THE ANTHROPIC PRINCIPLE - IS THE UNIVERSE SPECIALLY DESIGNED TO SUPPORT LIFE?

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Scientists are often impressed by how finely-tuned the world is for the existence of life. If any of a large number of fundamental physical properties of the world were slightly different, biological life would be impossible. The observation that we inhabit a world which is uniquely suited to us has led to the development of a scientific principle called the anthropic principle. This principle asserts that we see the universe the way it is because we exist. There are two forms of the anthropic principle, a weak form and a strong form. Most scientists find the weak anthrophic principle to be a useful methodological principle, but few scientists believe in the strong form of the principle. Others claim that the anthropic principle is not a scientific principle at all, but is just an irritating tautology. The principle is lucidly described in Theories of Everything by J.D. Barrow (Clarendon Press, 1991).

The weak anthropic principle recognises that the fact of human existence requires certain conditions to be met regarding the past and the present structure of the universe. In other words, the conditions we observe in the universe must be such that allowed carbon-based observers like ourselves to arise and evolve within a certain time-frame. This time-frame must reside in a window of opportunity bounded at the late end by the death of the sun and, at the early end, by the requirement that the elements that compose our bodies must be present. Therefore, when intelligent observers find that the conditions in the universe are suitable for their existence, this is no reason for surprise or wonder.

One application of the weak anthropic principle is to 'explain' why the universe is about 15 billion years old. Living systems on Earth are made from carbon-based molecules in which carbon is combined with hydrogen, nitrogen, phosphorous and oxygen. The cosmologists tell us that, in the beginning, there was only hydrogen and a little helium. All of the heavier elements in nature were subsequently bred in the interiors of the stars by nuclear processes. At the ends of their lives, many stars explode and spew the heavier elements into space, where they become incorporated into molecules, planets, and eventually people. The process whereby the biological building blocks of life are produced is long and slow. It took about 10 billion years from the big bang origin of the universe before our solar system was formed. Another billion years passed before life began on Earth. Life subsequently evolved for about 4 billion years. And so, this is why the universe is about 15 billion years old.

The weak anthropic principle mainly concerns itself with large-scale observed properties of the universe. Strong versions of the anthropic principle attempt to account for the fundamental constants of the universe and assert that the universe must have those properties that allow life to develop. There are many fundamental constants, including the force of gravity, the charge on the electron, and the ratio of photons (basic units of light) to nuclear particles (protons and neutrons). It has often been observed that the force of gravity, for example, is set at an ideal level for the existence of life. If the force of gravity were slightly higher the stars would burn more rapidly. Consequently our sun would burn itself out in one billion years, instead of its present 10 billion year life-span, and this would not allow enough time for the human species to evolve. On the other hand, if the force of gravity were slightly less than it is, the sun would burn more slowly and the temperature would be cooler. Consequently, the temperature on Earth would be too low to sustain life as we know it.

The ratio of photons to nuclear particles is also most convenient. This ratio plays a vital role in determining the rate at which the cosmos expands. If the ratio were significantly higher than it is, the universe would expand so quickly that the stars and galaxies probably would not have formed, and consequently there would be no place for life to inhabit.

The strong form of the anthropic principle leads to the conclusion that there may be a large number of alternative universes, each with its own configuration and possibly its own laws of science. In most of these universes conditions will not be right for the development of life, and consequently these places contain no scientists or philosophers to contemplate them and to ask questions such as 'why is the universe the way we see it?'

Before the work of Nicolas Copernicus (1473-1543) mankind was assigned a position of preeminent importance in the natural world. The universe was thought to be centred on man. After Copernicus everything changed - mankind was denied any special cosmological status. But now, if you accept the anthrophic principle, a limited degree of status is again conferred on mankind. The anthropic principle would not restore pre-Copernican status, but it does accord some privilege to mankind.

