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DETERMINISM, INDETERMINISM, EVOLUTION, AND FREE WILL

by Trevor Pitts

For the purposes of this essay, we define three types of determinism:

Type A, the determinism of 19th century classical physics. Given exact knowledge of all physical laws, and exact knowledge of the state of the universe at any given time, there is only one state at each point in the past or future of that state, and their characteristics are predictable exactly.

Type B, abandoning the requirement of prediction, but retaining the rest of type A.

Type C, a limited determinism. There are many possible future outcomes for such states, but all outcomes obey the physical laws, and there is only one past state at any point in the past of a given time.

All types agree that if we run the laws and events backward in time from now, there is only one consistent set of past events. Type A and B agree that their logic applies equally in both time directions, type C is irreversible, the arrow of time is real. So we should consider reversed time, that is to investigate what present conditions imply about the past in all three cases.

Type A is false, if even infinitesimal inexactitude is present. The universe is permeated by so-called deterministic chaotic processes, which are effectively infinitely sensitive to initial conditions if determinism is claimed to be valid for times of the order of the life of the universe. This is because chaos acts as an amplifier of minuscule differences over time. *Essentially, there is no change in initial conditions so small that chaotic systems will not be altered significantly over short time scales* [1]. Therefore, considering chaos in reversed time over billions of years, initial positions of particles in the far past would have had to be exact to better than a trillion trillion trillionth of the radius of the smallest known object of finite size. This would be required in order to produce deterministically our state of the universe now, rather than some other state. As we see below, such precision is a physical impossibility.

Type A and B are false if any mechanism involving any element of randomness exists. The following is a thought experiment to illuminate this issue. It is frequently assumed that quantum uncertainties are negligible except on the scale of atoms. This is false on two levels. It is a fundamental error to use the word ‘uncertainty’. It implies the old, comfortable, notion that the uncertainty is a function of the disturbance of the measured system by the impact of the measuring entity. This is known to be false[2]. Quantum phenomena involve irreducible elements of probability, that is, the outcome is uncertain in the more basic sense that it is always one of a number of alternatives, never less than two. Let us consider somewhat larger particles, dust, in order to see how this affects the macroscopic world.

Dust sized things can be very important, e.g. viruses are tiny and sometimes lethal, so is Chernobyl fallout. Let us take one nanogram as an illustrative size. According to De Broglie, (footnote A) a virus of this size in a strong breeze has a wave character (the smaller the particle the more wavelike its behaviour). Its quantum wavelength (hence approximate positional indeterminacy) is about ten to the minus sixteen centimetres. This is very small, but due to Brownian motion the dust is buffeted by millions of air particles per second, each of which moves it slightly to a newly uncertain position . Since A or B determinism has to get everything exactly right, we can add up the indeterminacy for each buffet. For a million buffets per second, in a year of 30 million seconds, the dust has undergone total indeterminacy in position of about a micrometer, a thousand times its diameter. Worse, every air molecule which hit it had De Broglie indeterminacy of about one percent of its molecular diameter *for every collision*. According to Ruelle[1], if our atmosphere was newly affected by the particle motion induced by the gravitational force of a single electron as distant as the edge of the visible universe, our atmosphere would measurably change, globally, in two weeks. So infinitesimal positional indeterminacy is important. The slightly indeterminate Brownian motion above also applies to sperm cells in liquid. Quantum indeterminacy influenced your conception. Radioactive decay is random as the result of the quantum character of nuclei, so quantum indeterminacy changes heredity by inducing mutations.

In reality, therefore, there is a significant component of indeterminacy of quantum origin, amplified by ubiquitous chaotic processes so as to falsify both A and B determinism. There is no reason for despair, however. Reality is very limited in the range of possibilities and clearly type C deterministic to the extent that later states are entirely *dependent* on earlier states in that only those states characterized by a physically lawful evolution (i.e. change over time, not evolution by natural selection) of such states will exist, even if they are not exactly *determined*. Illustratively, if the game is cricket, ‘measurements’ such as ‘89 not out’ may exist, or maybe 88, but not ‘1-nil away loss’ (soccer) nor ‘checkmate’ (chess). Further, only one means of evolving from dead, disordered or less ‘fit’ states to living, more ordered or better states has ever been devised. That means is by selection and amplification of at least partly undetermined changes, and it works even while obeying the requirement for the universe’s disorder (i.e. entropy) to increase overall. If there were no indeterminacy, no possible alternate states, there can be no natural selection and so the assertion ‘God did it all’ would be defensible.

