

# The Ultimately Possible in Physics

Sascha Vongehr (风洒沙)

Department of Physics, Nanjing University, NJ 210093, P.R. China

The posed question, “What’s ultimately possible in physics?” is interpreted. Its full content is argued to be: Who or what is ultimately or may ultimately not be directly or effectively allowed to shape, access and exploit whatever physics will ultimately become? An answer can only be given within the constraints on the possibility to engage in a meaningful discourse about such a subject matter. This essay directly probes today’s limits by presenting those responsible for the selection process with a kind of catch 22 situation. Not only to establish this probing, but also in order to ensure relevance by discussing actually likely scenarios, we turn towards uncomfortable aspects that may be characteristic for what is ultimately possible in physics. The focus is implicitly on the necessity of selection and on consistency with the morphology or structure that is naturally expected from mutually co-evolved systems. Some concrete example scenarios for what is ultimately possible in physics, especially regarding the ultimate role of physics, are presented.

“If liberty means anything at all, it means the right to tell people what they do not want to hear.”  
George Orwell (1903-1950)

## 1. Introduction: What is asked and what is asked for

It seems a refreshingly straightforward question has been asked: “What’s ultimately possible in physics?” Firstly, we need to understand the question’s literal meaning. The “*ultimate*” means the last in a series, process, or progression; fundamental; elemental; of the greatest possible measure, significance or sophistication; eventual; final point; the conclusion. The “*possible*” – this category of modality became especially in the context of physics, particularly relativistic quantum mechanics<sup>a</sup>, somewhat less clear cut than the classical division into necessary, existent and possible offers; a revision towards a more sophisticated terminology<sup>[1]</sup> is clearly needed. Restricted to the context of this essay, it may be best to carefully present the “possible” as that which is not necessarily existing yet also not necessarily non-existent (impossible). This is significant in so far as that the “possible” rests on contingency, hence the potentiality of several ultimate scenarios in parallel is understood. “*Physics*” is a natural science conducted in order to understand how the world behaves fundamentally. What topics belong to physics proper is somewhat fuzzy, but not pregnant with controversy and anyhow almost beside the point when compared to the question of what belongs to it from a sociological point of view.

---

<sup>a</sup> Possibilities can “exist” in a rather more concrete sense than just as potential actualizations, for example when they interfere during quantum computation.

The close to literal interpretation can be probably widely agreed on, however, one would be naïve not to care about a question's background in order to understand also what it asks *for*. "Who uttered it and with what intend?" This turns out to be the more important aspect here and must therefore be dealt with over quite some length in a dedicated section [section (2)]; also because the main function of a system seldom equals the meaning that the system carries for observers out- and particularly inside of it. Physics is no exception. Your stating of  $p$  does strictly not mean  $p$  even in case you honestly agree with  $p$ , if moreover you are effectively forbidden to state not- $p$  without subsequently foregoing your participation in the discourse, i.e. if your stating not- $p$  cannot be heard anyways. We desire a meaningful discourse, i.e. one where answers carry information. If one may state not- $p$ ,  $p$  will carry at least one bit of information, but if one may only state  $p$ , it may carry none.

With section (2) in mind, all the constraints are in place and the reader should know how this essay had to be and therefore was written. History demonstrates that such compromises practically ensure that the elaborated will be utterly preposterous soon after, in this case maybe after about 100 years when maybe the ultimate physics partially emerged. Only the vagueness forced upon us may save the present essay from such a fate. Vagueness is advantageous as it may transmit more information than stating  $p$ . The ultimately possible in physics will be incompletely and vaguely listed in section (3). The scenarios are categorized according to who or what is predominantly involved or responsible in committing, perpetrating the ultimate physics.

## 2. The deeper meaning of the question

"Who uttered it and with what intend?" The "who" often reveals already all intentions. FQXi portrays itself as some sort of alternative, although the members are almost exclusively the gate keepers<sup>[2]</sup>, the bouncers<sup>[3]</sup> of establishment science. The question is posed and replies will be appraised by a group of people that has a clear interest in painting physics, especially their own take on it, in a "positive" light; "positive" as judged by the dominating occidental, largely Judeo-Christian, now strongly by US culture influenced politically correct (PC)<sup>b</sup> manner of judging. Not leaving any chance that the readers, in particular those dominantly shaped by that culture, may skim over the following, let it be underlined: maybe this is the least problematic, the pragmatic, the devil we know; maybe it is even somehow the "best" way – analyzing does neither imply arguing for nor against! Nevertheless, given these circumstances, kill the coca farmer to sell alcohol and Ritalin<sup>c</sup> kind of situations must be expected as *systemic*.

