On the Meaning of Being Alive

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I have been always intrigued by the question: what is the meaning of being alive? A question, which is, of course, much debated by biologists.

I think the following reference is a good representation of this debate and I recommend it as a starting point to understand the biological intricacies underlying it, and the point of view of biologists. It is an article in Scientific American by L.P. Villareal:

https://www.scientificamerican.com/article/are-viruses-alive-2004/

The article tackles the question as to whether viruses are alive or not, and gives a negative answer. The question is anyway fundamental because biologist perceive viruses as representative of a boundary between life and inert chemistry.

My feeling is that biologist are, so to say, conditioned by their own expertise and knowledge. As explained in the article they put forward some criteria, that should be satisfied by a living being.

"For example, a living entity is in a state bounded by birth and death. Living organisms also are thought to require a degree of biochemical autonomy, carrying on the metabolic activities that produce the molecules and energy needed to sustain the organism. This level of autonomy is essential to most definitions".

Clearly the last three criteria exclude viruses.

I will now comment on the first one.

I remember when I was at high school the teacher of sciences told us students that death is a necessary condition for life, in keeping with the first criterium above.

I was about seventeen (1962). With my evidently already emerging mathematical inclination, I thought to myself:

"How could one possibly prove this statement? As a matter of facts, it looks to me impossible to prove it!".

I didn't externalize my doubts in that occasion though, feeling that it would be useless.

Fast forward. It was in 1988 when an event showed that I was completely right!

Here comes, as mathematicians say, a counterexample!

But I learnt of the counterexample only in 2012, thanks to an article on the New York Times:

https://www.nytimes.com/2012/12/02/magazine/can-a-jellyfish-unlock-the-secret-of-immortality.html

which, of course, I strongly recommend as well.

In 1988, Christian Sommer, a German marine-biology student in his early 20s, discovered that a jellyfish, known to biologists as Turritopsis dohrnii, is practically immortal, in the sense that when it ages it regenerates himself, coming back to a baby state, and the same happens if you try to kill him, for example, if you stab him.

Later on in 1996 a team of Italian biologists published a paper on the Turritopsis dohrnii entitled "Reversing the Life Cycle", which has had, incredibly, little resonance at the time.

In 2022 New York time got back to the topic, citing another article published in the same year on The Proceedings of National Academy of Sciences, in which the authors started to study Turritopsis dohrnii genome, figuring out the sequences that are involved in regeneration. We are far away from a complete understanding, let alone from driving useful conclusions for humans, which are very different form these jellyfishes.

We human do have regeneration capabilities thanks to the stem cells. For example, if we are wounded our organism perfectly regenerate the tissues involved. It is only for a cruel choice of Mother Nature if these mechanisms are not as extended as those of Turritopsis dohrnii.

Also notice that this is the precise sense, in which we should understand immortality. As a matter of facts, nothing is really immortal, not even the universe, and so we must understand immortality in the sense of a regeneration capacity, which excludes natural death, as well as some other kind of death (of course, if the Turritopsis dohrnii is eaten by a fish it dies).

So one of criteria for being alive put forth in the Villareal's article is easily shown to be wrong.

Anyway, the present write up does not aim to discuss and contest the other criteria, this is the task of biologists, and it is not my job.

Rather, I propose a complete shift in focus.

Specifically, I propose a radical change in perspective: that is, to revisit the question from a mathematical rather than a biological point of view.

And all mathematicians know very well that the more abstract is the approach the more powerful are its consequences and potential applications. So I will argue accordingly.

Let me start coming back to Descartes, and take inspiration from him:

"*Cogito ergo sum*"

First of all, ergo means therefore. Thus this is what mathematicians call a statement of a sufficient condition:

I think therefore I am

Well "I am" can be understood as I exists, but it is perfectly clear that Descartes intended "I am alive", in the same way as Shakespeare intended us interpret the words of his hero Prince Hamlet:

"To be or not to be, that is the question".

