades

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June 28, 2016

Reference:
The Evolving Block Universe and the Meshing Together of Times:
arXiv:1407.7243

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Thesis

Both bottom up and top down causation link the arrows of time to the direction of time at different physical scales.

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Theme

Time exists in the real universe, not Minkowski spacetime (Smolin)

The hierarchy of structure and causation

The context in which this all occurs is the hierarchy of structure and causation.

Level 10:	Cosmology	Sociology/Economics/Politics
Level 9:	Astronomy	Psychology
Level 8:	Space science	Physiology
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Table 1: *The hierarchy of structure and causation for inanimate matter (left) and for life (right).*

Direction of time

Evolving Block Universe:

A block universe with dynamics governed by the General Relativity field equations but with a future boundary that is the ever-changing present. This future boundary changes as time passes (Broad, Muller).

Age of universe is proper time measured along Ricci eigenlines since start of universe

Continually increases with the passing of time

Planck Satellite in March, 2013 determined age of universe to be $T_0 = 13.82 \times 10^9$ years

N.B. not the age of galaxies in the Universe: age of Universe.

It is now $T_1 = T_0 + 4$ years old. Block universe is a little bigger than then.

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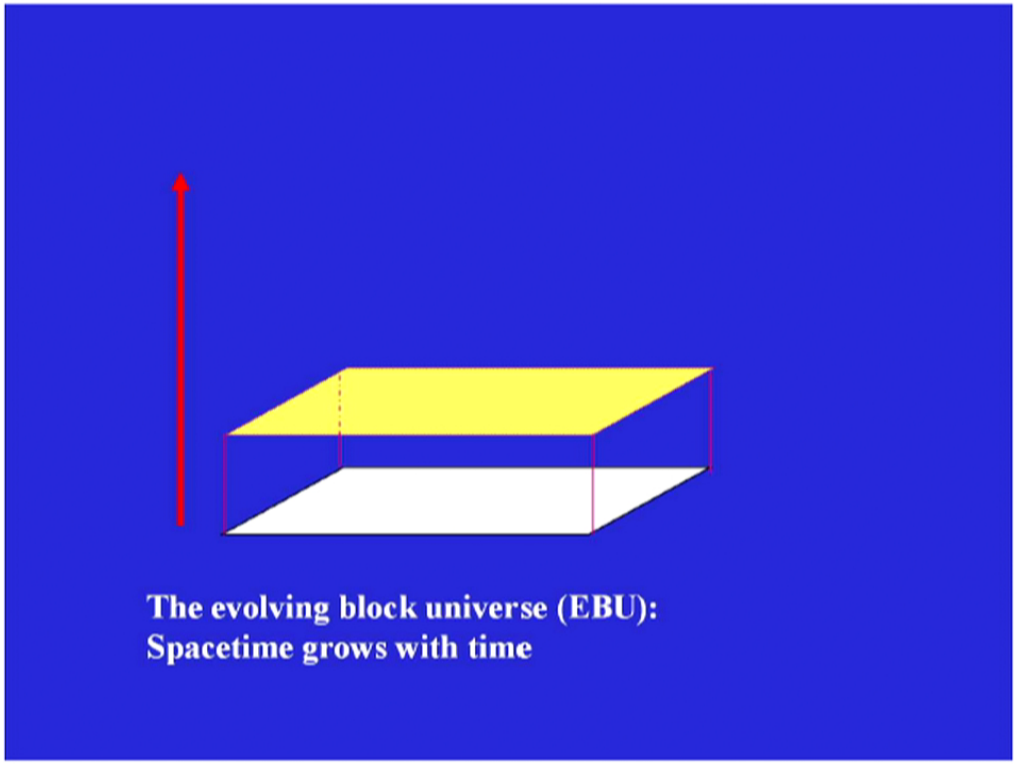
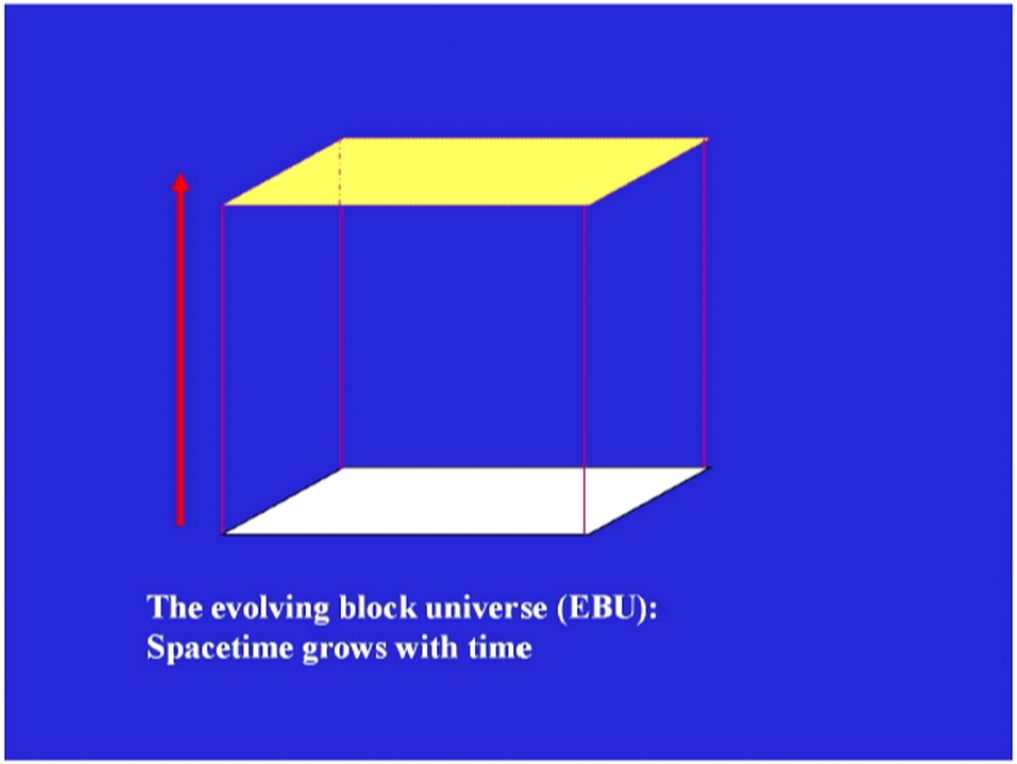
Evolving Block Universe