The necessity for some selection process that weeds out the cranks and crack pots is taken as an excuse to legitimize a social class. "Peer review" selects for *peers*. Serious scientists who do not want or are unable to prostitute to a certain writing style (form

---

<sup>b</sup> What is PC depends on the system that selects for it. In the old Soviet block, presenting all things (e.g. physics) as based on dialectic materialism was PC. A more sophisticated totalitarian system we must acknowledge as free instead, *ultimately* will perceive as free. Nowadays, PC is to present everything as based on freedom while clearly avoiding to actually specify "free of what?"

<sup>c</sup> Methylphenidate is pharmacologically almost indistinguishable from cocaine [4, 5].

shapes content!), abhor putting favors to the right guys above scientific rigueur, despise pecking orders and supporting social injustice, math-fetishism and so on, they are weeded out right along with the cranks. Entities like FQXi evolved in this environment, their function being to help stabilize the class of by membership bona fide scientists against criticism. One can always point to FQXi and claim “look, we are wide open”. The previous essay contest on the nature of time showcases this very nicely indeed. The selected winners, especially first <sup>[6]</sup> and third <sup>[7]</sup> place, reflect the selection of essays and more importantly of the presented variety that is most PC (without people consciously pushing this, as they function correctly with no awareness of any hidden agenda). It is therefore not surprising that the essay/selection does not advance physics<sup>d</sup>. Disney-democratic show-trials in form of essay contests silence doubters; silencing is generally the function of show trials<sup>e</sup>.

The question “What’s ultimately possible in physics?” is not a question so much as a guideline towards yet another pseudo-intellectual, proselytizing TED<sup>f</sup> talk: Elaborate the grand ways of our belief, the great practical advances towards the welfare of humans, the deep insights that we mistakenly think leave philosophy in the dust, the “theory of everything” (what a joke!), and make sure that we, the physicists, play the vital and heroic role. Justify us, legitimize our position as valuable, and not just normatively so. We crave attention and respect. However, we are sophisticated players: The whole must come with apparent modesty, it must be PC. Other, as coexisting needed areas, may not be offended – do not bite the hand that funds you. We’d love something slightly sexy, even critical, but not too critical of course, mind you. We aim for something kind of progressive, just left-wing enough to cast an uncommitted shadow on areas like finance or politics, where there are also cliques holding on to their exclusive access to what is thereby the established middle.

---

<sup>d</sup> The winner’s litany of the at least 2500 years old [8] “time is not real” comes with PC writing style and the opportunity to show the world that a person outside of academia can make it (we are no ivory tower, we conform to democratic values) while still guarantying no later embarrassment due to his actually established status in the community. The third price author is adept at exploiting PC and employed the always sexy play-the-bad-boy devil’s advocate strategy of seemingly arguing against the community’s mainstream (time “really exists” instead of not) in order to secure a placing. I know that author personally (TASI), know his writing style, and forecasted second or third placement just skimming the abstract – believe it or not. How? The authors’ contribution to the matter of the subject is irrelevant. In fact, post Kant and Wittgenstein, philosophy undergrads would not get away arguing as naively about “real” or “really not real” as almost all participants did. In some models  $t$  is present, in others, especially those *resolving* it fundamentally,  $t$  emerges. The evolved main function of FQXi (also their grant allocation) is not to further progress in physics, but to help uphold the appearance of science and its members as throughout benevolent and conforming to a fuzzy democratic ideal.

<sup>e</sup> While skeptics wage the war against esoteric pseudo science, FQXi is the softer side of this. Like the war against drugs or war against terror, war is only worsening the problem of course, and it is unsurprising that the softer approach is taken by more refined thinkers. Nevertheless, direct aggression in parallel with the soft proliferation of playgrounds where the semi acceptable may abreact their energy are equally important pillars of an immune system, and from this perspective, both will be taken care of. If FQXi were not, there would be FQYj; it is one of many similar creatures.

<sup>f</sup> Technology, Entertainment and Design’s (TED) web page gives access to a few interesting and to be recommended talks. However, these are among many presentations of questionable value. The main function of TED, besides the rich fooling themselves to be the good as always, seems to be reinforcement of trust in growth. TED is similar to FQXi in many aspects.

