<u>Why are the laws of physics the way they are?</u> [1]

Stephen Ames[2]

1 Introduction

There are various scientific approaches to answering this question. For example, arguing *to* the laws from something physically more fundamental. String theory is pursuing that kind of argument. Based on the mathematics of David Finklestein, S.A. Selesnick[3] pursues our question in the following form, 'where does physics get its Lagrangians?' On the other hand V.J. Stenger[4], previously Professor of astronomy and physics at the University of Hawaii, provides a scientific answer to the question, 'where do the laws of physics come from?' Remarkably, his elegant and mathematically detailed derivation of the laws is driven by the requirement that the models physicist develop to describe objective reality cannot depend on the standpoint of the observer. At the end I will comment on Stenger's work, partly because of its relevance and partly because we espouse completely different metaphysical views.

I want to be clear at the start that I assume theoretical physics will achieve a satisfactory explanation of how our universe comes to be operating according to the laws of fundamental physics from the earliest moment after the big-bang.

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1 This paper is an extended version of the paper I will present at the conference on 5th July 09.

2 From the History and Philosophy of Science Programme, The University of Melbourne.

3 Selesnick, S.A., *Quanta, Logic and Spacetime*, (World Scientific, New Jersey, second ed., 2003)

4 Stenger, V.J., *The Comprehensible Cosmos, Where Do The Laws of Physics Come From?*, (Prometheus Books, 2006)

In this paper I will outline the argument for the following purposive answer to our question. *Why are the laws of physics the way they are? In order that the universe be knowable through empirical inquiry by embodied rational agents.*

Given my starting assumption, you should reasonably expect me to highlight what it is about 'the way the laws of physics are' that justifies such an answer to our question. I trust this expectation is sufficiently fulfilled in what follows.

Of course there are problems to be confronted. Hume, Kant and Darwin are just three names that might easily come to mind as representing problems confronting any possibility of a purposive answer. I will briefly return to them at the end.

However, I will present an argument *to* design, not a version of the traditional argument *from* design. Also, it is not based on 'fine-tuning', anthropic principles, intelligent design, or 'god of the gaps' arguments. The argument has three parts, the physics, the transition from physics to metaphysics and the metaphysics, which I call 'a metaphysics of inquiry'.

On the one hand the natural sciences understand the universe as operating according to processes described by 'blind' natural laws, including the laws of physics. This is widely taken to undermine the appeal to a purposive explanation of these laws. It is widely taken as a powerful contradiction of the belief that the universe is created and ordered to some purpose by God. On the other hand if a purposive answer exists, it should at least specify some purpose to which the universe is ordered and show how that explains why the laws of physics are the way they are. If available the argument would block the inference from 'blind' to 'purposeless', for then some larger purpose would be served by 'blind' natural laws and processes.

The point is that we are surrounded by 'blind' causal processes deployed for a variety of purposes. One response here might be that while we have plenty of examples of people using 'blind' causal processes to achieve purposes, nothing

about the blind natural processes of the universe suggest they are serving or expressing or in anyway operating for a purpose. No explanatory task in the sciences calls for a purposive account of natural laws and natural processes. Of course a variety of philosophical or theological positions might call for a purposive account of the universe. But it is true that no explanatory task in the sciences calls for a purposive account of natural laws and natural processes and no mere 'gap' in scientific knowledge justifies raising a purposive answer. How from a scientific starting point does the alleged possibility of a purposive answer to our question even arise?

In physics, fundamental laws are commonly presented and used in terms of what is called 'extremum principles'. Historically, this approach to natural philosophy was introduced by Leibniz in 17th century and Maupertuis in the 18th century based on various metaphysical and theological considerations. It was called the principle of Least Action.

This approach was taken up by Leonhard Euler and then by Joseph-Louis compte de Lagrange in a beautiful mathematical formalism for mechanics, while cutting the metaphysical and theological moorings. A little later William Hamilton did a similar thing for mechanics and optics. The whole approach was extended to other areas of science by Hermon von Helmholtz.

Today variational or extremum principles are everywhere in physics, with no trace of any metaphysical or theological origins. A discussion of extremum principles in physics is given by Roger Penrose in his, *Road to Reality* , (Jonathan Cape, London, 2004).

Given my theological and philosophical commitments I wondered whether the last word had been spoken about the relation between extremum principles and metaphysics. Could it be that variational principles still presuppose a metaphysics? As far as I can see only two physicists in 20th century, took extremum principles in physics as evidence for the operation of final causes in

nature. They were Max Planck and David Bohm. This is because extremum principles involve integrals which require the starting point and end point of the integration to be specified. Max Planck and David Bohm took the fact that an end point had to be specified as evidence for final causes in nature. But this won't do for the following reason. It is mathematically possible to go from the integral form to the standard differential form of physical laws. The two forms are equivalent mathematical descriptions of the same process. The differential form gives a moment by moment description of the process. No end point needs to be specified. It is hard to see how a mathematically equivalent statement of laws in integral form can tell us anymore about the world.

This first objection was made by W. Yourgram and S. Mandelstam in their important monograph, *Variational Principles in Dynamics and Quantum Theory*.[5]

> "The belief in a purposive power functioning throughout the universe, antiquated and naïve as this faith may appear, is the inevitable consequence of the opinion that minimum principles with their distinctive properties are signposts towards a deeper understanding of nature and not simply alternative formulations of differential equations in mechanics."[6]

Secondly, Yourgram and Mandelstam appeal to the work of R. Feynman[7] as a way to use the least action principle while dissolving any ground for proposing any metaphysical use of this principle. They claim to show,

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[5] Yougrau, W. and Mandelson, S., *Variational principles in Dynamics and Quantum Theory*, (Pitman, London, 1968). The importance of the work is indicated not only by the contents but also by the encouragement, interest, support that the authors received from L. de Broglie, E. Schrodinger, W. Heisenberg, M. Born, R. Oppenheimer, M. von Laue and A. Speiser.

[6] Ibid. p.174.

[7] Feynman, R. P., 'Space-Time approach to Non-Relativistic Quantum Mechanics', *Review of Modern Physics*, Vol.20, p.267, 1948

"Feynman's principle, although it is actually not a variational principle, does non the less generate, in a direct and consummate fashion, a variational principle, when the conditions are such that classical mechanics provides a valid description of the system under consideration."[8]

In classical mechanics a unique path is picked out for a particle by the requirement that the path always be such as to extremise the action S (minimum or maximum) over the whole transition from initial to final state, represented by $\delta S = 0$. The odd implication is that the particle somehow 'knows' what is the unique path to follow. In the Feynman's path integral approach to quantum mechanics the quantum system traverses all possible paths between the initial and final states. In the classical limit the least action path is not picked out, it 'falls out' as the remaining constructive contributions of the partial transition amplitudes in the region of the classical path after the mutual cancellations of the amplitudes from the other paths.

I do not follow Yourgram and Mandelstam on Feynman. The reason is Steven Weinberg's assessment of Feynman's work.[9] Weinberg highlights many advantages of Feynman's path-integral approach to quantum mechanics [10] but points out that a better version of Feynmans' approach to quantum mechanics can be derived from the canonical approach to quantum mechanics pursued by Weinberg[11] using Lagrangians and assuming the extremum condition $\delta S = 0$. [12] On the other hand Feynman's path-integral approach leads to wrong results in

[8] Yougrau and Mandelson, (1968), p.137.
[9] Weinberg, S., *The Quantum Theory of Fields Vol.1*, (Cambridge University Press, Cambridge, 1995), p.377.
[10] Weinberg (1995), p.377.
[11] Ibid. p.377.
[12] Ibid. pp.292.

certain contexts[13] but these errors do not occur using the Lagrangian approach pursued by Weinberg.[14] This still leaves the first objection.

My wondering whether extremum principles in physics might be shown to still presuppose a metaphysics was finally undermined when I considered under what conditions it might be possible to undermine the first objection. As a first step there would need to be some deeper physical story from which it would be possible to derive integral form of the laws of physics and then using the Euler Lagrange equation derive the laws of physics in the form of differential equations. This would be another way of doing physics. Of course this might turn out to be a version of the physical answer to our question – here via the Lagrangian 'route'. There would be no guarantee that a deeper 'metaphysical' reading of nature would follow from this way of doing physics.

Shortly after accepting this sobering conclusion, I found a physicist who had pursued precisely this path in physics. It is Prof. Roy Frieden, at the College of Optical Sciences in the University of Arizona, see his *Physics from Fisher Information, A Unification*, (Cambridge, 1998).[15] The deeper physical story is provided by Fisher information. I stress that Frieden's work showed no interest in nor any grounds for thinking this Fisher information approach to physics could have anything to do with metaphysics.

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[13] Ibid. p. 377.

[14] Ibid. p.377.

[15] For criticism of this work see, Lavis, D. and Streater, R.,(2002), 'Physics from Fisher Information', *Studies in the History and Philosophy of Modern Physics*, **33B(2),** p.327-343.

