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This white paper emerges from conversations that I have been having on longevity with Guy Spier, Maya Elhalal and others. It presents my current thinking on this topic. While it's pretty clear to me that many of us (or at least our children) will most likely live for 1,000 years or more, my experience has been that even when it comes to intelligent and thoughtful others, this probable reality has yet to dawn on them.

I wanted to set down my thoughts as a way of educating my friends and others within my network for four reasons.

- a. To help the reader to understand why extreme longevity is inevitable.
- b. To start conversations about the implications of this.
- c. To learn from others who might contribute to my knowledge on this topic.
- d. To help increase the resources (financial, brain power, political support, etc) that society allocates towards this important goal.

It goes without saying that this paper is the product of my own reading and research. While it has been extensive, it has not been systematic. This paper represents the current state of my evolving understanding of the areas covered. Thus, there are likely to be gaps in my knowledge and understanding of many of the topics.

With this in mind, to the extent that you have thoughts, comments and suggestions, please don't hesitate to email me: [ori@emergingvaluefund.com](mailto:ori@emergingvaluefund.com), and I will incorporate them into an updated version of this document and recirculate.

### **Why We Will Live For At Least 1,000 Years (And Probably More)**

My thesis is that medical technology will develop ways to reverse and repair the accumulated damage in our bodies that we call "aging". Doing so will also prevent the various illnesses of aging such as cancer, diabetes, alzheimer's and heart disease. While our technological progress will be punctuated and irregular, each advance will incrementally extend our human lifespan. For most of us, these advances should be sufficient, each time, to increase our lifespan long enough to allow time for the next advance, such that our healthy lifespan should be, effectively, infinite (but let's call it 1,000 years).

### **Explanation**

While this may be a startling claim, I hope to show you that it is not at all unreasonable and ultimately inevitable.

We start with the claim that the human body is just a machine. Indeed, an extraordinarily

complex one, but at the end of the day, a machine that is subject to the same universal laws of physics, mechanics, chemistry and biochemistry. In other words, there is nothing mystical or magical about how the human body works.<sup>[ii]</sup>

Given sufficient technology, knowledge, time and resources, there is nothing, in principle, that will prevent us from maintaining the human body in the same way that we can maintain other machines. And in the same way that any other machine, given the right care and replacement parts, can be maintained forever, so can our human bodies.

When viewed in this way, we can understand medicine as simply a form of highly complex engineering applied to the human body. Once we have mastered the relevant technologies and techniques, the challenges will not be insurmountable.

Indeed, medicine is rapidly transforming into information science. This is a process which started with gene sequencing and has moved on to new technologies like iPS cells and CRISPR - where we are increasingly mastering our ability to synthesize the tools and materials we need. Moreover, as more and more of medicine becomes information science, it will benefit from exponential, rather than linear, progress.<sup>[iii]</sup>

### **Understanding Aging**

The best way to understand aging is to consider it a gradual accumulation of different types of damage in the body.

In order to understand the concept of accumulated damage, let us use the analogy of a laptop computer. When it is new, the hard drive is mostly empty, it has few programs installed and runs rapidly and faultlessly. But over time, the hard drive gets filled up and fragmented, more and more software gets activated on startup, malware and spyware creep in, the registry gets cluttered, etc. Moreover, dust enters the casing, the cooling fan slows down and the springs in the keyboard get worn out.

These are all forms of “accumulated damage” which result in the laptop becoming slow and faulty. After accumulating all this damage, we can say that the laptop has “aged”. Many aspects of the laptops functionality degrade until it succumbs to old age (too much accumulated damage) and dies.

When it comes to a laptop, we understand how to rejuvenate it: we can de-fragment, or reformat the hard-drive, or even replace it. We can add and replace memory and faulty keys - or even the whole keyboard. We can reinstall the operating system from scratch and remove unneeded software. We can use an anti-virus program to remove malware. And we can even replace and upgrade the CPU and/or the motherboard. In doing so, we can stop and even reverse the aging of the laptop, and can, in principle, keep it running forever.

Similarly, the illnesses of aging are either caused by, or are a direct manifestation of damage accumulated in the human body. For example: Heart disease is mostly caused by the accumulation of plaque in the arteries. If we were able to remove that plaque, we would largely remove heart disease. Similarly, Alzheimers is believed to be mostly the result of

accumulated junk in and between brain cells as well as the loss of neurons. All of these forms of accumulated damage are, in principle, reversible.

Aubrey de Grey <sup>[iii]</sup> and others have already identified the seven types of accumulated damage in the human body that we call “aging”. He has also identified plausible methods by which medical science, or medical engineering will be able to stop and reverse all of these seven types of accumulated damage. Researchers are already working on methods and cures to stop and reverse all these.