Evolving block universe: its future boundary is the present
Continually increases with the passing of time

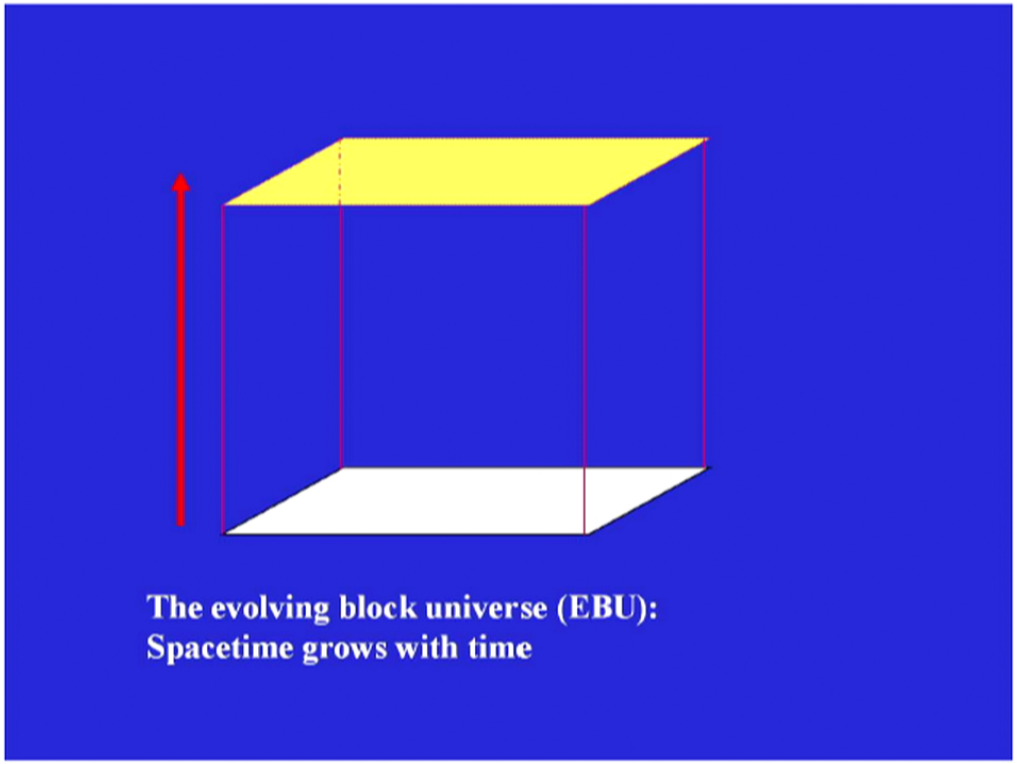
Direction of time



The evolving block universe (EBU):
Spacetime grows with time

Direction of time is direction in which spacetime is growing
Points from start of universe to the present, globally determined

Direction of time



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Direction of time

Direction of time is determined through initial conditions for the evolution of spacetime. Bottom up effect of local gravity everywhere in expanding universe determines its evolution as time passes.

Evolution equation is is the Friedmann equation (time symmetric)

$$\frac{\dot{a}^2 + kc^2}{a^2} = \frac{8\pi G\rho + \Lambda c^2}{3}$$

Gives standard outcome in radiation dominated early universe: ($k/a^2 \simeq 0$, $\Lambda \simeq 0$, $p \simeq \rho/3$), time t since start of universe,

$$a(t) = a_0 t^{1/2}, \ t > 0 \qquad (1)$$

Expansion, not contraction: universe getting larger with time

Time symmetry implies there is also a contracting solution: $a(t') = |t'|^{1/2}, t < 0$. Set $t' \to t$, get (1), as in observed universe. Initial condition for what is observed: $\lim_{t\to 0} da/dt > 0$.

Can order frames by increasing value of age of universe, direction of time points from from fixed edge to moving edge.

Issue

Why do local arrows of time agree with non-local direction of time?

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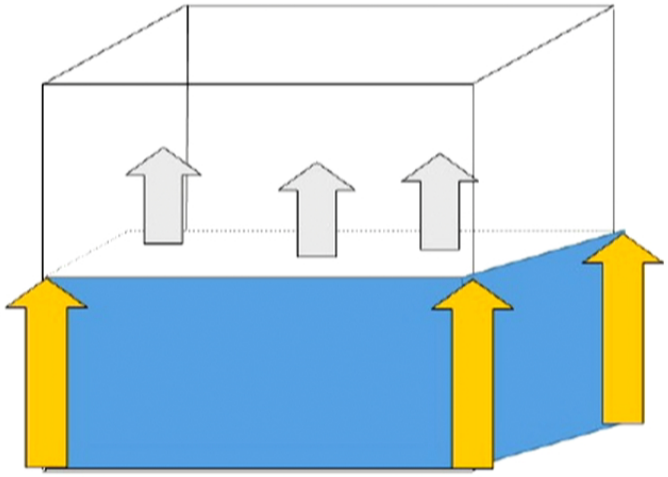