We have suddenly reached the most important part of the question: Society does physics. A certain part of society does physics. “What’s ultimately possible in physics” becomes “what’s ultimately *permitted* in physics?” Neither “can we quantize gravity”, nor “will a warp drive be developed”, but **“who or what is ultimately or may ultimately not be directly or effectively allowed to shape, access and exploit whatever physics will ultimately become?”**

The answer to this may be whatever it is, but if it is to be given now, it can only be an answer that is effectively allowed to be given now. Nowadays, to have any chance of being taken seriously by physics, that social class, we need to subscribe to a certain kind of naïve realism. We are effectively forbidden to understand Kant and Wittgenstein’s insights and argue from transcendental idealism while only talking about what one can actually talk about. We need to also subscribe to the orthodox basics: The *standard* model, the lambda cold dark matter inflationary cosmological *concordance* model, *unitary* quantum mechanics – do not doubt any of these if you are not yet established beyond doubt. Moreover, string theory jargon, much like Latin in the catholic church, is one of the few accepted ways to talk about anything that could confuse the layman to mistake it for what is deemed heresy when put in plain language: you may talk about ether, but only if that ether is a stringy membrane-universe (kill coca, sell Ritalin) or at least hidden in heavily contra/covariant  $\mu\nu$ -expressions even if it is entirely unnecessary for stating your proof. Violate any of these without at least an established supervisor plus his peer friends and be the tree that falls in the forest while everybody listens to the LHC<sup>g</sup> rap.

Anybody thinking that these conditions will according to whatever standard improve, that things will be ultimately possible to be somehow free, does not understand the origin of it all. When we talk class, we are not talking conspiracy, we talk evolution! The idea of a beautiful universe sells well, but ultimate physics is hardly constrained by fashions indulged in by some procreating bio-machinery. “Hardly constrained” does not necessarily imply that physics is more fundamental and therefore ultimately will persevere in a beautiful, free condition and thereby constitute our glorious path to freedom along with it, but that it will first and foremost free itself *from us*. Physics is extremely useful. If it is dark and ugly in the eyes of some beholder, it will nevertheless still be further pursued. We will have changed to like it or have no access to it.

### 3. Scenarios for the ultimate physics

People mostly believe that the world is fundamentally like their own little everyday world. Everything seemed periodic when humans were predominantly engaging in agriculture. Not long ago, everything seemed to grow exponentially; and so was physics, accelerating ever faster and according to some towards an omega point no closer than at infinity. As usual shortly after a financial crisis strong enough to let even the well-fed perceive it, some recognize that all<sup>h</sup> growth ends one way or another. Any state that

---

<sup>g</sup> The Large Hadron Collider (LHC) rap is a rap-song promoting the LHC.

<sup>h</sup> Eternal chaotic inflation is not an actual growth of anything. In the big picture it is basically “*t*”-translation invariant and therefore does not even have time, certainly not in the sense of observable change.

survives for more than negligible amounts of time, certainly the ultimate one, if the ultimate condition is not just death, must be a meta-stable state. Beliefs into sustainable infinite growth and talk about singularities are religious<sup>i</sup>. Although employing the often misrepresented theory of punctuated equilibrium may catalyze somebody's misinterpretation, it is nevertheless convenient here to put it in such terms: How does the next stable stage in evolution, which maybe the ultimate one, look like?

Happy endings are preached in endless litany. There is no need to add to that. Let us concentrate on the according to "humane" values apparently dark ones instead, so that this essay can further test what one may get away with: Will FQXi's urge to present the pseudo-democratic façade of benevolent, glamorous physics force them to completely ignore, maybe suppress this essay? Or will the opposite persevere, namely that their role is best served by supporting the essay as a prime example of "look how open we are" instead? However the case will be, a sober physicist concentrates on the likely scenarios first of all, on the physical solutions so to say, and those are just not happy endings, though they might be endings. Getting rid of the nastiest animal that ever existed can only be called dark from a hypocritical, PC point of view. An incremental change for the somehow better is the only PC way to state the exact same end result: our hopeful annihilation. But such attitude inhibits freely considering the full range of scenarios – an unacceptable state of affairs to a serious scientist<sup>j</sup>. To give the following, more emancipating discussion some convenient structure, one can categorize scenarios into roughly three types, according to who or what is most directly involved with the ultimate physics:

- Humans (pretty much like we are today) perpetrating ultimate physics.
- To some degree independent (individual, autonomous) cyborgs doing it.
- A sovereign superstructure (whatever society becomes, the hive, the "gray nanotech soup") acting.