It could be argued that the anthropic principle is just as anthropocentric as cosmological thinking before the time of Copernicus. The strong form of the anthropic principle seems to rule out the possibility of the existence of life that is not broadly similar to life as we know it. This may not be sensible. After all, there are several examples of accomplished scientists who have credibly speculated on forms of life, radically different to life on Earth, in works of science-fiction (e.g. Fred Hoyle in The Dark Cloud (1957)). One can imagine such intelligent alien life-forms contemplating their surroundings in other universes, and devising their own anthropic principle to rule out a possibility of intelligent life in a universe such as ours because the constants of nature in our universe would not support a life-form such as theirs!

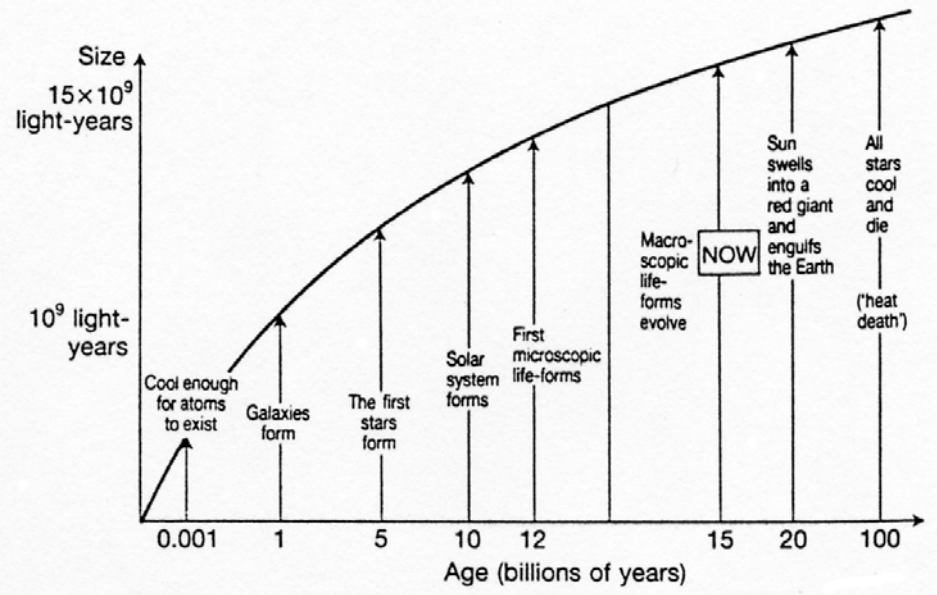
It is important to point out that the anthropic principle (at least in the weak form) is not a causal explanation - it does not claim that the existence of life causes the constants of nature to have their observed values. The principle acts more to constrain the features of the universe than to explain them. In other words, if the nature of the universe differed markedly from what we see, we would not be here to comment on it.

Albert Einstein had the happy knack of making comments that are memorable and hence frequently quoted. At one stage he said that the reason he studied physics was to discover ‘if God had any choice in the way He made the universe’. Physicists really do not know yet if there was any choice in this matter. However, some believe that the theory of quantum mechanics leaves room for choice. The origin of the universe involved quantum processes, and such processes determine the probability of events, but not the events themselves. It could therefore be argued that choices did exist, many were acted on and there may be many universes created in accordance with laws that allow for randomness in the fundamental constants. These fundamental constants may differ from universe to universe, leaving many universes unfit for life. In such a scenario the anthropic principle makes sense.

On the other hand, if the physical laws reigning at the birth of the universe allowed for only one set of values for the physical constants, then the anthropic principle would seem to be unnecessary. In this scenario the universe is absolutely determined from the start and the

evolution of life is guaranteed.

Of course, there is another way of thinking that is a rival to the anthropic principle, and this can be called the God principle. This states that the reason we find the universe tailor-made for our existence is because it was deliberately designed for our existence. God created the universe the way it is as a home for intelligent life. Science can only deal with natural explanation and therefore cannot subscribe to the God principle. Religion responds to the unique fitness of the world for life with the God principle; science responds with the anthropic principle. A cynic might remark that the anthropic principle is the closest some atheists can get to God.



The universe has been expanding with time from its beginning in the Big Bang. Life on Earth could only begin and develop in our universe in the window bounded on the early side by the birth of the stars and on the late side by the death of all stars of the universe.

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