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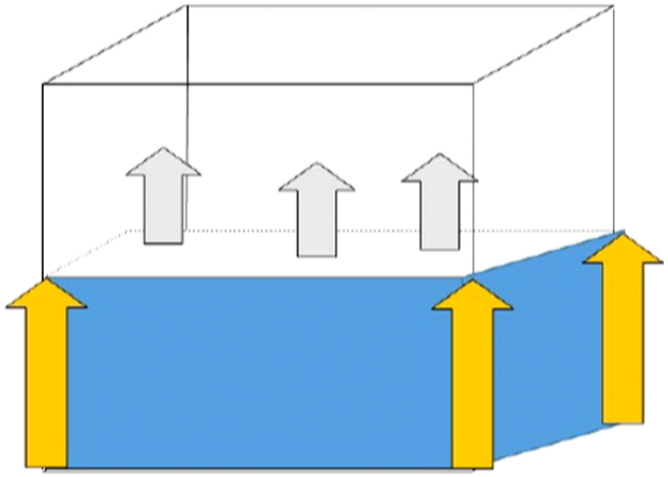

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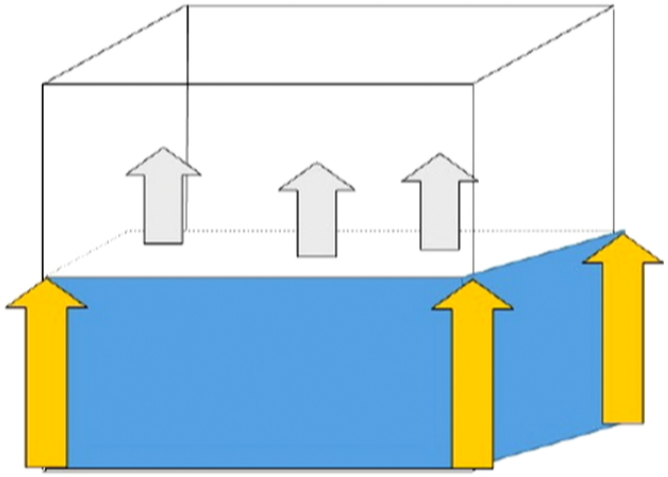

- Thermodynamic arrow of time (Albert)
- Electrodynamic arrow of time (Weinstein)
- Psychological arrows of time: memory, action (Albert)

Thermodynamic arrow of time

The thermodynamic arrow of time arrow aligns with the direction of time because of special initial conditions at the start of the universe:

A Past Hypothesis (Penrose, Albert, Carroll)

Entropy can't grow if it's already a maximmum We need a cosmological hypothesis that in the very distant past entropy was much lower. Hence universe must start off in a smoothish state in order that standard thermodynamics will apply in the forward direction of time and inflation will work as usually supposed (Penrose)

Appealing to this boundary condition at the start of the universe gives the 2nd law in future direction of time when we coarse grain because of overwhelming probability (Eddington, Penrose).

This is a top down effect from variables described at large scales to local physics (if it was not true everywhere 2nd law would not apply in the same way everywhere).

Thermodynamic arrow of time

The basic arrow of time (the thermodynamic 2nd law) spreads to local physics in a top down way from global initial conditions.

Example: Nucleosynthesis in the early universe : by (1),

$$T(t) = \frac{10^{10}K}{t_{sec}^{1/2}} \Rightarrow \langle v^2 \rangle = \frac{3}{m}\frac{1}{k_B T} = \frac{3}{m}\frac{1}{10^{10}k_B}\frac{a(t)}{a_0} \qquad (2)$$

(as time passes, universe gets larger and therefore gets cooler). This determines nuclear reaction rates and so H_e^4 fraction $Y_p \simeq 0.25$ which would not be explained if time ran the other way: depends on rate of decay of neutrons to protons after neutrinos freeze out and equilibrium ends

$$n \rightarrow p + \bar{e} + \nu_e$$

Top-down effect from macro variables (defined only at cosmological scale) to statistical effects of weak force and nuclear processes.

The hierarchy of structure and causation

In the natural sciences hierarchy (left), this is a top-down effect from variables at levels 9 and 10 to efefcts at levels 4 and 5.