2 The Physics

Frieden takes Fisher information as the key to explaining the operation of the laws of fundamental physics and deriving their mathematical forms. For the list of the laws of fundamental physics he has obtained so far see appendix1. For the list of publications up to 2007 in well known physics journals see appendix2. For the list of new predictions he has made see appendix3. I should say that this approach to physics is not an exercise in pure thought. The derivations make use of physical knowledge. For example in deriving Maxwell's equations, the existence of electric and magnetic fields are assumed, but not any relation between them. I need to say something about Fisher information to help provide a very brief introduction to Frieden's work.

(A) Fisher Information

'Fisher Information' is a measure of information first introduced by R.A.Fisher, at Cambridge in the 1920s, who showed that Darwin's theory of evolution by natural selection made sense statistically. Later, Fisher information shows up in the work of H.L.Cramer and C.R. Rao. They were theorizing about how to measure a quantity that is subject to 'noise' and so is fluctuating around some mean value. It is known as 'classical measurement theory'. A celebrated result[16] is the Cramer Rao Inequality, $I e^2 \geq 1$, where e^2 is the mean square error in the estimates of the mean value of the parameter being measured and I is

[16] Van Trees, H. L., *Detection,Estimation, Modulation Theory, Part I*, (1968), pp. 66-68. Trees notes that the inequality was derived by, . Cramer, H. L. , *Mathematical Methods of Statistics*, (1946) and, Rao, C. R., 'Information and Accuracy Attainable in the Estimation of Statistical Parameters', *Bull. Calcutta Math. Soc.* 37, 81-91, (1945). The orignial work was done by,. R. A. Fisher , 'On the Mathematical Foundations of Theoretical Statistics', *Phil. Trans. Roy. Soc. London*, 222, 1922, pp.309–368.

Fisher information.

$$I \equiv \int 4 \left(q'(x) \right)^2 dx, \quad \text{Fisher Information} \quad \text{(one dimension)} \qquad (1)$$

q(x) is the square root of the probability density function describing the fluctuations *x* of the parameter around its mean value and is known as the 'probability amplitude function'. It is assumed that *q(x)* is 'shift invariant' and so is independent of the parameter being measured. It is possible to make measurements in a way that yields the lower bound, so that $I e^2 = 1$ So, *I* can be measured. Notice that *I* is defined on the probability amplitude functions *q(x)* describing the fluctuations, not on measurement and so *I* is a measure of the degree of order of the fluctuations. The use of amplitude functions comes from R.A.Fisher's work, quite independently of quantum mechanics, as J. Wheeler acknowledged.[17]

Earlier in his career Prof. Frieden made an international reputation for being able to turn fuzzy images into clearer images, whether of galaxies of stolen car license plates. He was able to retrieve the lost information using a Fisher Information. One day he noticed that one of the equations he had obtained using Fisher information had exactly the same form as Schrodinger's equation. He was surprised but thought nothing of it. Some time later he came across an article by a A.J.Stam[18], a Dutch mathematician, showing how to go from the Cramer Rao Inequality to Heisenberg's Uncertainty Principle. Frieden then seriously started to wonder if there was a deeper connection between the laws of physics and Fisher information. This became his 'physics from Fisher information' project, with many of the results indicated in the appendices.

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[17] Wheeler, J.A., (1994), *At Home in the Universe*, Woodbury, AIP Press, p.304.
[18] Stam, A.J. , *Information and Control*, **2**, 1959, p.101.

Frieden also followed J.Wheeler's[19] idea of articulating the whole of physics in terms of information.

(B) Frieden's approach to physics [20]

Fisher information arises naturally via the Cramer Rao inequality in the context of a thought experiment about parameter measurement defined by *E* and *W* (my symbols).

E represents idealised empirical inquiry for parameter measurement conducted by rational inquirers, (whether human or alien), assuming:

- isolation of the system being measured from the influence of other physical systems;
- no-noise or other loss of information due to the measuring device;
- unbiased estimation of parameters; on average estimations equals the actual mean parameter value.

W represents the fluctuations to which a parameter is subject and is taken over from classical measurement theory. Here the fluctuations are assumed to be intrinsic to space and time, rather than being the effect of other forces.

This statement of the premises for the derivation now brings out clearly how the active role of the inquirer or observer is a premise in the derivation of the *CRI*: not just, $Ie^2 \geq 1$, but $E, W \Rightarrow Ie^2 \geq 1$. *E* and *W* can be shown to be premises in all the derivations of the laws of fundamental physics from Fisher

[19] Wheeler, J., in, Zurek, W.H., ed., *Complexity, Entropy and the Physics of Information*, (Adison-Wesley, New York, 1990), p.3.

[20] Frieden, B.R., (1998, 2004); Frieden, B.R., and Gatenby, R.A., eds., *Exploratory Data Analysis Using Fisher Information*, (Springer, 2007), chapter 1.

information, including the Lorentz transformation. The 'active' role refers to the rational inquirers (whether humans or aliens) that, even in the thought experiment, are the in-eliminable conductors of empirical inquiry, which aims to produce epistemically significant results, because the experiments conform to rationally established epistemic standards. This emphasizes the rationality of empirical inquiry, not the consciousness of the inquirers.

Assumption *W* is motivated by the use of classical measurement theory with regard to measurement of parameters subject to 'noise', which is ubiquitous. Why are the fluctuations in the parameters of a physical system taken to be due to *intrinsic* fluctuations in space and time? If the parameter fluctuations were taken to arise *extrinsically* from causal interactions from other physical systems, this would contradict the first point under *E*. Secondly, such a causal interaction would presumably be according to one or more laws and so the idea of physical laws would be 'smuggled' in as part of the premises. This would contradict one of the aims of the physics from Fisher information project, viz., to give an account of where physics gets its Lagrangians and therefore an account of physical laws, without presupposing the operation of physical laws. The assumption of *intrinsic* fluctuations in space and time does not itself presuppose or entail the results to be obtained. The use of 'space and time' shows that a pre-relativistic context is the presumed starting point. A first task of the whole project is to derive the Lorentz transformation.

While Frieden *illustrates* what he means by these fluctuations by reference to quantum mechanics and to quantum cosmology[21] he does not discuss the motivation for introducing the assumption here represented by *W*. The *motivation* stemmed from using the classical measurement theory as the context in which Fisher information naturally arises. The nature of these intrinsic fluctuations deserves further discussion from the perspective of a

[21] Frieden, B.R., (2004), pp. 28,164.

Fisher information approach to physics and in the light of other work in physics, with the work of R. Cahill, R., C.M. Klinger [22] as one example.

It turns out that Fisher information *I* has many properties relevant to physics. For example, *I* is a functional already in the form of an action integral. The same form as used in the Lagrangian approach to mechanics and as is found when other areas of physics are put into Lagrangian form. Fisher information *I* in eq.(1) may be generalized for parameters θ_n, n = 1, *N*, in four space-time dimensions (*x,y,z,ict*), giving, [23]

$$\left.\begin{aligned} I &= \sum_{n=1}^{N} 4\int \nabla q_n(\mathbf{x}) \,.\nabla q_n(\mathbf{x})\, d\mathbf{x} \qquad d\mathbf{x} = dxdydzdct \\ I &= \sum_{n=1}^{N} I_n \qquad I_n = \int i_n(\mathbf{x})\; d\mathbf{x} \qquad I_n(\mathbf{x}) = 4\; \nabla q_n(\mathbf{x}) \,.\nabla q_n(\mathbf{x}) \end{aligned}\right\} \qquad (2)$$

Another property is the *I* – Theorem[24], $dI/dt \leq 0$. A third property is that *I* is Lorentz covariant.[25] Gauge invariance ensures observables are unaffected by choice of reference frame. Any change of coordinate system that leaves observable quantities unchanged is called a 'gauge transformation'. The mean square error, e^2 , is an observable, and so should be unaffected by choice of

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22 R. Cahill, R., C.M. Klinger, 'Self-Referential Noise as a Fundamental Aspect of Reality', in, D. Abbott and L. Kish eds., *Proceedings of the 2nd International Conference on Unsolved Problems of Noise and Fluctuations (UPoN 99)*, Adelaide; Australia,11-15th July, **Vol. 511**, *American Institute of Physics*, 43, (2000).

23 Frieden, B.R., *Science from Fisher Information, A Unification*, (Cambridge University Press, 2004); pp. 58 - 64.

24 Plastino, A.R. and Plastino, A., (1996), 'Symmetries of the Fokker-Planck equation and the Fisher-Frieden arrow of time', *Physical Review E*, **54**, No. 4, p. 4423.