Let's now look at the condition "I think". Here thinking is intended at the highest possible level, namely human thinking.

Human thought is a thought endowed of consciousness, a thought that invented Mathematics, which is the only selfconsistent system that we know of, and has made possible a gnoseological miracle. I would not say in the sense that mathematics allows us to interpret the universe (which is a naive statement), but, rather, in the sense that mathematics allows us to formulate meaninful theories and use them to make computations about various phenomena unfolding in the universe, with results that collimate with measurements.

Thus we are able to predict the outcome of various natural and artificial processes (and in certain case even control them, in the sense of influencing them in order to comply to specific goals formulated by ourseves, which, in a nutshell, is what Control Theory is about within Applied Mathematics) .

I can't resist recalling Blaise Pascal pense' number 237, which is not only a scientific milestone, but also an enchanting piece of unintended poetry.

"L'homme n'est qu'un roseau, le plus faible de la nature, mais c'est un roseau pensant. I l ne faut pas que l'univers entier s'arme pour l'écraser; une vapeur, une goutte d'eau suffit pour le tuer. Mais quand l'univers l'écraserait, l'homme serait encore plus noble que ce qui le tue, puisqu'il sait qu'il meurt et l'avantage que l'univers a sur lui. L'univers n'en sait rien.

Toute notre dignité consiste donc en la pensée. C'est de là qu'il nous faut relever et non de l'espace et de la durée, que nous ne saurions remplir. Travaillons donc à bien penser voilà le principe de la morale."

Pascal and Descartes are two giant of science and human thought. And I would say that the space and the emphasis that textbook dedicate to the various masters of human thought is inversely proportional to their cultural stature. Let alone that the most important of them all, like, for example, Kurt Godel, are typically not even mentioned.

But let's move on, arguing in a mathematical fashion, to investigate whether we could make the condition not just sufficient but necessary too. If we can achieve this, we would automatically get a definition of life, or, more specifically, define what is the meaning of being alive.

In other words, if we could also make the necessity statement (that is, a statement that goes in the converse direction):

"I am therefore I think"

(which with the present definition of thought is clearly false) we would have an equivalence between the capability of thinking and the property to be alive, because at this point we could state:

"I am if and only if I think".

Now this inverse statement of Descartes sentence is very far from necessity.

Why?

Because he refers to the most sophisticated possible form of thought. And notice that this form of thought resides in our brain.

Therefore to move on toward necessity we must generalize the concept of thought, looking for what we might dim to be the most weak or elementary form of thought.

In other words, such form of generalized thought must be defined as the minimal capacity recognizable as capacity of thinking.

Thus I propose:

Thinking is any activity capable to at least elaborate (and possibly implement) strategies (or at least one strategy), which are typically functional to extend in time the existence of the thinking entity genre for example by reproduction.

Call this form of thought generalized thought.

As a consequence, we are lead to state the following necessary and sufficient condition to be alive:

An entity is alive if and only if it is capable of generalized thought

This is the definition of a living creature, which we propose arguing on abstract mathematical ground.

And according to such definition, a *virus is definitely a living creature*, contrary to the consensus among biologist, for which the most elementary living entities are cells. A typical textbook will tell you (eukariote means having a nucleus and procariote the contrary):

"They (the viruses) are neither prokaryotes nor eukaryotes *because they are not living*".

By the contrary, not only the virus has a "clever" strategy (according to Villareal!) but it can even adapt the strategy to the circumstances, and it is also capable to implement his strategy, coopting the reproducing functionality of infected cells to the reproduction of himself. Thus viruses are alive with room to spare from our point of view!

Now a good indication that we have achieved something significant, is whether our conclusion give rises to some interesting questions. And this seems to me that this is indeed the case.

The structure of a virus is very elementary. There is a lot of variance, but all of them have a DNA or RNA (single or double strands) and a capsid, an involucre, which protects the strands.