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Electrodynamic arrow of time

Feynman and Wheeler (1945, 1949): time symmetric solution of equations

$$E_{\rm tot}(x,t) = \sum_n \frac{E_n^{\rm ret}(x,t) + E_n^{\rm adv}(x,t)}{2}. \qquad (3)$$

If the absorber relation

$$E_{\rm free}(x,t) = \sum_n \frac{E_n^{\rm ret}(x,t) - E_n^{\rm adv}(x,t)}{2} = 0$$

holds due to conditions in the far future, then

$$E_{\rm tot}(x,t) = \sum_n E_n^{\rm ret}(x,t).$$

The total field is retarded and causality is not violated.

EBU Electrodynamic arrow of time

In the EBU: the future does not exist yet, so we can't integrate Greens function over future, only over past. Electromagnetic field is

$$E_{\rm tot}(x,t) = \sum_n E_n^{\rm ret}(x,t).$$

– only past Green functions in integral solutions of Maxwell's equations

This will have terms due to

- electric charges
- initial field: incoming radiation.

If the latter is small (a Past Condition: no source free radiation coming in) then the field is determined by charges through the retarded Green's function - as is usual in local physics. Again a top-down effect from global conditions to local physics.

Emergence involves top down processes

Emergence of life occurs through Darwinian selection. This involves top down effects because selection is an adaptive process: the outcome is different if the environment is different.
At micro level, selection of

- Metabolic networks
- Gene regulatory networks
- Proteins
- Signal transduction networks

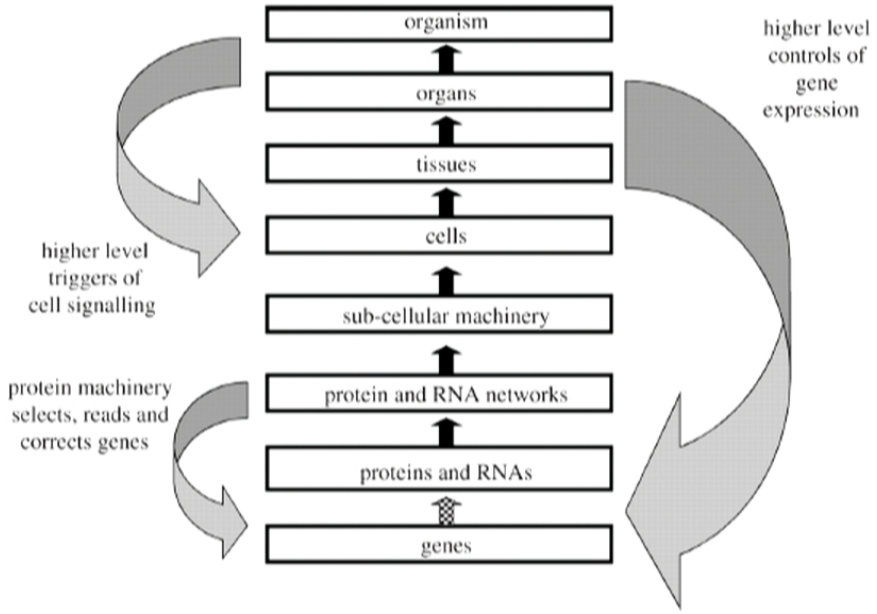
(Andreas Wagner: Arrival of the Fittest). At higher levels, selection of

- Physiological systems
- Individuals
- Social groups

In all cases selection of the outcome is environment dependent and involves an arrow of time (birth, growth and development, survival or death).