25 Frieden (2004), p. 65.

gauge for a given physical scenario. From the lower bound of the Cramer Rao Inequality, $I = e^{-2}$, and we should expect Fisher information I to be invariant with respect to choice of gauge.[26] A fourth property is that I is an inner product and so is invariant under a unitary transformation. Mathematically many unitary transformations hold for complex probability amplitude functions. Such transformations can be applied to Fisher information I. Frieden shows how the probability amplitude functions $q(\mathbf{x})$ can be repackaged as complex amplitudes $\psi(\mathbf{x})$.[27]

$$\psi_n \equiv N^{-1/2} (q_{2n-1} + iq_{2n}), \quad n = 1,2, \ldots N/2, \quad i = (-1)^{1/2} \qquad (3)$$

leading to,

$$\sum_{n=1}^{N/2} \Psi_n^* \Psi_n = N^{-1} \sum_{n=1}^{N} q_n^2(\mathbf{x}) = p(\mathbf{x}) \qquad (4)$$

Substituting eq. (4) in eq.(2) and using imaginary coordinates, leads to,

$$\left.\begin{aligned} I &= 4Nc \sum_{n=1}^{N/2} \int I_n \, d\mathbf{r} \, dt \qquad \text{where } i\mathbf{r} = i(x, y, z) \\ I_n &= [- (\nabla\Psi_n)^* . \nabla \Psi_n + (1/c^2) (\partial \Psi_n/\partial t)^* \partial \Psi_n/\partial t] \end{aligned}\right\} \qquad (5)$$

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26 Ibid., pp. 106-107. Interestingly, this is supported by the fact that the Fisher information derivation of Maxwell's equations, yields these equations in the form of an electromagnetic potential ***A***, φ; ibid., chapter 5.

27 Ibid. , p. 66. The justification for introducing imaginary numbers is that the Cramer Rao Inequality holds for real and imaginary parameters; ibid. , pp.441- 444.

Frieden thinks of Fisher information I as implicated in the data, (via the Cramer Rao Inequality) whereas, "information J is the level of Fisher information at the source, i.e. in the effect that is observed."[28] Any observation is the output of an information-flow process.

$$J \quad \xrightarrow[\text{probe particle}]{\text{messenger}} \quad I$$

Frieden postulates that "such information flows are passive so that I can never exceed J."[29] Thus , $I \leq J$ entails $0 = I - \kappa J$, $0 < \kappa \leq 1$, a 'zero principle'. The probe particle disturbs J by δJ and Frieden takes the information flow as implying that I is perturbed by δI. Furthermore Frieden postulates, $\delta I = \delta J$ and so $\delta(I - J) = 0$, an 'extremum principle'. [30] Defining $K = I - J$, leads to $\delta K = 0$. This is Frieden's principle of 'Extreme Physical Information' (*EPI*)

$$\text{EPI} \quad \left\{ \begin{array}{ll} K = I - J & \\ \delta K = 0 & \text{'extremum principle'} \\ 0 = I - \kappa J \ , 0 < \kappa \leq 1, & \text{'zero principle'} \end{array} \right\} \quad (6)$$

Frieden uses the *EPI* in all his derivations of the laws of fundamental physics – save the derivation of the Lorentz transformation, which uses the Cramer Rao Inequality.[31] This provides some *a posteriori* justification for the two postulates of the *EPI*. On this view the laws of physics are brought into operation as an effect of the probe particle disturbing the information

[28] Frieden and Gatenby, (2007), p. 21.
[29] Ibid. p.21.
[30] Ibid. p.28.
[31] The derivation in Frieden (1998) was criticized by Lavis and Streater (2002). See the derivation in Frieden (2004).

characterizing the system being measured. While the *EPI* is a general variational principle, it needs to be supplemented with empirical information for each derivation to be completed.

(C) My approach

I am much informed by Frieden's work and follow many of his results. Two things particularly mark my interest. Firstly, I start by highlighting independent evidence that there is an interesting relationship between physics and Fisher information. This is found in two papers by W. Wootters[32] and, S.L. Braunstein and C.M. Caves.[33] Braunstein and Cave extend Wootters' work by showing that the problem of the distinguishability of quantum states can be mapped onto that of precision parameter estimation, using the Cramer Rao inequality. They show that the statistical distance between pure quantum states is attained by maximizing Fisher information via the lower bound of the Cramer Rao inequality. The conclusion is that maximising the state distinguishability is equal to the Hilbert space angle between two quantum states. A similar result is obtained for distinguishability over all quantum measurements for pure and impure states. These two papers show an interesting relationship between Fisher information, via the Cramer Rao Inequality, and the distinguishability of quantum states and the structure of Hilbert space.

This provides prior physical justification for further inquiry into the relationship between physics and Fisher information. Frieden's work has pioneered one way of pursuing that inquiry, which began independently of the

32 Wootters, W.K.(1981), 'Statistical Distance and Hilbert Space', *Physical Review D*, 23, No.5, p.357.

33 Braunstein, S.L., and Caves, C.M.,(1994), 'Statistical Distance and the Geometry of Quantum States', *Physical Review Letters*, 72 ,No.22, p.3439.

work by Wootters or Braunstein and Caves. Furthermore all the work being published in standard physics journals examining other links between Fisher information and physics points in this direction. One example is the connection between Fisher information and thermal physics.[34]

My second interest is to go beyond the level of *a posteriori* justification for Frieden's two postulates provided by his derivation of many of the laws of fundamental physics. I have examined whether these postulates, the 'variational principle' and the 'zero principle', may be derived from the same theoretical starting point as Frieden, viz. classical measurement theory, concerning a thought experiment about parameter measurement under conditions defined by E and W. I will only be able to sketch this work here. The details of the derivation are set out in a paper[35] presently being scrutinised by colleagues before being submitted to a physics journal for publication.

Classical measurement theory assumes a measurement interaction between a probe particle and the system being measured, but it says nothing about what goes on in that measurement interaction. However to derive the two postulates requires some idea of what is going on in the interaction.

In this austere theoretical context, the challenge was to start with the thought experiment about parameter measurement under conditions defined by E and W, leading to $E, W \rightarrow Ie^2 \geq 1$, (with I represented by equations (2) and (5) and assuming its many properties). On this basis I proceeded to develop other resources needed so as to be able to elaborate an account of what is going on in the measurement interaction within time interval δt, and then derive the two postulates.

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[34] See references in, Plastino, A., and Plastino, A.R., 'Information and Thermal Physics', in, Frieden, B.R., and Gatenby, R.A. (2007), pp. 119-154.

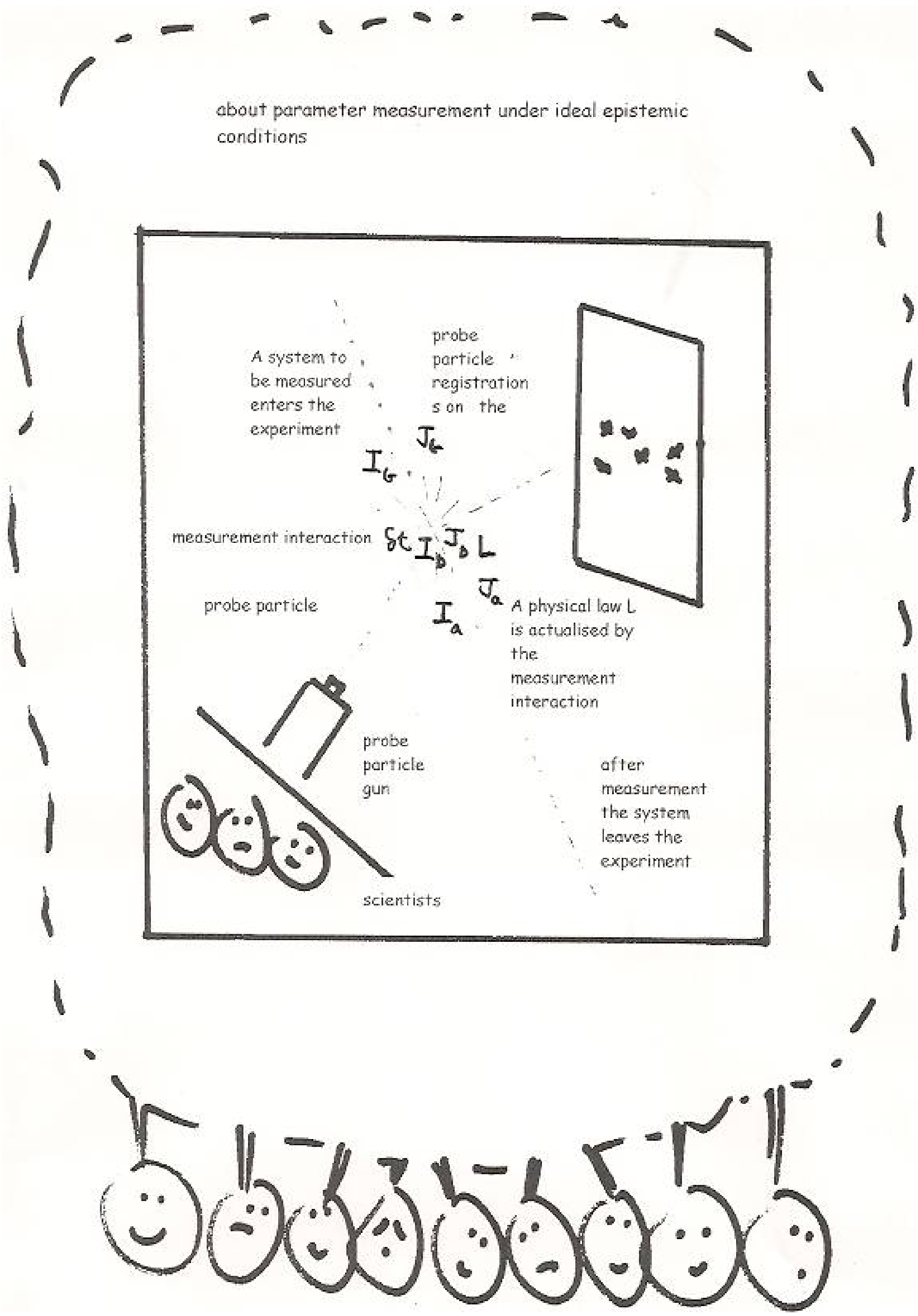
[35] Ames, S., 'The derivation of a variational principle for physics, from Fisher information', pp.1-49.

