**DOOMSDAY REVISITED:** CONCISE ANTHROPIC HISTORY OF GENUS HOMO.

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ABSTRACT

Since the emergence of our species, a hundred thousand years or so ago, the number of people involved in each doubling of the global population has had the roughly constant magnitude evaluated by von Foerster as of order **ten to the tenth.** It is shown here that this rather large number can be understood as being determined by the number of nucleons in the genome.

INTRODUCTION

This 80th birthday meeting has reminded me of the meeting (organised at Cambridge by my former classmate Martin Rees) when I was only half this age, at which I first put foreward (but did not publish) what has been melodramatically refered to (notably by John Leslie) as the **"doomsday argument**". It concerned the application of the **anthropic principle** to the future of our terrestrial human race.

What is to be understood in this (local as distinct from cosmological) context by the "anthropic principle" is the postulate that one has equal *a priori* probability of finding oneself in the situation of any comparable (in this case human) being. This can be construed as (weakly) deductive evidence favouring scenarios in which the number of people living in our future will be roughly comparable with the number who have already lived in our past (while the likelyhood that that there would be many more would be proportionally reduced).

This raises the question of how many did live in our past. At that Cambridge meeting 40 years ago I had naively assumed that our past was representable by a Malthus type model, meaning exponential growth with a constant doubling timescale of the order of a human breeding timescale, something like half the biblical lifetime of seventy years. In such a model the number of previous lives would be only of the same order as the number living at present. To agree with the anthropically expected limit, our population growth would need to be drastically cut off within a few generations from now, a scenario that might indeed be describable as 'doomsday'.

HYPERBOLIC POPULATION GROWTH.

Before the foregoing conclusion could be published it became clear that it was actually invalid, as the applicability of the Malthusian model on which it was based was limited to intervals short compared to the doubling timescale. When I looked at the United Nations population estimates I saw that the actual population doubling time was by no means constant as the exponential model would require, but is in remarkable agreement with a "hyperbolic" model in which the doubling timescale halves on each successive doubling. Whereas population growth in the exponential model is simply proportional to the population itself, it is instead proportional to its square in the hyperbolic model. What actually has been constant, in rough order of magnitude, ever since our human ancestors deviated from the Neanderthals, is the number of people involved in each doubling, which (as first observed sixty yearscago by Heinz von Foerster) is roughly of the order of **ten thousand million**. Since the emergence of homo sapiens, there have been something like ten such doublings, of which a couple during my own eighty year life.

Since we have now got down to the regime of applicability of the Malthusian model, in which the doubling time was of the order of the breeding time, the number of people involved in a doubling is now comparable with the total population. The conclusion is therefor that the number of people who have lived so far is of the order of ten times the number alive now. The anthropic implication is thus that the number of people who will live in the future is likely to be also of this magnitude, namely a **hundred thousand million**.

This last conclusion, on the basis of the Foerster model, may seem less alarming than the original (unpublished but widely circulated) suggestion on the basis just of the naive Malthusian model. However it

still maintains the implication that a sudden "doomsday" type catastrophe can be avoided only if the global population undergoes sufficient gradual reduction in the long run. This excludes not only the economist's dream of perpetual growth, but even the ecologist's dream of perpetual sustainability. (Its credibility is reinforced by its consistency with implications of the finitude of non renewable ressources.)

What this reasoning leaves open is the (effectively political) question of whether our descendents will constute a high population for a relatively short time (just a few generations terminating catastrophically) or a much smaller population lasting a much longer time. It is even conceivable that by diminishing as the time reversed miror of the preceeding hyperbolic growth the future population might produce an unlimited number of future lives, albeit with probability tending to zero.

For those (including theoretical physicists like Dirac and Dyson) who are concered with the ultimate survival of humanity in the distant future, the outcome of the foregoing reasoning is discouraging. However there is relatively good news for those who are more worried about the immediate danger of an apocalyptic catastrophe of human origin, such as a third world war, in the nearer future of our own lives. For this more down to earth application, the anthropic message is relatively encouraging. Ou conceivable participation in such an Armageddon would situate us as a minority, of the order of **ten thousand million** future lives, as compared with the total of all,future lives, which we would expect to be not much less than the number of past human lives, of the order of a **hundred thousand million**.

GENETIC MUTATION RATE

From an academic point of view, the interesting question is why the number of people involved in each doubling of the population has this easily memorable magnitude, which happens to be roughly the number of nucleotides in the genome, namely about **ten to the ten**.

To answer this it is instructive to consider the mechanism whereby genetic evolution depends on the supply of the random nucleotide mutations that are needed for long term Darwinian evolution. It is expected and found that natural mutation rates tend to be optimised to allow for the fact that many of them will be harmful, so so that in a typical reproduction there will be only a few mutations over the entie genome. This means that under the most favorable conditions, in which a single nucleotide is responsible for a major development, the number of individual contributions to the breeding of such an individual will need to be of the order of the number of nucleotides in the entire genome, which for the genus Homo (and other animals) is of order **ten to the ten**. This means that in a population of a **million** it will require about **ten thousand** generations to obtain such a mutant individual.

THE MIMETIC TRANSITION

It would appear from the fossii record that genetic evolution, particularly of brain size, actually did occur at such an exceptionally rapid rate in Erectus and other species of our genus Homo until the emergence of our own species, Sapiens. Since that time, competing species, including the Neanderthals, have been centirely elimiated, while genetic evolution in the only surviving Homo species, namely ourselves, has slowed down to an almost comlete stop! Although our species has undergone many times the doubling timescale that was sufficient for substantial evolutionary progress in our predecessors, the most modern humans are still biologically classifiable as belonging to the same species as their earliest Sapiens ancestors.

Instead of Darwinian evolution of the familiar biological kind, our species has been characterised ecxclusively, ever since its origin, by evolution of the kind describable as memetic, meaning the development of exchangable know-how of very diverse kinds ranging from the wheel to the limited liability company.

One of the most obviously important effects of this memetic evolution has been the accelerating expansion oft he global population, in accordance wih the Foerster formula as described above.

The question is why the number of individuals involved in substantial increase of brain capacity in previus species has turned out to be about the same as the number involved insubstantial increase of the global population in our own species.

The reply I would suggest is that as our species developed, the genetic contribution to our collective progress would have been overtaken by the (initially negligible) memetic contribution. The latter would have become dominant from about the stage at which the population doubling timescale became comparable with the timescale of the previuosly dominant genetic contribution.

From then onwards the population would have evolved in accordance with the hyperbolic (not exponential) model with a doubling number that would have remained fixed at the Foerster value, of the order of **ten to the ten**, which can now be understood as the number of nucleotides in the genome.