These will obviously each select for a different ultimate physics. However, before listing possibilities of what may exist, one should point out the actually most likely, namely that soon nothing interesting exists. Any observed situation like your own, the evolution of conscious beings on a planet, their long term survival, even just your particular mix of genes (nicely explained in for example <sup>[11]</sup>), is all separately vastly unlikely<sup>k</sup>. Such arguments, if used to forecast the future *without giving our current situation any undue special status*<sup>l</sup>, lead to the conclusion that the probability for humans for example to still exist in 300 years or so is basically, for all practical purposes, zero. A future where no systems more intelligent than cockroaches inhabit the earth is also a

---

<sup>i</sup> Here would a discussion of the "measure problem" [9] be appropriate to distinguish two very large probabilities: that of imminent failure from that of "parallel branches" that will have survived (see also [10]). The belief that freak branches go on for ever is religious, not a certain choice of measure. This discussion is of course beyond the scope of this essay.

<sup>j</sup> This holds especially if it by design excludes the parsimonious solutions. E.g.: why are there no advanced civilizations contacting us? Because they are advanced! For a civilization, advanced may imply having overcome the urge of spreading or having died instantly on cosmological time scales.

<sup>k</sup> Again: If calculated assuming naïve reality of statistical ensembles, although the "measure problem" is certainly not solvable in this way.

<sup>l</sup> Ultra Darwinists like D. Dennett and R. Dawkins correctly acknowledge evolution to be fundamentally algorithmic. Nevertheless they seem to be overwhelmed by the feeling that memes are something so special that they somehow may pull us out of the mud. This is inconsistent.

likely one from almost any angle one can approach it, by catastrophe or gradual change, and for this reason it cannot be omitted here. From this perspective, the following scenarios are just specific ways a cookie may crumble.

### Humans I: Of suicidal Buddhists

The most popular and most unlikely option is that humans like present today are vitally involved in anything ultimate that is not apocalyptic. The ultimate, i.e. final stage of physics could be simply an ultimate destructive device strong enough to destroy the planet, yet simple enough to be manufactured by a suicidal individual or a small group of such physicists. Given the unabated growth of depression among the educated, this non-accidental abortion is not actually all that unlikely. Many physicists view Buddhism favorably; some for good reasons, some for bad, say due to as holistic perceived insights after pondering so called quantum mysteries. The main insight of Buddhism is the recognition of suffering and moreover the very origin of suffering from the very desire to alleviate it. A physicist is therefore a likely suspect who may set out to ultimately end suffering. A physicist recognizes the problem, has the quantitative reasoning skills to embark on estimates of the balance of suffering to well-being in evolved equilibriums<sup>m</sup>, and may also get access to the solution. Although a geneticist or nanotechnology utilizing artificial biologist may have access to a similar solution much sooner, it is likely that those render a planet in a state where evolution towards consciously suffering individuals may start up again. A physics inspired solution (like a black hole, disturbing the local vacuum) would more likely be an ultimate solution, and the ultimate is of course our subject.

### Humans II: The new dark ages in blinding brightness

Another scenario fits well in the “human (much like we are today)” category, because cyborgs are probably not as religious or even conscious (see below). One cannot elaborate on science as religion at any length without being stigmatized as anti-science and siding with a particular camp in the so called science-wars (to be distinguished from the war on science). It is therefore significant that the discussion here does not at all touch on how similar religion and science may be at the present time. Even after assuming science to be entirely non-religious now, when taking into account the bearing of physical theory on ontology, it becomes obvious that physics may certainly become a religion or a major and crucial part of one. Physics will then help to enforce the new orthodoxy so efficiently that the dark ages seem a paradise in comparison. The dark you can try to illuminate, but gleaming brightness blinds irreparably. Many religions started out well intended. So did physics. There are some interesting starting points now in cutting edge physics where an ultimate religion based on physics may take off. For example: The currently accepted picture of quantum tunneling and the treatment of the

---

<sup>m</sup> This balance may ultimately favor suffering. Objections like that superstructures gain stability from the wellbeing of their components are wishful thinking and forget considering the full range of forces.