Fisher information I is defined on the probability amplitude functions describing the intrinsic fluctuations W. It has the same form for all measurement scenarios. This suggests some other term is needed to distinguish measurement scenarios, which I introduce as follows. Fisher information I has the form of an inner product and so is invariant under a unitary transformation. There are many unitary transformations. I hypothesise that among the many mathematical possibilities there is at least one (possibly more) physically significant unitary transformation for Fisher information I, from the space-time $\boldsymbol{x}$ coordinate to an unknown conjugate $\boldsymbol{\eta}$ coordinate. Let 'J' represent the unitary transform 'mate' of I. J inherits many of the properties of I.

Since the fluctuations are assumed to be intrinsic, we may think of I as the measure of the order of these fluctuations, quite independently of whether measurement is being made. The basic idea is that Fisher information I and its unitary transform 'mate' J are the measure of the order of the fluctuations $\psi(\boldsymbol{x})$ in the x coordinate space and $\Phi(\boldsymbol{\eta})$ in the unknown $\boldsymbol{\eta}$ coordinate space respectively. This holds whether or not measurements are being made.

Parameter measurement proceeds by firing probe particles at successive copies of the physical system being measured. The probe particles interact with the system being measured and eventually register on the output-space of the measuring device. The system being measured passes out of the measurement device. Before the measurement interaction the system being measured is characterised by Fisher information terms I_b, J_b, but after the interaction by I_a, J_a. The I-Theorem indicates the possibility of loss or no-loss of information could take place, even under ideal epistemic conditions.

I assume that within the time interval δt of the interaction, the probe particle disturbs the intrinsic fluctuations W of the parameters of the system being measured. This disturbs the probability amplitude functions describing these fluctuations and so disturbs the information terms, I_b and J_b, leading



A fascinated group of people at the seminar enter into a thought experiment

Fig. 1

within δt, to I_D and J_D , (D for 'disturbance'). After δt I_D becomes I_a and J_D becomes J_a. The measurement scenario is indicated in Fig.1. below.

Any acceptable account of what is going on within δt must meet the following three criteria:

C1 it has to be shown that the equivalent of the two axioms in the *EPI* occur in time interval δt;

C2 there needs to be a coherent Fisher information account of how the measurement interaction fulfils C1;

C3 it must be possible to show that any account of a measurement interaction that meets C1 and C2, also connects to the standard approach to physics.

The case of no-loss of information, $I_b = I_a$, $J_b = J_a$, is not straight forward, but it is not difficult to meet C1. My analysis shows that this disturbance has two components. One is a transposition of the unitary transformation between I and J, $I_b \rightarrow J_D$, $J_b \rightarrow I_D$. The other is an infinitesimal disturbance of I_D by δI_D and J_D by δJ_D, where, $\delta I_D = \delta J_D = 0$. This is not to misread $\delta I_D = \delta J_D = 0$ as a disturbance rather than a lack of disturbance. Variational calculus shows how $\delta I_D = 0$ is consistent with a particular kind of disturbance of the probability amplitude function $\psi(x)$, within δt, on which I_D depends. This leads to the conclusion that the measurement interaction brings about 'EPI_D', within the time interval δt.

For the case of loss of information no new theoretical resources are available to help gain some insight into the measurement interaction in δt. Since loss of information is the opposite of no-loss of information I proceed by establishing the essential conditions leading to no-loss of information and then systematically negate them. This generates a range of logically possible forms

of the measurement interaction. There follows an argument by exhaustion to see whether any of these logical possibilities meet the three criteria.

My analysis shows that two of the logical possibilities are acceptable. Each has two components; one is a loss of information such that $I_D < J_D$, and an infinitesimal disturbance of I_D by δI_D and J_D by δJ_D, where $\delta I_D = \delta J_D = 0$. The difference between the two acceptable cases concerns the loss of information. One suffers a direct loss of information $I_b \rightarrow I_D$, $J_b \rightarrow J_D$, while in the other case there is a transposition *with* loss of information, $I_b \rightarrow J_D$, $J_b \rightarrow I_D$. Each of these possibilities meets C2.

The conclusion is that the measurement interaction brings about 'EPI_D', within the time interval δt. Combining the no-loss and loss of information cases, we obtain,

$$EPI_D \quad \left\{ \begin{array}{lll} K_D = I_D - J_D & & \\ \delta K_D = 0 & \text{'extremum principle'} & \\ 0 = I_D - \kappa J_D,\ 0 < \kappa \leq 1, & \text{'zero principle'} & \end{array} \right. \qquad (7)$$

(D) Meeting C3 – making the connection to established physics

The disturbance of the system being measured due to the measurement interaction produces an infinitesimal transformation of the $\psi(\boldsymbol{x})$ and of the corresponding amplitude functions in the conjugate coordinate space. This infinitesimal transformation leaves the action $K = I - J$ stationary, $\delta K = 0$. It is therefore a symmetry transformation. The Fisher information approach to physics can therefore take up all the resources of variational calculus and it can take up the Lie Group[36, 37] as a theoretical resource for *its* exploration of

[36] Weinberg, S., (1995), *The Quantum Theory of Fields Vol.1*, Cambridge, Cambridge University Press, pp. 306 – 314; (a) pp. 50 - 53.

possible physically significant unitary transformations between I and J. For the same reason this approach to physics can take up Noether's theorem, with the measurement interaction implying symmetries and thus conservation laws. The probe particle interaction brings about constraints on the fluctuations of the parameter(s) being measured, defined by the EPI_D. These constraints turn out to be the well known laws of physics.

The analysis shows that the EPI_D holds for three distinct types of measurement interaction: (A) no-loss of information, with transposition; (B) direct loss of information, but no transposition; (C) transposition with loss of information. Criterion C3 is partly met because (A) corresponds to Frieden's derivation of quantum mechanical results, (e.g. Klein Gordon equation, Dirac equation, Heisenberg uncertainty principle and others) and (B) corresponds to Frieden's derivation of the equations of General Relativity and Maxwell's equations. The probe particle is the only 'free variable' in this analysis, so it is assumed that different kinds of probe particles, bring about the different type of measurement interactions.

It is not yet clear what physical interpretation to offer for (C). Comparing and contrasting interaction types suggests (A) (transposition and no-loss of information) and (B) (no transposition and loss of information) could be special cases of (C) (transposition with loss of information). Furthermore, whereas (A) leads to quantum mechanics and no-loss of information, and (B) has no quantum mechanics and loss of information, we should possibly consider (C) as leading to quantum phenomena with loss of information. Since (A) and (B) lead to physical laws that are time reversible, it is worth exploring whether (C) leads to physical

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[37] Olver, P.J., (1993), *Applications of Lie Groups to Differential Equations*, (Springer-Verlag, New York, Cambridge, Cambridge University Press) Chapter 4.

laws that are time irreversible. This suggestion is based on a paper by Ilya Prigogine.[38]

(E) Conclusion

Dropping subscripts and gathering all the premises used to derive the EPI_D, we obtain the following result,

		E , W, I, OA	$\Rightarrow$	EPI
i^{th} measurement scenario		EPI , OA_i	$\Rightarrow$	$^{\backslash}L_i$
		$^{\backslash}L_i$ ID_I	$\Rightarrow$	L_i
		E, W, I, OA_i ID_i	$\Rightarrow$	L_i
For all scenarios,	R1:	E, W, I, AOA	$\Rightarrow$	L

OA Other assumptions besides *E* and *W*

OA_i Other assumptions for the i^{th} measurement scenario

$^{\backslash}L_i$ An equation with exactly the same form as a well known law of fundamental physics

ID_i Identity postulate for unknown constants. This is supported by empirical evidence made relevant by the details of the derivation.

L_i The well known law of fundamental physics

AOA Represents 'all the other assumptions' for all the measurement scenarios.

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[38] Prigogine, I., "Why Irreversibility? The formulation of classical and quantum mechanics for non-integrable systems", *International Journal for Quantum Chemistry*, 1995, Vol. 53, Issue 1, pp. 105 – 118.

L represents all the laws of fundamental physics so derived.