Emergence involves top down processes

These processes of biological emergence crucially involve epigenetic effects



Denis Noble: Interface Focus 2 (1), 55-64 (the heart).
Eric Kandel: In Search of Memory (brain and synapses)

Emergence arrow of time as a bottom up process

Although the emergence of complexity crucially involves top down as well as bottom up processes, the emergent arrow of time is determined in a bottom up way from the underlying microphyiscs

The thermodynamic and electromagnetic arrows determine the other local arrows in a bottom up way through processes of emergence:

- Biochemistry and molecular biology,
- Cell biology
- Brain: action potentials

These then give the evolutionary and psychological arrows of time

Note: the psychological arrow of time points in the direction of expansion of the universe, which is why we see the universe to be expanding.

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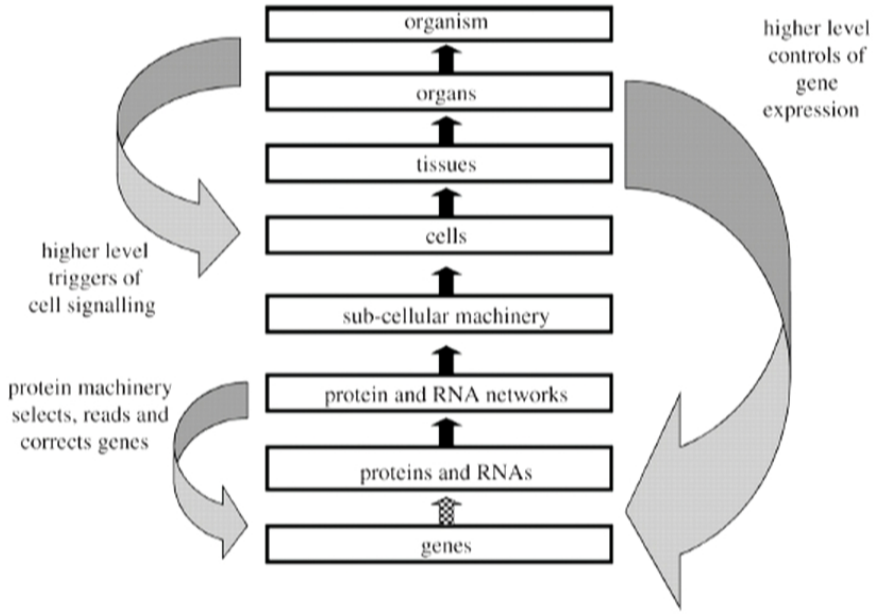

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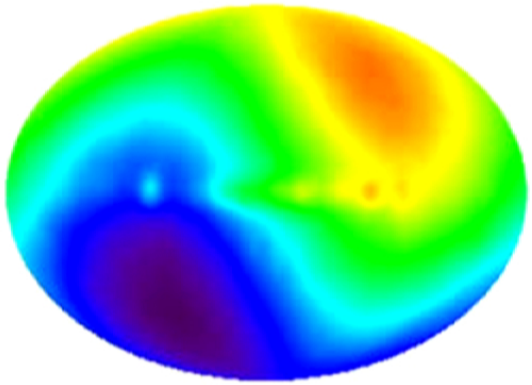
- ADM formalism can be used along Ricci eigenlines with a proper time parameter (arXiv:1208.2611)
- The real universe is not Lorentz invariant. The Local Group is moving at 627 ± 22 km/s relative to the cosmological reference frame defined by the universe. We don't live in a de Sitter universe.



Evidence: The cosmic dipole caused by our motion relative to the universe

Final Remarks

Need to add consideration of gravitational arrow of time and CPT issues.

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Overall Conclusion

Temporal passage is a fundamental feature of reality, not illusory. It is well described by an Evolving Block Universe, with a future boundary that changes with time (Broad, 1923).

See http://plato.stanford.edu/entries/broad/

"From molecular to modular cell biology"
L H Hartwell, J J Hopfield, S Leibler and A W Murray
Nature Vol 402 SUPP C47 (2 DECEMBER 1999)

"We argue here for the recognition of functional 'modules' as a critical level of biological organization. Modules are composed of many types of molecule. They have discrete functions that arise from interactions among their components (proteins, DNA, RNA and small molecules), but these functions cannot easily be predicted by studying the properties of the isolated components. We believe that general 'design principles' — profoundly shaped by the constraints of evolution — govern the structure and function of modules. Finally, the notion of function and functional properties separates biology from other natural sciences and links it to synthetic disciplines such as computer science and engineering."