Thus there is no brain for sure.

And so where resides its thinking capability? What are the mechanisms underlying this capability of thinking?

The answer to the first question can only be: it resides in the DNA or in the RNA according to the cases. So we already see a first interesting consequence. Thought can be host by a DNA or RNA, and thus, while a brain certainly is functional to thinking, it is not required in general.

We don't know how generalized thought is host and we don't know by what mechanisms this thinking is made possible. I guess that we don't have, at the present state of art, the slightest idea about how answers to these questions can be given.

I think that neither the evolutionary perspective has the answers, nor the idea that all this is made possible by chance makes any sense.

And I think as well that these questions are interesting and nice questions, which have not been posed so far.

They deserve substantial efforts of investigation, leaving alone, the pointless debate on whether or not viruses are alive.

DNA was discovered by F Crick and J. Watson (see [1]) in 1953. Interestingly, E. Schrodinger, one of the fathers of Quantum Theory, has lucidly stated in his book (see [2]) that in the genes there should be molecules capable of encoding a complete description of a human body and its functionality. Watson said that Shrodinger's book inspired him to study the problem.

If one looks to the way DNA is replicated during Mithosis or at the way the DNA is used by the cell to produce proteins, he/she realizes that these processes are extremely complicated.

For example, here is a very succinct description of second process. Protein are encoded in subsequences of the DNA called genes. When a gene is activated, by means of a further mechanism, it is transcribed in a messenger RNA. So the transcription in a RNA sequence requires recognizing the start and the end of a gene within sequences of huge length and then individuating the appropriate gene. Then the gene is transcribed in a RNA strand, which undergoes further modifications, and then gets out of the nucleus in the cytoplasm. Here the ribosomes read the code, three letter at a time, and to each triplet produce an aminoacid forming the chain that morphs into the protein. This is a very sketchy description, reality is much more complex and so is the description of the various mechanisms involved. For example ribosomes and how they work. And then there are the regulation mechanisms that determine for each cell what are proteins are to be produced and what are not, at any given time.

And this is not all. In the DNA there is a lot of repetition of sequences. They make a substantial part of the whole DNA.

Until recently, biologist used to call these sequences junk DNA. This is the exact antithesis of what it is meant to be a scientific mentality. A true scientist never denies evidence. If repetitions are there it will be for a good reason. When one does not understand something, it should be happy undertaking the new challenge: lets start a hard investigation and work to give an explanation! **"Travaillons donc à bien penser!"** Which is just the opposite of saying "because I don't understand this fact, it means that it is wrong".

Anyway today the scientists are starting to understand the reason of these repetitions.

Now all this bewildering complexity excludes in my opinion, as a complete explanation, any hypothesis of an haphazard origin of life or any evolutionary theory.

Under all these mechanisms there is a huge amount of thought: it is the most monumental and complex enterprise of engineering that we know of.

Again: Where is hosted the thought that performed the design of leaving entities and how this thought has worked to conceive all these extremely complicated and yet perfectly working mechanisms, which make life possible?

Beyond that and adding to this feeling that haphazard is impossible in biology, I strongly agree with the idea that to a very large extent biological mechanisms are quantistic in nature. There is a lot of obvious evidence for that, as stressed by R. Penrose in both the books [3] and [4].

So we have here huge mysteries here that deserve a thorough investigation. This is good news. A life without mysteries would be, in my opinion, a dull and boring life, more than that, it would be a miserable life. Working at solving mysteries is the most noble human activity and is the one major way to give us a reason to be living.

References

[1] J. Watson, DNA THE SECRET OF LIFE", Arrow Books, London, 2004.

[2] E. Schrodinger, "What Is Life?" Cambridge University Press, Cambridge 1967

[3] Roger Penrose, "The Emperor New Mind", Oxford University Press, 1989.

[4] Roger Penrose, "Shadows of the Mind", Oxford University Press, 1994.