Does a form of limited free will exist, like type C determinism? Define it as: for any state of the universe including a state of consciousness, there is more than one potential state of that consciousness for each potential future state of the rest of the universe. So, therefore, free will increases total indeterminacy. If we grant the falsity of type A or B determinism, we can imagine two types of behavioural mutation. Type I results in inheritance of some narrow behavioural change. Type 2 is inheritance of a mechanism to allow a wider variety of behaviour to be shown by the organism for a given range of stimuli from the environment. Call type 2 *freer will*. Obviously, populations with freer will need fewer favourable mutations, so less time, to arrive at some superior adaptation of behaviour than type 1 populations. So one would expect that if freer will is possible, it will be preferentially selected, then expanded. Consider the birds which have obtained more food by learning to drink milk through the thin aluminium caps of milk bottles on British doorsteps. Flexibility pays off versus rigidity.

The animals with the most complex behaviour, us, can make mental models of the world, using pictures, language and symbols to communicate them to others. Humans thereby change the environment to increase populations and satisfy increasingly complex desires. It is obvious from the most cursory survey of history that individuals, cultures and even businesses making certain types of choices and adaptations dominate the world and slowly improve it, at least technologically. They also appear to be creative. How can this be reconciled with the determinist assertion that there can be no possible alternative to a given conscious state at any instant? This assertion implies that some fantastically specific initial conditions at the Big Bang produced the existing, (a priori immensely unlikely) planet full of life and mind. Vast alternative crowds of dead or mindless states would result, deterministically, from almost any tiny difference in this purported exceptional beginning state. If type C is correct, a much broader range of initial conditions is consistent with present-type outcomes than type B. Indeed, type A and B allow only *one* possible initial state. If we regard the ‘fine tuning’ of the universe for life to be suspicious, then we should be far more suspicious of A and B determinism.

The evidence is that a reasonably benign set of initial conditions on Earth existed, which could have had a certain scope of variation (of the order of a few per cent in mass or temperature, say) and still allowed some form of life to become established. The principal basis for this view is that life appeared extremely early, almost as early as possible, which argues that it was not an overwhelmingly unlikely result requiring perfect conditions. Life evolved primitive but very diverse forms, of which a tiny minority of species have descendants today. The evidence is that very different animals and plants might have occupied the ecological niches that exist today, with similar success, except that their ancestors were wiped out by comet and asteroid impact. The orbits of these bodies in the long term are chaotic, hence indeterminate to a significant degree. So initial conditions on Earth could have had diverse outcomes.

Analogously, there is evidence that a young human’s brain has far more connections between neurons than an adult. Apparently, useless ones for the child's circumstances disappear and useful ones persist and ramify into new arrangements, eventually producing an adult adapted to its culture and language[3]. This implies that each individual’s fundamental mental structure evolved independently based on the initial unique ‘wiring’ combined with experiences and the particular biochemical environment provided to the brain by the body. No wonder we have such distinct personalities and talent sets. If we arrive at similar results, it is by very different mental pathways.

What is the mechanism of limited free choice? Perhaps Brownian indeterminacy in ion diffusion across synapses is amplified to give some scope for trial and error. Increasingly sophisticated preconscious elimination of poor solutions might give us a selection of options. Education, talent and experience could prune this tree of options to give us conscious decisions and creativity.

Even if the mechanism for the mind's ability to make at least minimally free choices is still elusive, the evidence for the ability is everywhere. The mechanism of pain is elusive. No one doubts its existence. Since when has the absence of a known mechanism for an observed phenomenon given pause to the speculations of a philosopher?

If the experimental evidence is this clear, why is the debate so fierce? I believe the culprit is the dead hand of a false science, 19th century and earlier classical physics. The great simplicity and explanatory power of this physics, and especially its compatibility with common sense pictures of reality have given it an afterlife in philosophy. The situation is made worse by the fact that the chief survivor of this physics, Einstein's relativity, is deterministic and thought to be incompatible with quantum theory's indeterminacy and irreversibility. Science leaps in progress only at points of impasse. Quantum theory itself arose from Planck's tentative solution to a calamitous failure of classical physics so puzzling that it was called 'the ultraviolet catastrophe'. So it seems plausible for philosophy to look beyond this present impasse in science. Roger Penrose believes that some sort of reconciliation of this impasse will occur by understanding the point at which irreversibility occurs, i.e. where all but one quantum alternative disappears. This essay argues that, if Penrose is wrong, so was Darwin, and the fossil record is an interminable practical joke by God.

Footnote:

(A) I take the De Broglie wavelength of a moving particle to be equal to the uncertainty in position. It is given by Planck's constant, *h*, divided by the product of the mass and velocity (i.e. momentum) of the dust or the gas molecules. I used a breeze of 100 cm/sec, mass of one billionth of a gram, h is 7×10^{-27} erg sec.

References:

1. D. Ruell, *Chance and Chaos* (Princeton, 1993), p.75
2. N. Herbert, *Quantum Reality* (Doubleday Anchor, 1985), p. 110
3. J. McCrone, *New Scientist*, 22 January 2000, p.22