Given *E*, *W*, *I* and all other assumptions, *AOA*, the operation of the laws of physics *L* may be explained and their mathematical forms derived.

I call *R1* the 'rational tuning' of the laws of physics to the idea of idealised empirical inquiry conducted by embodied rational agents, somewhere in the universe. This is quite different from the well known physical 'fine-tuning' of universe for carbon based life.

R1 holds within a thought experiment or, equivalently, it holds within a fiction. Does it hold in the actual univese? An affirmative answer is supported by five reasons.

- The laws obtained by the Fisher information approach to physics are the laws of physics that operate in the actual world.
- The measurement interaction can take place outside of a measurement context. It does not depend on the 'consciousness' of inquirers.
- All the terms in the result *R1* are well known in the actual world.
- New results obtained by Frieden et. al. open to testing.
- Independent support for the *Physics from Fisher Information* project from the work of W.Wooters and, S.Braunstein and C.Caves noted above.

The function of the fiction is to bring to light the relationship between the terms shown in *R1* that is otherwise unnoticed.

What follows from *R1* is that from the earliest moment after the big bang, when the universe is operating according to the laws of fundamental physics, these laws are already rationally tuned to idealised empirical inquiry, even though actual inquirers don't show up until billions of years later. This is what

it is about 'the way the laws of physics are', that needs to be explained. Commonly, the initial reaction is that *R1* can be explained within the resources of the natural sciences, by an extension of evolutionary cosmology. This leads to discussing the move from physics to metaphysics.

3 The move from physics to metaphysics

This move confronts at least two challenges. We need to ask whether it is logically possible for a scientific theory to explain how it is that *R1* holds from the earliest moment of the universe after the big bang. If so, end of story – no further seeking for an explanation is justified. If not there is another challenge. We need to ask whether it is reasonable to treat *R1* as a brute fact. If so, again, end of story. If not, well then, but only then, would we be justified in further seeking an explanation.

It turns out that both challenges can be met successfully. Logically, no scientific theory (as construed) can explain *R1*. Understandably this claim has occasioned some surprise. The immediate thought of more than one person is that 'evolutionary cosmology' can do the job. That is the scientific account of the 13.7 billion year old universe from the big bang until now, including the evolution of life on planet earth, can account for *R1*. This deserves some attention.

(A) Evolutionary Cosmology

Evolutionary cosmology (*EC*) tells the story of the emergence of carbon based life on planet earth. Contemporary evolutionary biology tells a complex story aiming to show, among many other matters, how human beings have evolved on planet earth equipped with rationality and acting accordingly. It is well established that we can only tell the story of the evolution of carbon-based life

on planet earth by telling the story of the evolution of the universe from the moment of the 'Big Bang'.

Broadly speaking we can summarize *EC* as follows: assume the laws of fundamental physics *L*, also fluctuations *W*, Fisher information *I* and all other assumptions *AOA*, some initial conditions and whatever else is currently used to tell an accurate and adequate account of the development of the cosmos, even 'multiple universes', and so call all these "*COSMO*"; assume the key processes of chemistry, call these "*CHEM* "; assume evolutionary biology, call this "*BIO*"; and assume a whole raft of contingencies, call these "*XX* " for "X factors". Given these assumptions it is possible to explain how human inquirers have evolved equipped with rationality and with various historical and cultural processes, call these "*CUL*" , it is possible to explain in particular, how there came into existence human inquirers who hold to and carry out experiments in accord with *E*, who therefore instantiate *E*. Thus *EC* may be summarised as follows:

EC:

$$\textit{COSMO including W, I, OA, L,} + \textit{CHEM} + \textit{BIO} + \textit{CUL} + \textit{XX} \xrightarrow{\textit{explains}} E$$

Thus *EC* entails the *L*, *W*, *I*, *OA* and *E* and therefore *EC* entails *R1*, since,

R1:

$$E, W, I, OA \xrightarrow[\textit{entails}]{\textit{explains}} L$$

Since *EC* entail *R1* and *R1* defines the 'rational tuning' of the *L*, *EC* entails the 'rational tuning' of the *L*.

The *EC* explanation of *R1* proposes an account of the evolution of intelligent life on planet earth, claiming thereby to explain *R1*. This is mistaken. To see the problem, we need to take stock of the fact that *E* is obtained initially quite independently of *EC*, from some general beliefs about rationality and the world in which inquiry is assumed to take place. It is true that we know about rationality because human beings instantiate rationality, whereby they think and act for reasons, and this is known independently of how the origins of that instantiation might be explained. It is on this basis that *EC* can be assessed as a successful explanation or not of *E*, where *E* is known independently and epistemically implicated in generating *EC*.

The *EC* explanation of *R1* terminates with an entailment from *EC* to *R1*. Now an entailment is not necessarily an explanation and this is the case here. What *EC* proposes is an explanation, not of *R1*, but of how, via evolution on planet earth, *E* is instantiated in human inquirers. The *EC* proposes an explanation of how, eventually, (borrowing the arguments for *R1*), we come to know *R1*. It is not an explanation of *R1* because it does not explain how it comes about that the *L* were already 'rationally tuned' to *E* from the earliest time after the big-bang. The *EC* explanation of *R1* fails.

My claim that no scientific theory can explain *R1* does not depend on rebutting one counter argument. Here is a more general argument.

(B) More general difficulties for a scientific theory to explain R1

It is worth reiterating that I assume theoretical physics will be successful in its aim of providing an account of the universe that will include how it comes to operate according to laws *L*. But will it be able to explain how *R1* holds from the earliest moment of the universe? Assume some physical theory T_{Phys} can explain *R1*. What will T_{Phys} look like? As a physical theory T_{Phys},

- is a ‘blind’ theory (causal/‘mechanical’; final causality not included),

- concerns physical conditions, processes, leading to the Big Bang and thereafter to the L (let it include string theory, M-theory, multiple universes, ……),

- presents a valid argument, to deduce the result *R1*, viz. : $T_{Phys} \rightarrow$ *R1*.

Three problems confront T_{phys} as an explanation of *R1*.

#1 For T_{Phys} to offer a valid argument, the conclusion cannot contain terms that are not in the premises proposed by T_{Phys}. Therefore, T_{Phys} must include or lead to *E*. Recall that *E* helps define a thought experiment concerning idealised empirical inquiry by embodied rational agents for valued epistemic ends, in the future of (at least) one of the multiple universes to be produced by the physical processes proposed by T_{Phys}. But this means T_{Phys} is not ‘blind’ and so cannot be a physical theory.

#2 At the point where T_{Phys} must include *E*, in the conditions prior to the Big Bang of our universe, *E* represents a thought experiment about empirical inquiry, conducted by rational agents according to ideal epistemic standards, in principle anywhere in the universe. What provides the thought experiment? Even naturalists think it requires all of evolutionary cosmology to account for the evolution of *E*. A physical theory T_{Phys} alone cannot provide *E*.

#3 T_{Phys} has to explain *R1*. But *R1* is not a causal physical process but a rational inference (explanation/logical entailment). It is not the kind of thing explained by physical theories. See W. Sellars[39] and more recently the

[39] Sellars, W., ‘Empiricism and the Philosophy of Mind’, in Feigl, H., and, Scriven, M., *eds*.,

discussion by J. McDowell,[40] which locates the relations of explanation and entailment in the logical space of reasons and this is logically different from the space of subsumption under natural law.

The result *R2* follows:

R2: On the proposed account of a physical theory,
if T_{Phys} is a physical theory it logically cannot explain *R1*.

(C) Can R1 reasonably be treated as a brute fact?

Consider the following argument.

(1) *R1*

(2) If no scientific or non-scientific explanation of *R1* is possible, *R1* is a 'brute fact'.

(3) No scientific theory can explain R1.

(4) No non-scientific explanation of *R1* is possible.

(5) Therefore *R1* is a brute fact.

The argument is valid. If we reject (5), which premises will we reject?

(1) OK

(2) Stipulates what is meant by a 'brute fact'.

(3) OK

(4) Says that there is nothing outside or beyond what the natural sciences can tell us, that can explain *R1*.

Minnesota Studies in the Philosophy of Science, vol. 1, (1956).

40 McDowell, J., 'Naturalism in the Philosophy of Mind', in, De Caro, M. and Macarthur, D., *eds.*, *Naturalism in Question*, (2004).

Are there any arguments against (4)? I argue that *E* is obtained initially quite independently of *EC*. It is obtained by rational inquirers, with certain aims and some general beliefs about rationality and about how the world operates, deciding what should be done to ensure inquiry is effective. We know about rationality because human beings instantiate rationality, whereby they think and act for reasons, but this is known independently of how the origins of that instantiation might be explained. Of course particular applications of these standards of inquiry may invoke specific scientific knowledge, for example controlled random, double blind trials in testing drug efficacy.

This is one argument for thinking of *E* as something beyond the theories of natural science and that *E* is non-trivially involved in explaining the laws of fundamental physics *L*, as shown in *R1*. This provides rational grounds for wondering if something beyond the natural sciences might explain *R1*. But (4) would lead us to expect any such explanation to be impossible. Hence (4) should be set aside as unreasonable. Therefore (5) does not follow and we reasonably set aside the claim that *R1* is a brute fact.

