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QUANTUM CONCEPTS AND THE ANTHROPIC PRINCIPLE

ANTHROPIST: I am a meaningful part of the Universe, which has developed in just such a way that I should appear.
MECHANIST: You are the improbable result of random processes. Had things turned out in a slightly different way then you would not be here to marvel at how purposeful everything is.
ANTHROPIST: But they didn't!
MECHANIST: But they might have! If the present state of the Universe *was* a coincidence (which I believe is the case) then you would have exactly the same evidence for purposiveness that you have now.
ANTHROPIST: And if the Universe was purposive (which is what I believe to be the case) then you would have exactly the same evidence for coincidence that you have now.

The above dialogue outlines the two basic positions that have been taken on the question of cosmology; the study of the existence of the Universe. The Mechanist is a well known character of philosophical disputation, but who is the Anthropist?

In recent years, largely due to the work of Brandon Carter and R.H. Dicke, the Anthropic Principle has found some support in cosmology. The Principle is perhaps best appreciated in contrast to the Deductive Principle, that which underlies the methodology in which one posits a set of initial conditions for the Universe and extrapolates (hopefully) to the present. One thereby assigns no particular importance to the emergence of Man as a self-regarding and Universe-regarding agent. He[1] becomes nothing more than the chance product of a material Universe.

The Anthropic Principle on the other hand, takes as its starting point the *fact* of the existence of Mankind and tries to elucidate the circumstances which developed in just such a way as to bring it about. To quote Calder,[2] "in its strongest form the Anthropic Principle noted that the overall character of an observable universe had to be suitable for the creation of observers". "The initial conditions of the Universe are not known", writes Gale[3], "and the physical laws that operated very early in its history are also uncertain; the laws may even depend on the initial conditions. Indeed, perhaps the only constraint that can be imposed on a theory reconstructing the initial conditions of the Universe and the corresponding laws of nature is the requirement that these conditions and laws give rise to an inhabited Universe."

The anthropic approach has arisen in large measure from the failure of the mechanistic empiricism that has formed the basis of deductive science. It is only recently, for instance, that biologists have admitted that Evolution is not a scientific theory in quite the same sense that, say, structural engineering is. Evolution cannot form the basis of experiments and is not therefore subject to proof or falsification; whereas if a structural engineer uses the wrong theory then his bridges fall down.[4]

The palaeontologist can at least test models of evolution for goodness of fit to parts of the fossil record other than those in the context of which they were devised, the cosmologist cannot even do this. There is only one Universe, and only one solar system that is available for direct observation. A few heavy planets may have been located orbiting other stars, but we know nothing about them, nor about how common planets actually are.[5] The condensation theory supposes that, as a primordial gas cloud collected under its own gravitation, the planets condensed out of it soon after the sun was born. This view would lead one to conclude that most sun-like stars have planets. Michael Wolfson's model of the established sun dragging a ribbon of gas from a passing protostar would predict a low probablility of planets, since stars do not tend to pass near one another, and a correspondingly low likelihood of life. There are those who believe that planetary probability is a red herring, Hoyle and Wickramsinghe for example regard comets as more conducive to the development of primitive forms of life. Planets would still presumably be necessary for the development of intelligence however.[6]

It is by no means definite that we should actually recognize extraterrestrial life, were we able to find it. Olaf Stapledon has speculated on the possibility of sentient stars[7]; and similar difficulties surround the identification of intelligent life. Dr. Lilly has claimed that there are two intelligent species upon the earth — man and dolphins — whereas some cynics might deny that there is even one, in the tradition of Gandhi who, when asked what he thought of Western civilization, replied that he thought it would be a good idea.

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Perhaps the most startling work on the Anthropic Principle, the way in which the Universe exists in just such a way as to make intelligent life possible — perhaps even inevitable, is R.H. Dicke's development of certain ideas of the quantum physicist P.A.M. Dirac. Dirac found startling numerical relationships between the orders of magnitude of some of the basic values of the Universe. In particular he noted obvious relationships between values for the number of massive particles (protons and neutrons) in the visible Universe (10^{80}), the age of the Universe in atomic units — one such unit being the time required for light to traverse a distance equal to the radius of a proton (10^{40}) — and the gravitational coupling constant (10^{-40}). Coupling constants describe the energy of a particle in a field of force: the gravitational coupling constant is one based on Newton's constant for gravitational attraction expressed in terms of the mass of a nucleon, (a neutron or a proton).

It must be noted that these are dimensionless numbers, that is they hold irrespective of the units of measurement used. Moreover they indicate orders of magnitude, and are therefore not significantly affected by the slightly different values which the data upon which they are based are now taken to have as a result of better experimental determination since the time Dirac was writing. Dirac regarded these relationships as meaningful, although he was unsure what they meant.

The real surprise came when Dicke showed that while there was a *necessary* relationship between the number of particles and the gravitational coupling constant[8], the relationship between these values and that for the age of the Universe is *contingent* — that is to say it now happens to be the case; it was not so in the cosmological past and will not remain so in the cosmological future. It happens in fact to be the case for precisely that part of the lifetime of the Universe when one could expect there to be intelligent life around to which it would be meaningful. (I should explain here that the chemical conditions necessary to sustain life as we know it are best met with at certain times in the existence of certain sorts of planet orbiting certain sorts of star in a particular way. This is most likely to happen, as it has happened for us, in the central section of the lifetime of the Universe.)