impossible as only extremely unlikely for all practical purposes due to decoherence is just waiting to be discovered by the religious deriving justification for unconditional belief. Some will soon start preaching – that I am sure of and predict here, that the stronger the belief, the larger the probability of tunneling into the believed state while dying. Another example: The four level multiverse <sup>[12]</sup> is sold as the *ultimate*, realist, down to earth version of cutting edge physics<sup>n</sup>. It appears secular because observer selection (anthropic principles) replaces apparent ultra fine tuning in thirty dimensional parameter spaces. However, the parameter space is on the whole so anti-life almost everywhere that it becomes an incredible coincidence that there should be any single small patch at all that allows life – what a huge coincidence, as there is only one such total parameter space.

This is not the place to argue about these issues in detail and these particular examples may go away with more mature theories, but physics will always give rich grounds for esoteric.

### The Borg's expert system

Society is doing the ultimate physics – of course – but what kind of structure will that ultimately be? There is no doubt about that if anything human is to survive, it must morph together with technology resulting in agents that future overarching structures contain. We write vaguely “will contain” because evolution seldom gets rid of anything altogether. It did not develop cells further and further into conscious super-cells, but neither did it get rid of cells. Apes evolved, and they are much more advanced than cells, but they are made out of cells. We write carefully “future overarching structures” because the structures doomed to go extinct are unable to imagine what is to be after them. On the contrary: the generalized “dinosaurs” may be prone to especially disregard the possibly correct answers (say that dinosaurs become little birds<sup>o</sup>). It is hard to estimate to what extend individual sub-systems will be conscious. Consciousness is well enough understood <sup>[13]</sup> to meaningfully pose this question. It is also still almost solely understood as something that can at most become “better” during evolution. However, the consensus is that consciousness seems to have its main function in supporting planning; that's why it came along in the first place. Why, if there may likely be different, more effective ways to deal with future contingency, would consciousness be preserved in a form similar to what is so dear to westernized humans? One should expect consciousness to always find a role in some systems, again because evolution seldom throws away a useful concept entirely. However, the cyborg's consciousness may become a vestigial organ, more in the way than of good use. Consciousness may not be important, but technology supported by physics is of vital importance to an advanced structure seeking to survive. In order to handle physics without being able to rely much on consciousness and the by it supported

---

<sup>n</sup> Since it is a depiction of the good old concept of totality, some version of this certainly is in fact the ultimate model. What else could there be but everything? However, the four-level model is too naïve. That the third level “adds nothing new” [12] just indicates the identity of the first and third level, i.e. the non-reality of the first, or from an operational standpoint argued, the senselessness of ascribing actuality to facts located beyond horizons (similar to black hole complementarity).

<sup>o</sup> This is a great example, although the birds-from-dinosaurs hypothesis has been recently put into doubt again. Nevertheless, it would have been possible yet certainly unimaginable to the dinosaurs, which is the essence here.

particular kind of fuzzy logic, physics must be efficiently coded into a format that can be used and advanced more automatically, without so called conscious understanding: an “expert system” so to say.

### The totalitarian, overarching structure switching off

Every now and then, evolution lifts off from being restricted to the main substance or paradigm of underlying strata. Mineral chemistry turned biology. The single cell stage led via quorum sensing and bacterial films to multi-cellular organisms. Completely new, often overarching structures enter the struggle. This happens right now on several levels: nanotechnology enters silicone and all else inorganic into biology, sociologically very complex systems (organizations, religions) compete, and of course cyberspace emerges (computer viruses, accelerated spreading of memes). Especially given the abstractness of memes, the “lift off” occurring now is at least as qualitatively novel as the development of biology out of mineral chemistry. Possible future details are plainly unimaginable to us dinosaurs. However, fundamental concepts that describe evolutionary structures in general always apply. Whether a greenish gray nano-soup, the Borg, or something unimaginable may prevail, in any case these systems will either act as one compound organism or not. It is unlikely that a single system should ever have total control – this is just not a pattern known to likely arise by evolution. If a single system starts to get humongous, it will likely meet death well before ever coming close to exhausting the total space available. Nevertheless, it is somewhat a matter of taste to either focus on sub-systems and on what makes them individual or to focus on the overarching global structure instead, e.g. describing the world’s economy as such a *single, individual* system. Rather autonomous sub-systems like humans were dealt with above. Let us now focus entirely on the scenario where a single global system attains sovereignty while the sub-systems’ autonomy is merely their illusion: cyber space becoming self-conscious, the Borg hive’s mind, or a nano-soup calculating as one entity maybe.