Those holding to scientific naturalism as an ontological thesis would reply that epistemology ultimately has a natural ground in natural processes described by the natural sciences as argued in the *EC* explanation of *E*. Hence, they would say that *E* is not "something beyond the theories of natural sciences" and so does not create a problem for (4).

But this does not take account of two points. The first is the fact that evolutionary cosmology, *EC*, or any T_{phys}, cannot explain how the laws of fundamental physics, *L*, are already rationally tuned to *E* in the earliest moment after the big-bang. This is another argument for thinking of *E* as something beyond the theories of natural science.

The second point is the way *R1* is a new problem for scientific naturalism. Physicalism is the strongest form of scientific naturalism. According to physicalism, the ultimate ontological constituents of what exists are physical constituents.[41] For both reductive and non-reductive physicalism, what exists is either an instance of these ultimate ontological constituents or complex configurations of the same. These ultimate ontological constituents are not explicable in terms of something more fundamental. By definition there are no deeper non-physical constituents of these ultimate ontological constituents. For physicalism the laws of fundamental physics *L* are either among the fundamental ontological constituents of what there is or are themselves brought about by what is physically more fundamental. Either way, physicalism denies the *L* are explicable in terms of non-physical constituents. [42]

But *R1* says that the operation of *L* may be explained and their mathematical form derived from premises that non-trivially include *E*, where *E* helps define a thought experiment about rational inquirers, pursuing the valued ends of empirical inquiry, according to idealised epistemic standards. *R1* holds in the actual universe. The operation of the *L* is explained and their mathematical forms derived from what is 'non-physical', since *E* manifestly includes the 'mental'. Furthermore, *R1* cannot be explained by any scientific theory, including any physical theory. These points contradict the basic tenant of physicalism and so create a new problem for physicalism. If physicalism were true this situation would not be possible. Thus *R1* provides evidence against physicalism and so against scientific naturalism. It is unreasonable to appeal to

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41 For example, Stoljar, D., 'Physicalism', *Stanford Encyclopedia of Philosophy*, http://plato.standford.edu/entries/physicalism/ , 2001, pp.2; Papineau, D., *Philosophical Naturalism*, (1993), p. 9.

42 The possibility that the mental may be incorporated in what counts as physical is recognized as a challenge to phyicalism by Stoljar (2001), p.12; Poland, J., *Physicalism*, (Clarendon, Oxford, 1994), p. 287; and would appear to be a problem for Melnyk's account of physicalism, see Melnyk, A., *A Physicalist Manifesto: A Thoroughly Modern Materialism*, (Cambridge University Press, New York, 2003), p.27.

scientific naturalism to support (4).[43] Again, it is unreasonable to claim that *R1* is a brute fact.

A weaker objection has also been offered to this conclusion: while it is not possible to prove that *R1* is a brute fact, it cannot be ruled out. Perhaps the universe just turns out to be such that *R1* is a brute fact. My response is that I neither want to nor need to prove that *R1* is not a brute fact. Something like the principle of sufficient reason would be needed to prove that point and that would be to import a metaphysical position, which I have aimed to avoid. All I need to do is to show it is unreasonable to treat *R1* as a brute fact. I think the weaker position is also unreasonable. Under what conditions could one have reasonable grounds for thinking that *R1* is a brute fact? Since (3) still holds, the weaker position would be reasonable if there were some grounds for holding (4). But I have already shown why (4) is unreasonable.

I conclude,

R3: It is unreasonable to treat *R1* as a brute fact.

R4: *Given R2* and *R3* it is reasonable to seek further for an explanation of *R1*.

4 A metaphysical explanation of *R1*

What must minimally be assumed to hold in order to explain *R1*? Any explanation of *R1* must include the thought experiment *E*. Something capable of rational thought, could envisage *E*. This 'something' should be thought of as some kind of 'rational agent', envisaging rational agents (inquirers) pursuing valued epistemic ends in some universe. A rational agent must also be assumed

[43] This is a fragment of a much larger discussion of scientific naturalism.

because thought alone is not enough to explain the existence of our universe in which *R1* holds.

In addition, we must assume, minimally, some kind of basic stuff, which this rational agent orders in the light of envisaging *E*. (The minimum needed to explain *R1* does not require God creating *ex nihilo* as Kant made clear. A separate argument would be needed to identify the 'rational agent' of this argument with the God of theism or of various religious traditions.) This correctly treats this rational agent as envisaging *E* as a purpose to be enacted.

For our universe, *R1*, the 'rational tuning' of *L* to *E* , may be explained as follows. Assume some kind of rational agent with a purpose that at least includes forming a universe that is knowable by embodied rational inquirers conducting empirical inquiry under ideal epistemic conditions in that universe.

Assume there is also some basic 'stuff' and that in the light of this purpose, this rational agent orders this basic 'stuff' so that it eventually brings about a universe (possibly one among many others), of which our best physics gives an account, which among other things is characterized by *W* , *I* and *AOA*. Given this purpose and these characteristics, the universe operates according to laws, whose operations is explained and mathematical form entailed by *E, W, I* and *AOA*, and these laws are *L*. Call this result *R5*, which I summarise as follows:

R5 *R1* can be explained by minimally assuming that some kind of rational agent has structured some basic 'stuff' to form this universe, (one among many) of which our best physics gives an account, and characterised by *W, I, AOA*, and laws *L*, in order that the universe can be known through empirical inquiry by embodied rational agents.

Notice this is not a 'god of the gaps' argument. The argument assumes the (eventual) success of theoretical physics in giving an account of the physics of

the universe, including multiple universes. It is unaffected by a scientific elaboration of 'COSMO', the cosmology in *EC*, the evolutionary cosmology story represented above.

This is an argument from physics to metaphysics.[44] It is a metaphysics because it goes beyond physics to what physics does not inquire into. It is however a metaphysics of inquiry. As such it logically cannot be in conflict with empirical inquiry. Most importantly, this answer to our question is not a science stopper! It logically cannot inhibit either empirical or theoretical inquiry in physics or any other science. On the contrary, it encourages the continuing exploration of both physics and metaphysics.

From *R5* we should expect other aspects of the universe besides *L* to provide evidence that the universe has been ordered to the end that the universe is knowable through empirical inquiry by embodied rational inquirers. This expectation is fulfilled as follows:

- it is now well established that the physical universe is fine-tuned across many physical constants and the laws of physics, for producing carbon based life, including intelligent carbon based life;

- the universe it is also fine tuned to be widely characterised by 'locality' and 'linearity', which are the physical bases for being able to inquire into particular processes and phenomena, without having to study everything else as well;

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44 Contrast the move from metaphysics to physics by J. Leslie, see his, *Infinite minds: A Philosophical Cosmology*, (Clarendon Press, Oxford, 2001). Leslie argues that our life producing universe exists because it is ethically required.

- evolutionary cosmology shows how carbon based intelligent life has in fact evolved in the universe.

Here I also want to briefly comment on the work of V.J. Stenger mentioned earlier. Stenger addresses the question, 'where do the laws of physics come from?'

" The laws of physics are not handed down from above. Neither are they rules somehow built into the structure of the universe. They are ingredients of the models that physicists invent to describe observations. …… If the models of physics are to describe observations based on an objective reality, then those models cannot depend on the point of view of the observer. This suggests a principle of *point-of-view invariance* that is equivalent to the principle of covariance (or cosmological principle or Copernican principle) when applied to space-time. As Noether showed, this leads to the principles of energy, linear momentum, and angular momentum conservation and essentially all of classical mechanics. It also leads to Lorenzt invariance and special relativity. When generalised to the abstract space of functions such as the quantum state vector, point-of-view invariance is identified with gauge invariance. Quantum mechanics is then just the mathematics of gauge transformations with no additional assumptions needed to obtain its rules, including the superposition and uncertainty principles. Conservation of electric charge, isospin, and other quantities follow from global gauge invariance. The forces in the standard model of elementary particles are fields introduced to preserve local gauge invariance. Gravity can also be viewed as such a field. Thus practically all of fundamental physics as we know it follows directly from the single principle of point-of-view invariance."[45]

I take Stenger's main point that the model of physics is developed on the main assumption of point-of-view invariance. This is the assumption that in this universe there is no preferred reference frame for observation. The physics

[45] Stenger, V.J., 'Where Do the Laws of Phyiscs Come From?' p.1.
This paper is based on his book and may be found at,
http://www.colorado.edu/philosophy/vstenger/Nothing/Laws.pdf .

of the actual universe turns out to conform to this model as indicated by a myriad of precise observations. This is further independent support for my conclusion that the universe is structured in order to be knowable by embodied rational inquirers, in principle anywhere in the universe. Furthermore the point-of-view invariance or covariance which is a presupposition of Stenger's approach is a natural consequence of the Fisher information approach to physics.