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Brandon Carter[9] has tried to relate the Anthropic Principle to Everett's Many Worlds Interpretation of Quantum Mechanics. The title gives some indication of the relevance of this idea. The Anthropic Principle invites comparison between the world as it is and the world as it might have been, Everett obligingly provides an ever increasing number of 'might-have-been' worlds. In order to understand Everett's theory it is necessary, briefly, to place it in its quantum mechanical context.

Although light is always registered by recording devices as particles (photons), in space it behaves as a wave. Light beams can interfere and cancel one another out in the same way that two sets of water ripples can create smooth patches of water where the peaks of one and the troughs of the other coincide. In quantum mechanics this is described by the Schrödinger Equation. In the ideal situation a coherent wave of light from a source impinges at the same instant upon two equidistant slits, 1 and 2, with a light detector placed at the back of each. If the combined energy of the wave reaching the slits corresponds to that of a single photon of light (and levels as low as this have been achieved in interference experiments) then either one or the other, but not both, of the detectors will record the light. The Schrödinger Equation describing the situation developing over time makes use of six dimensions, three for each slit. The probability of an observation being made at a particular point is equal to the square of the amplitude (height) of the Schrödinger wave at the appropriate point. When one of the detectors is activated the wave function is said to collapse, giving a 100% probability for one outcome and 0% probability for all the others, there is only one other in the simple, ideal case described.

How, why and indeed whether this collapse comes about is one of the most hotly debated questions in Quantum Mechanics. Everett[10] proposed in 1957 that it does not happen at all. The Schrödinger function for the whole Universe splits in two, and in one Universe the photon is registered at slit 1 and in the other Universe at slit 2. Brandon Carter used this idea as the basis for discussing universes in which life did not appear as opposed to those within which it did. He suggested, for example, that the gravitational coupling constant (and therefore gravitation generally) would have to have about the same value that it actually does have for stars to develop of the size and stability necessary to support planets with life as we know it on them.

This kind of development rests on a misunderstanding of Everett's idea. When the wave function of the Universe splits (if it does) then the two universes that result are identical in every respect except that of the position of the particular photon (or electron, or proton) with which we are concerned. Of course the photon might be the one that triggered King Harold's eye so that he ducked the arrow at the Battle of Hastings, and the electron might be the one that enabled an unstable base to exist in a replicating strand of DNA and thus caused one of the important mutations in one of our prehominid ancestors, but the underlying laws of nature will be the same in all of the ever-dividing universes. The laws of "our" Universe will go back to every point of division. Carter, or anyone else for that matter, is quite free to speculate on what would have happened if the fundamental characteristics of the Universe had not been as they are, but Everett's theory is of no real relevance.

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Another interpretation of quantum mechanics however, may offer rather more understanding. Niels Bohr developed Complementarity to come to terms with the Jekyll and Hyde nature of light outlined above. What he did was in a Zen-like manner to "unask" the question of whether light (and matter) "really" consisted of particles or of waves. In free space light behaves as a wave, in macroscopic interactions it seems to be corpuscular; the same goes for matter. The basis of complementarity was that it is perfectly acceptable for something to possess contradictory qualities, so long as it does not possess them at the same time. "Andrew Kirby is in London" is sometimes true and sometimes false, but since it is never both at the same time then there is no real difficulty. Similarly the wave and the particle pictures compliment one another; in any particular context either one or the other fits, but it never necessary or desirable to decide between them.

Although Bohr developed Complementarity in the context of Quantum Mechanics, there is no doubt that "he considered such relations of complimentarity the dominant feature in all fields where describing experience requires considering the conditions under which experience is gained" to quote Peterson[11]. Bohr used the example of a living organism, which can only be mechanically studied by depriving it of precisely that quality which is the object of study.[12] There is a complementarity between mechanistic and vitalistic interpretations of life.

The Peterson quotation would seem to be particularly relevant to the Anthropic Principle. What deductive cosmology tries to do is to give an account of the way in which the Universe has come about without considering that it has done so in just such a way that we are here to seek for such an account. I suggest that what we have here is a clash between a mechanistic, causal account and a teleological (end-oriented) account. The mechanistic cosmologists have chosen a standpoint which makes them unable to recognize any purposiveness in the unfolding of the Universe. The Anthropists, having taken that as their starting point, must elucidate the circumstances that brought it about. The possibility of reconciling the two is on a par with that of a man playing on the white squares of the board playing a meaningful game of draughts with a man using the black squares.

Perhaps the best argument for the application of the Anthropic Principle is that the limitations of mechanistic empiricism are at their greatest when dealing with unique events that cannot be replicated. The Anthropic Principle offers a philosophy of hope, the hope that our existence is more than a quirk of improbability, and this is something that cannot go unexamined.

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1 The masculine singular third-person pronoun is used purely for stylistic and not discriminatory reasons.

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