For example, one type of accumulated damage is the gradual loss of cells over time. This can, in principle, be repaired by introducing embryonic stem cells into the target areas of the body. Extensive research and development is already being done in this area. Another type of accumulated damage is the accumulation of junk between the cells of the body. This type of accumulated damage can, in principle, be repaired by teaching the body’s own immune system to attack and eliminate this accumulated junk.

### **Strategies To Combat Aging**

Once we understand that aging is essentially the accumulation of damage at the organ, cellular and molecular level within our bodies, four interconnected strategies become apparent to combat aging:

1. Slowing down the accumulation of damage in the body
2. Reducing, delaying or bypassing the effects of accumulated damage in the body
3. Repairing the accumulated damage in the body
4. Replacing body parts that have accumulated too much damage

All four strategies are already being pursued in parallel. Because they are interconnected, it is likely that success and progress on any of the four strategies will help inform and promote progress on the other three strategies. From my reading and analysis, I believe that only strategy #3 will lead to an indefinitely long healthy lifespan – sadly this strategy receives, by far, the fewest research dollars. It is my hope that this whitepaper will help drive more money and resources towards strategy #3 possibly via donations to the nonprofit leading this type of research – [www.sens.org](http://www.sens.org).

### **Conclusion**

Over the next few decades, medical science – increasingly called medical engineering will provide ways to both stop and reverse the accumulation of damage in the human body that we call aging. As a result, healthy life expectancies will increase rapidly until reaching the tipping point where healthy life expectancy increases by more than one year every year at which point death due to aging becomes improbable. If we exclude horrific dystopian futures such as a global nuclear war, or similar overwhelming disasters, I see no credible future scenario where an essentially infinite healthy lifespan for humans does not happen.

The only significant uncertainty from my perspective is timing.

### **Objections or Q & A**

1. New medical developments will be available only for the super-rich:

Like all new technologies, new medical solutions will rapidly filter down from the rich to the middle class to the poor as economies of scale reduce costs.

2. Progress may take much longer than we expect.

Initially, progress may well be slower than what we expect and our lives might end before sufficient progress is achieved.

But the predictions above have significant margin of safety.

- A lot of research is already being conducted in this area<sup>[iv]</sup>
- As mentioned before, medicine is becoming an information/ engineering science subject to exponential progress.<sup>[v]</sup>
- We are making progress on other technologies which will also help - including nanotechnology, artificial intelligence, artificial organs and others.
- Incremental progress will increase lifespan, buying more time for more progress.
- We ourselves can accelerate progress by donating money to sens.org and similar foundations and by voting for leaders that support scientific research and progress.
- Lastly, as progress is made and more people realize the truth of this thesis, an enormously large amount of society's resources will be allocated towards these goals.

3. Extending life span beyond 120 and reversing aging may be an "all or nothing" endeavor.

Until we can stop and repair all seven types of accumulated age related damage in the human body and cure all age related diseases, making partial progress may be of limited value since it just means something else will kill us soon after. For example, it has been argued that curing cancer would only add about 3 years to the average human lifespan as those that would have died from cancer end up dying from some other age related illness soon after.

- This is possibly true but does not break the thesis, just delays it.
- We are already working on methods to stop and reverse all seven types of accumulated damage and curing all age related diseases.
- Age 120 seems to be the age where we are likely to suffer from all age related illnesses simultaneously. In other words, at age 120 most humans would suffer from terminal cancer,

terminal Alzheimer's, terminal diabetes, terminal heart disease, etc all at the same time. Therefore, breaking beyond the 120 age limit may indeed be all-or-nothing. However, extending healthy lifespan up to 120 is probably not all-or-nothing with partial progress having meaningful life extending impact.

- For myself and many others, age 120 is still a long time away - thus there should be sufficient time to make progress on all fronts.

- Partial and even limited progress on all fronts will buy us more time to make further progress.

4. Radically extending lifespan will cause severe problems of overpopulation, social unrest, mass unemployment, pollution, water shortage and other problems

- As life expectancy increases, birth rates will rapidly decline.

- We are well on the way to solving energy, water, pollution, food and other problems via advanced technology. Once these issues are solved, overpopulation will no longer be a problem. The earth can sustainably host tens of billions of humans.

- Mass human unemployment is inevitable due to the rise of AI, regardless of lifespan extension. With universal basic income, this becomes a positive as humans are freed from the bondage of working to survive and can, instead, devote their time to leisure activities.

<sup>[i]</sup> Several early readers of this whitepaper have tried to argue that the human brain is somehow "magical" or beyond the laws of physics. There is zero evidence to support such claims.

<sup>[ii]</sup> <http://www.kurzweilai.net/the-law-of-accelerating-returns>

<sup>[iii]</sup> <https://www.amazon.com/Ending-Aging-Rejuvenation-Breakthroughs-Lifetime/dp/0312367074>

<sup>[iv]</sup> <http://www.sens.org/>

<sup>[v]</sup> <https://singularityhub.com/2016/10/26/medicine-will-advance-more-in-the-next-10-years-than-it-did-in-the-last-100>