Another question I wish to explore about Stenger's argument is what happened to his point-of-view invariance presupposition. If the argument was laid out in full would this presupposition appear in the premises? A comparable illustration is the derivation of the Cramer Rao Inequality. It is easy to simply use the conclusion $Ie^2 \geq 1$. However the argument is, $E, W \rightarrow Ie^2 \geq 1$. Likewise it is possible to derive many of the laws of fundamental physics using Frieden's *EPI* principle. But the fully stated argument is represented by *R1*. Is it possible that Stenger's argument might entail another version of the 'rational tuning' of the laws of physics to the requirement of observation?

Lastly, Stenger regards the laws as reflecting underlying symmetries and these symmetries are taken to be symmetries of the void, since on his view, nothing is more symmetrical than nothing. But symmetry is unstable and so there spontaneously occurs symmetry breaking that eventually leads to our universe. Accepting this part of Stenger's view for the moment, it may be positioned in relation to the discussion of evolutionary cosmology, above, as the origin of all that is in 'Cosmo'. It extends *EC*. It may help explain *L*, but this will still not explain *R1*. These points set up an interesting discussion with Stenger's work.

5. **A brief note on Kant, Hume and Darwin**

Kant says of the physico-theological proof for the existence of God, usually called the argument from design or the teleological argument, that it,

> "deserves to be mentioned with respect. It is the oldest, the clearest, and the most accordant with the common reason of mankind. It enlivens the study of nature, just as it itself derives its existence and gains ever new vigour from that source." [46]

That argument rests on analogy with human art. A watch points to a watchmaker, a house to an architect. In these examples the 'designer' works with raw materials. Nothing is said about the origins of these materials. Kant concludes,

> "[t]he utmost therefore this argument can prove is an *architect* of the world, who is always very much hampered by the adaptability of the material in which he works,not a *creator* of the world, to whose idea all things are subject." [47]

This paper conforms to that limit since it claims only that the world is designed, but leaves open the question of whether the existence of the universe is metaphysically contingent and therefore largely leave open the question of whether the designer is also the creator of the world.[48]

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[46] Kant, I., (trans. Smith, N.K.), *The Critique of Pure Reason*, (1933), B561 – 2.

[47] Ibid. B656, (italics original).

[48] The question is addressed by Craig, W.L., retrieval of a cosmological argument for God, in, 'Naturalism and Cosmology', Craig, W.L. and Moreland, J.P., eds., *Naturalism, a Critical Analysis*, (2000), Chapter 9. My preferred approach is represented by Lonergan, B. , *Insight*, (Dartman Longman and Todd, London, 1958), Chapter XX, and by Ward.K., *Rational Theology and the Creativity of God*, (Basil Blackwell, Oxford). In different ways each authors approach the argument for God from an inquiry into inquiry.

At the risk of oversimplification I summarise one major strand of Kant's thought as follows: whether as a presupposition of inquiry that aims to attain a whole body of knowledge concerning nature[49], or in the distinction between organisms and aggregates in nature[50], reason finds indispensable, as a presupposition, the *idea* of nature as the product of a highest intelligent cause acting according to purpose[51], utterly different from though doubtless thought on analogy with human art.[52] Natural phenomena are treated as if they are all purposively interrelated. For example, Kant asserts that we must,

> "consider from a teleological point of view not only merely certain parts of nature, such as the distribution of land, ……, but make this systematic unity of nature completely universal, in relation to the idea of a supreme intelligence. For when we treat nature as resting on purposiveness, in accordance with universal laws, from which no special arrangement is exempt, however difficult this may be to establish in any given case. We then have a regulative principle of the systematic

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49 "This unity of reason always presupposes an idea, namely, that of the form of a whole of knowledge – a whole which is prior to the determinate knowledge of the parts and which contains the conditions that determine *a priori* for every part its position and relation to the other parts. This idea accordingly postulates a complete unity in the knowledge obtained by the understanding, by which this knowledge is to be not mere contingent aggregate, but a system connected according to necessary laws." *Critique of Pure Reason*, *op.cit.*, B673.

50 Kant, I, *Critique of Teleological Judgement*, Ak., xx, 217, 219); cited by McFarland, J.D. , *Kant's Concept of Teleology* (University of Edinburgh Press, Edinburgh, 1970), pp.93 – 96.

51 "This highest formal unity, which rests solely on the concept of reason, is the *purposive* unity of things. The *speculative* interest of reason makes it necessary to regard all order in the world as if it had originated in the purpose of a supreme reason. Such a principle opens out to our reason, as applied to the field of experience, altogether new views as to how the things of the world may be connected according to teleological laws, and so enables it to arrive at their greatest systematic unity. The assumption of a supreme intelligence, as the one and only cause of the universe, though in the idea alone, can therefore always benefit reason and can never injure it." *Critique of Pure Reason*, *op.cit.*, B 714 – 715.

52 *Critique of Judgment*, *Ak.*, v: 182; *Critique of Teleological Judgment*, *op. cit.*, 64, 370.

unity of teleological connection....."[53]

These purposive connections in nature are to be considered supplementary to mechanical connections, not a substitute for them.[54] Thus according to Kant,

> "The worst that could happen would be that where we expected a teleological connection (*nexus finalis*), we find only mechanical or physical connection (*nexus effictivus*). In such a case we merely fail to find the additional unity; we do not destroy the unity upon which reason insists in its empirical employment." [55]

What of the relation between mechanism and teleology?

> " It is true that in teleology we speak of nature as if its purposiveness was designed; but to avoid all suspicion of presuming in the slightest to mix up with ours sources of knowledge something that has no place in physics at all, namely a supernatural cause, we refer to design in such a way that this design is ascribed to nature, that is, to matter. In this way there can be no misunderstanding , since no design in the proper meaning of the word can be ascribed to lifeless matter. We thus give notice that this word here only expresses a principle of the reflective, not of the determinant judgement, and consequently is not meant to introduce a special ground of causality, but only to assist the employment of reason by supplementing investigation of mechanical laws by the addition of another method of investigation."[56]

According to Kant, the teleological view point helps us seek for purposive connections in nature, that we might not otherwise have noticed, but

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[53] *Critique of Pure Reason*, *op.cit.*, B719.

[54] McFarland (1970), *op. cit.*, p.33.

[55] Ibid., p.33, cited by McFarland from, *The Critique of Pure Reason*, trans. N.Smith, 1933, B715 – 716.

[56] *Critique of Teleological Judgment*, 68: 383; see also, ibid., 66: 376.

which might be otherwise explained. One such connection, of interest in view of my use of extremum principles, is Kant's discussion of Maupertuis' principle of least action, discovered in 1746. Kant noted,

> "Maupertuis proved … that the most universal laws according to which matter in general operates … are themselves subject to an overriding rule according to which the greatest economoy is observed in every action." [57]

Such discoveries, or the natural purposiveness of organisms, provide examples of the expected 'teleological connection' in accord with viewing the nature as designed by a higher intelligence. But even so we have no basis for saying that there is such an intelligent being. For to argue so, we would have to establish the prior proposition, "Organisms are not possible except through the operation of an intelligent cause."[58] This, says Kant, we cannot possibly establish, since,

> "strictly speaking we do not observe the purpose in nature as designed, but only read this conception into the facts as a guide to judgment in its reflection upon the products of nature."[59]

McFarland points out a parallel between Kant and Hume on this point. Hume argues that, "to say that all this order in animals and vegetables proceeds ultimately from design is begging the question"[60] because we

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57 Kant, I., *Only Possible Argument for a Demonstration of the Existence of God*, (*Ak.*, II, 98 – 99).

58 *Critique of Teleological Judgment*, *op. cit.*, 75: 399.

59 Ibid., 75: 399.

60 Ibid. p.126, McFarland cites, Hume's, *Dialogues Concerning Natural Religion*, p.179. Hume also accepts the principle the nature does nothing in vain – one of the roots of the least action principle – ibid. p.214.

would first have to prove that they are impossible in any other way.[61] All the appearance of purposiveness, final causality, teleology or design in nature doesn't allow us to argue that nature is in fact purposive or designed, as Darwin vividly demonstrated.

There are other important comparisons between Kant's argument and my argument above. According to Kant, teleology is a regulative idea introduced as a presupposition by which the highest form of systematic unity of knowledge may be envisaged if not attained. No such presupposition is at work in the argument above. Of course, we readily recognize the growing systemic unity of theoretical and empirical knowledge that may well be compared with a complex 'cross-word' puzzle,[62] though with no presumption of an intelligent agent designing the cosmic puzzle. This recognition, however, has no role in the above argument.

On the other hand I agree with Kant's view that mere appearances of design could be explained in other ways. As noted above Maupertuis' principle of least action is entirely consistent with the view that laws of physics in standard form are no more than second order differential equations, which, as it just turns out, may be conveniently and elegantly recast in Lagrangian or Hamiltonian form. To read this recast form of physical laws as evidence for final causes in nature begs the question as to why such a reading should be preferred to a reading entirely in terms of efficient causality. At the very least we would need independent evidence for preferring the former reading rather than the latter. This, however, is precisely what my argument provides, starting with Frieden's Fisher information approach to physics.