Perimeter Institute; June 28, 2016

DOWNWARD CAUSATION: BEYOND REDUCTIONISM

BEYOND THE ANTHROPIC PRINCIPLE, AND PERHAPS MORE ARROWS OF TIME AND "PAST HYPOTHESES"

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1. THE CURRENT VIEW OF THE ANTHROPIC PRINCIPLE: THE TUNING OF CONSTANTS REQUIRES THE "WEAK" ANTHROPIC PRINCIPLE AND THE MULTIVUNIVERSE WITH RANDOM VALUES OF CONSTANTS, THEN WE THE LUCKY.

2. NON ISOTROPIC UNIVERSE ABOVE LEVEL OF ATOMS IN CHEMISTRY AND BIOSPHERE. MOST COMPLEX THINGS WILL NEVER EXIST. IS THIS NON ISOTROPY FROM LOW DIVERSITY TO HIGH DIVESITY ALSO AN ARROW OF TIME?

3. WHY DOES HEART EXIST IN UNIVERSE? HEART WAS/IS SELECTED TO PUMP BLOOD, NOT HEART SOUNDS, THUS ITS FUNCTION IS A SUBSET OF ITS CAUSAL CONSEQUENCES. PHYSICS CANNOT DISTINGUISH SUBSETS OF CAUSAL CONSEUQENCES SO WE CANNOT REDUCE BIOLOGY TO PHYSICS.

4. THE EOLUTION OF THE BIOSPHERE: NATURAL SELECTION CONSTITUTES DOWNWARD CAUSATION. THE MUTANT E. COLI IS SELECTED AS A WHOLE ORGANISM IN ITS WORLD AND “CARRIES ALONG” ITS BENEFICIAL MUTATIONS. THE MUTANT DNA IS NOT SELECTED AT THAT LEVEL.

5. WHAT DOES “FITTER” MEAN? E. COLI JUST “GET TO EXIST” IN BIOSPHERE FOR A PERIOD. SO DID T. REX.

6. THE BIOSPHERE AND ECONOSPHERE HAVE EXPLODED IN DIVERSITY, EXPLODING INTO THEIR “ADJACENT POSSIBLES”, IE. WHAT CAN HAPPEN OR ARISE NEXT. BOTH THE BIOSPHERE AND ECONOMY CREATE THEIR ADJACENT POSSIBLES INTO WHICH THEY “BECOME”.

7. THERE IS NO NEWTON –LIKE “ENTAILING LAW” FOR THE EVOLUTION OF THE BIOSPHERE OR GLOBAL ECONOMY. THE PHASE SPACES INCLUDING EVER NEW FUNCTIONS CHANGE UNPRESTATBLY. WE CAN WRITE NO LAWS IN DIFFERENTIAL FORM, NOR INTEGRATE THEM. WE DO NOT KNOW THE RELEVANT VARIABLES. STRONG REDUCTIONISM FAILS BECAUSE THE BIOPSHERE AND ECONOMY ARE PARTS OF THE UNIVERSE.

8. EVOLUTION OF BIOSPHERE AND ECONOMY SEEM AN ARROW OF TIME. EG FOSSIL RECORD IS REAL, DIVERSITY EXPL0DED. IS THIS A “PAST HYPOTHESIS”? BUT UNLIKE STATISTICAL MECHANICS, WE CANNOT PRESTATE THE PHASE SPACES!

9. ON ANALOGY WITH THE ABOVE, WE ARE “NOT FORCED” TO ACCEPT THE ANTHROPIC PRINCIPLE. THE LAWS AND CONSTNTS CAN EVOLVE.