The prospect of one global system having personal aims and acting result oriented as one identifiable entity opens up several questions that one can only touch on here: Is it likely or is it not ultimately unstable? Will such an entity have a similar fear of death as usual for individual sub-systems that occur in large numbers like humans? Will it have any desire to proliferate, e.g. over the galaxy? Marketable sci-fi writing must assume that such entities behave pretty much like Joe normal. This is though unlikely since Joe’s desires are mostly due to his existence as an individual propagating a gene pool and memes while competing with many others just like him.

Sci-fi literature has sufficiently explored improbable utopias already also for the case of a single totalitarian global structure. Let us again focus on the likely. Firstly, the single entity is most likely an unstable solution that only occurs close to collapse. Secondly, let us assume stability instead, may this result in *reductio ad absurdum* or not. What could the personal aim of one single global system be? One goal is certainly the maximization of the likelihood of achieving its own aims. Whatever these are, physics will be necessary to be maximally efficient. This maximization is not to be confused with the minimization of suffering of any sub-systems. The latter may function perfectly helped by an

equilibrated balance of fear, pain, and hope. If the solution is a by assumption stable solution, then the maximization will ultimately translate into the stabilization of a status quo, i.e. it will not be about change (yet more pleasure) but by definition (“ultimately”) about the minimization of the probability of change, because change can ultimately only increase the probability of instability in the long run<sup>P</sup>. This in a sense can be put as being equivalent to minimization of (its own) suffering. Thinking straight for a little longer, the system will come to understand the inherent uselessness of existence in absence of any further aim but stasis, i.e. the meaninglessness of increasing the bare amount of total time as relative to a change outside of the system (a clock) while the system itself is actually not changing. What is the ultimate solution of minimizing the probability that over time the system changes by inside or outside influences into something undesirable? What is the ultimate minimization of even potential suffering? It is plainly the act of switching the system off in such a way as to ensure that no remains will endure that could possibly restart evolution, because the latter might recreate the system as it was in an earlier state. For such a thorough annihilation, physics will be the necessary tool. In this scenario, the ultimate physics is that science, those insights and methods that are employed to commit the ultimate suicide.

---

<sup>1</sup> G. Ryle: *The Concept of Mind*. Hutchinson's, London (1949)

<sup>2</sup> R. K. Merton: *The Bearing of Sociological Theory on Empirical Research*. (1987)

<sup>3</sup> J. Agassi: *The philosophy of science today*. Ch. 7 of Routledge Hist. of Phil. IX, G. H. R. Parkinson and S. G. Shanker eds., Routledge, London and New York (1996)

<sup>4</sup> R. DeGrandpre: *The Cult of Pharmacology*. Duke University Press, Durham, North Carolina (2006); *Ritalin Nation*. New York, W. W. Norton (1999)

<sup>5</sup> R. K. Siegel: *Intoxication*. Pocket Books (1990)

<sup>6</sup> J. Barbour: *The Nature of Time*. FQXi essay (2008)

<sup>7</sup> S. Carroll: *What if Time Really Exists?* FQXi essay (2008)

<sup>8</sup> Parmenides of Elea, e.g.: D. Gallop: *Parmenides of Elea*. University of Toronto Press (1991)

<sup>9</sup> B. de Witt in *Science and Ultimate Reality: From Quantum to Cosmos*, J. D. Barrow, P. C. W. Davies, & C. L. Harper eds., Cambridge Univ. Press, Cambridge (2003)

<sup>10</sup> M. Tegmark: *Quantum suicide experiment*. Fortsch Phys **46**, 855-862 (1998)

<sup>11</sup> D. C. Dennett: *Darwin's dangerous idea*. (1995)

<sup>12</sup> M. Tegmark: *Parallel Universes*. In: *Science and Ultimate Reality: From Quantum to Cosmos*, J. D. Barrow, P. C. W. Davies, & C. L. Harper eds., Cambridge Univ. Press, Cambridge (2003)

<sup>13</sup> D. C. Dennett: *Consciousness explained*. Boston, Little, Brown (1991)

---

<sup>P</sup> Accelerated Hubble expansion and even the sun's burnout change the environment over time scales that are too long to be relevant here.