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61 McFarland, (1970), *op. cit.*, p.126.

62 See Haack, (1995), *op. cit.*, especially Chp. 4.

I agree with Kant that we cannot argue from the mere 'appearances' of purposiveness or design in nature to an intelligent being who is the 'designer', because we cannot be sure there is no other way to explain the appearances. But the argument above has a different structure from Kant's argument. It does not start from a presupposition of teleology as a view point for organizing our knowledge, nor does it point to the appearances of design in nature. Rather, it shows that the result *R1* logically cannot be explained within the resources of the natural sciences. Specifically this means physics, cosmology, and evolutionary theory. The latter is part of the reason Darwinism is not a problem for this teleological argument. The conclusion holds for any development of the natural sciences in which physical causality remains 'blind'.

This differs from Kant's view that there are aspects of nature that appear to fit the teleological stand point but are explainable in terms of mechanical causality. Contrary to Kant, in my argument it is the empirical laws of fundamental physics, which underwrite causal explanations, that are themselves explained, and this by first explaining how the extremum principle, Maupertuis' principle of least action, physically comes about, from premises that non-trivially include Fisher information *I* and idealised empirical inquiry *E*.

Lastly, the 'rational agent' to which my argument *to* design leads, does not, in turn, immediately incur the burden of a call for its explanation. A call for an explanation of this 'agent' must be argued, just as I have justified further seeking an explanation of *R1*.

6 Conclusion

The paper has argument has obtained the following main results.

R1: E, W, I, *AOA* $\Rightarrow$ L

If we assume the idea of idealise empirical inquiry conducted by embodied rational inquirers, *E* , in principle anywhere in the universe, and some other assumptions, then operation of the laws of fundamental physics *L* may be explained and their mathematical forms derived.

R2: On the proposed account of a physical theory, if T_{Phys} is a physical theory it logically cannot explain *R1*.

R3: It is unreasonable to treat *R1* as a brute fact.

R4: Given *R2* and *R3* it is reasonable to seek further for an explanation of *R1*.

R5 *R1* can be explained by minimally assuming that some kind of rational agent has structured some basic 'stuff' to form this universe, (one among many) of which our best physics gives an account, and characterised by *W*, *I*, *AOA*, and laws *L*, in order that the universe can be known through empirical inquiry by embodied rational agents.

Why are the laws of fundamental physics the way they are?.

In order for the universe to be knowable through idealised empirical inquiry by embodied rational agents.

Appendix 1

Laws of physics that Frieden has derived

L_1	**Lorentz Transformation.**
L_2	**Relativistic mechanics, including the energy equation.**
L_3	**Klein-Gordon Equations**
L_4	**Time independent Schrodinger Equation – non-relativistic limit of L_3.**
L_5	**Dirac Equation.**
L_6	**Heisenberg's Uncertainty Principle.**
L_7	**Maxwell's Equations.**
L_8	**The Field Equations of General Relativity.**
L_9	**Newton's Laws, by approximation from L_2 and L_8 including the Virial Theorem.**
L_{10}	**The Maxwell-Boltzman velocity law of classical statistics.**
L_{11}	**The power spectral 1/f noise.**
L_{12}	**The Wheeler-Dewitt equation for a pure radiation universe.**
L_{13}	**The wave equation for quantum chromodynamics.**
L_{14}	**The EPR-Bohm effect describing entangled states.**
L_{15}	**The Higgs mass effect.**

Frieden, B.R., and, Gatenby, A.R., eds., *Exploratory Data Analysis Using Fisher Information*, (Springer, London, 2007), pp. 28-29.

Appendix 2

B.R. Frieden's main publications 1988- 2007

1988, Frieden, B. R., Applications to optics and wave mechanics of the criterion of maximum Cramer-Rao bound, *Journal Of Modern Optics,* **35**, No.8, p.1300;

1989a, Frieden, B. R., Fisher Information as the basis for the Schrodinger wave equation, *American Journal of Physics*, **57**, (11), pp.1004 – 1008;

1989b, Frieden, B. R., Fisher Information as the basis for diffraction optics, *Optics Letters*, **14**, No.4, pp.199 – 201;

Frieden, B. R., Fisher Information, disorder, and the equilibrium distributions of physics, *Physical Review A*, **41**, No.8, pp.4265 – 4276;

1991, Frieden, B. R., Fisher Information and the Complex Nature of the Schrodinger Wave Equation, *Foundations in Physics,* **21**, No.7, pp.757 – 771;

1992, Frieden, B. R. Fisher Information and uncertainty complementarity, *Physics Letters A*, **169**, pp.123 – 130;

1994, Frieden, B. R. and Hughes, R. J. , Spectral 1/f noise derived from extremised physical information, *Physical Review E,* **49**, No.1, pp.2644 – 2649;

1995a,Frieden, B. R.,'Physical Information and the Derivation of Electron Physics', in Hawekes P.E., (ed.), *Advances in Image and Electron Physics, Volume 90* ,(Academic Press, San Diego, pp.123 – 204;

1995b Frieden, B. R. and Soffer, B. H., 'Lagrangians of physics and the game of Fisher-information transfer', *Physical Review E,* **52**, No.3, 1995b, pp.2274 – 2286;

1996, Frieden, B. R. and Cocke, W. J. , 'Foundation for Fisher Information-based derivations of physical laws', *Physical Review E*, **54**, No.1, 1996, pp.257 – 260;

1997, Cocke, W. J. and Frieden, B. R. , 'Information and Gravitation' , *Foundations of Physics*, **27**, No.10, pp.1397 – 1412;

1998, Frieden, B. R., *Physics From Fisher Information: A Unification*, (Cambridge University Press, Cambridge);

1999a Frieden, B. R., Plastino, A., Plastino, A. R., and Soffer, B. H., 'Fisher-based thermodynamics: Its Legendre transform and concavity properties', *Physical Review E*, **60**, No. 1, pp. 48 – 53;

1999b Frieden, B. R. , 'F-Information, A Unitless Variant of Fisher Information', *Foundations of Physics*, **29**, No.10, pp.1521 – 1541;

2000a Frieden, B. R. and Soffer, B. H., 'A Critical Comparison Of Three Information Based Approaches To Physics', *Physics Letters A,* **304**, pp.1 – 7;

2000b Frieden, B. R. and Plastino, A.,'Composite fermion particles and Fisher information', *Physics Letters A*, **272**, pp.326 – 332;

2001a Frieden, B. R., Plastino, A. and Soffer, B. H.,'Population Genetics from a an information perspective', *Journal of Theoretical Biology*, **208** ,pp.49 – 64;

2001b Frieden, B. R. and Plastino, A., 'Higgs mass generation from the standpoint of information', *Physics Letters A*, **278**, pp.299 – 306;

2002a Frieden, B. R., 'Relations between parameters of a decoherent system and Fisher information', *Physical Review A*, **66**, Article No. 022107;

2002b Frieden, B.R.and Soffer, B. H., 'Black holes and optimum coding', *Physics Letters A*, **304**, pp.1 – 7;

2002c Frieden, B. R., Plastino, A. and Plastino, A. R., 'Schrodinger link between non-equilibrium thermodynamics and Fisher information', *Physical Review E*, **66(4)**, Article No. 046128 Part2;

2002d Frieden, B. R., Plastino, A. and Plastino, A. R.,'Non-equilibrium thermodynamics and Fisher information: An illustrative example', *Physics Letters A*, **304**, pp.73 – 78;

2003 Flego, S. P., Frieden, B. R. and Plastino, A., *et al.*, 'Non-equilibrium thermodynamics and Fisher information: Sound wave propagation in a dilute gas', *Physical Review E*, **68**, Article No. 016105;

2004a Hawkins, R. J. and Frieden, B. R., Fisher information and equilibrium distributions in econophysics', *Physics Letters A*, **332**, pp. 126 – 130.

2004b Frieden, B. R. *Science from Fisher Information, A Unification*, (Cambridge University Press, 2004).

2007, Frieden, B.R. and, Gatenby, R.A., eds., *Exploratory Data Analysis Using Fisher Information*, (Springer, London).

Appendix 3

New results predicted by Frieden and colleagues

. The predictions regarding free quarks and the combination of quarks. Frieden, B. R., Plastino, A. (2000)

. On population genetics. Frieden, B. R., Plastino, A. and Soffer, B. H.(2001)

. The prediction of an upper bound to the mass M_H of the Higgs particle H^0 and additional bosons to H^0, Z^0 and $W^{\pm}$. Frieden, B. R. and Plastino, A. (2001b)

. Prediction of enhanced number of black holes with large mass, resulting in an increased occurrence of gravitational lensing, and an enhanced ability to entrap relatively distant stellar objects. Frieden, B. R. and Soffer, B. H. (2002).

. A relation between the Weinberg angle θ_W and the Cabbibo angle θ_C. The standard model of elementary particles does not predict a relation between the two angles, whereas Frieden (2004) does.

. In biophysics: the prediction that the power of the grow process for cancer is the Fibonacci constant. Frieden, (2004).