xxxx,

I promised in my last phone call to lay out the possible solutions and hazards of achieving immortality. So here they are.

This is a big topic, and I cannot explain the details of every technological or scientific breakthrough that contributes to various possible sceneries. I shall just paint out one or two most likely (also least imaginative) way it can be done. In short, medical advancement will continue to prolong lifespan, much like it has been for the past few decades, if not a century. From what we currently know about genetics, cell division is "numbered". That means anywhere from 120 to 200 years maximum age for us. When we hit that, we may require either genetic modification to facilitate indefinite cell division (as cancer cells do) or repair the broken telomere ends (like rewinding a genetic clock, I shall explain later). Alternatively, we can choose to live in other life forms, software being an example. This is the main theme; let me fill in the knowledge gaps by going through each method in more details.

It is believed that Sciences and technologies grow exponentially, what took decades in the past now takes years. That may differ from our perception mainly due to social resistance, and lack of financial support. I am going to confine myself to those already working in labs, with the conscious that lack of investment and barriers of entry may further postpone commercial applications. Even if delays are to be expected, with an extra a hundred years in your life span, there are after all some hopes.

I shall start by telling you a bit about technologies already working in some of the hospitals.

The cost of genetic sequencing, which used to run at billion dollar figures in 1990s, has now dropped to around 1000 dollars. It is to drop another 10 fold in the next few years, a decade at most. (The drop is exponential, but not smooth like Moore's law) By then, most citizens in the civilized world can afford to have a copy of his gene map. This will help fuel an explosion in drug development. Why? At the moment, drug development is very expensive because you have to ensure your drug is lethal to no one, and useful to (almost) everyone. That results in waste in the form of drugs that are poisonous to some people but work wonder on others (thought to be due to genetic differences). In short, the current problem is that we treat all patients as the same. After the introduction of gene map, we can say for sure that medicine development will be somewhat streamlined, even automated. In fact, we have already seen an upshot in specialty medicine deployment in the past few years. That shall serve as a preview of what could come next.

Some diseases require medical operation. Luckily because operations can benefit more from physics and electronics than bio-chemistry, development in this area is ahead of medicine.

I saw on a news paper months ago that a patient with brain tumor was cured in three days after receiving few microwave shots a day. I knew about this technology maybe 4 or 5 years ago, it involves three microwave guns shooting wave into one's body tissues. The antennas are so pointed and tuned such that the waves form a constructive interference at the point of tumor. Since destructive interferences occur elsewhere, tissue damage is confined to the tumor. This technology took 4-5 years to become relatively cheap (10k GBP) in a few well equipped hospitals around the world. It may take another 10 years to become standard procedure (say, like sound waves used in removing kidney stones)

I recall seeing an article reporting a recent approval of blood substitute. The idea is to replace patient's blood, cool down the entire body by about 10 degrees, thereby making dangerous operation much easier to perform. But I could not find the article now, for not remembering which country approved it. Meanwhile, I checked the recent approved list on FDA website and identified an organic heart valve thing. I saw this idea 6-7 years ago. Ideally, the structure should be engineered from the patient stem cells, so to avoid body rejection after transplant. This one, however, uses tissues from cows. That is somewhat expected (I will explain later). Also on 2013 approved device list, a spectacle that stimulate retina by sending video signal to the brain was introduced. I remember telling you about an audio version few years ago, you even incorporated in your story <Cactus Head>.

Now onto stem cells, I said I don't expect to see it commercialized soon, that is because the impact will be revolutionary (hence there have been intense social resistance). At the moment, we are still to figure out how stem cells turn into other cells. In practice, we can turn them into blood, muscle filament, or skin pigment, but we do not know why they work. (Medicine often works before we understand why they work) There are a lot more complex structures we do not yet know how to program stem cells into (it involves bio-engineering in three-dimension; here dissolvable scaffolding is the key we are searching for). Progress is been constantly made, as evidenced by the introduction of artificial (yet costing million dollars) beef. Going from there to making entire vessel, then to artificial kidney, heart and other organs may be one or two decades away. As soon as that becomes doable, we will have cushion to fall back: If conventional medicine fails us, we can always replace the damaged organ with a new one. With stem cell incubation, they do not require a donor, or life long medication to contain anti-body rejection. We may not solve the mystery of cancer any soon, but we shall be able to detect their genetic markers before they spread. That is, cancer can be contained despite we haven't come to understand them. Oh, we will understand them. Computer simulation has so far accomplished modeling of single cell. You may say that is nothing. But that means we can now model how cancer works on single cell level. That is like going from clueless to having Newtonian mechanics.

Now I venture into something I lack even basic understanding–genetic medicine.

It is true that we do not need to modify gene to combat many diseases. Replacing faulty body parts shall do, like people keep replacing old water pipe and furniture in home. But it would be so much cheaper just to fix. For that we need to understand how gene works.

So far, our knowledge about gene is fragmented. That is mainly because experiments were expensive and slow. For example, if a researcher wants to know whether patients with certain disease carry the same genetic traits, he needs to perform the million dollar (the cost about 10 years ago) genetic sequencing on every one of them. To save money and time, researchers only sequence a small segment of selected chromosome (so 1/23 of the entire gene) which they think have the highest chance of finding the answer. Now, if sequencing becomes so cheap that nearly everyone got his blueprint in digital forms (there will be privacy issue to solve, another social resistance), researchers can finally focus on analyzing. Having said that, to develop a computer model that predicts exactly what will happen when a gene is altered will be difficult. It requires too much computing power. But to see correspondence between gene and disease would be much easier (comparatively). From there, researchers may learn how to fix some diseases once for all.

I talked on the phone about an old method of gene modification- the random bombardment of high energy particles at the object. This method worked with seeds of plants mostly. It is quite outdated and wasteful. The new methods involve too much bio-chemistry for me to understand, but the idea is simple: pinpoint the useful segment of alien gene, extract it, and introduce it to a modified sanitized carrier virus. From there, one can use precision tool to infect certain cells (the precision can be down to a single cell). The virus is modified such that it can hijack/merge with a foreign gene yet it carries no harmful “recipe” (DNA is the recipe for making proteins). Through this process, a person’s gene can be changed regardless of age.

Aging itself is a disease. Like most complex diseases, it cannot be traced to one source. But a definite cause we need to tackle is the shortening of telomere. The design of telomere demonstrates how lazy nature is (mainly because it is never survival the fittest, it is survival the fit enough). You see, when cells divide, the physical size of enzyme (the copy machine’s pen) limit its ability to copy the last few ‘words’ on each sequence. To prevent that from causing cells to fail, evolution provided a disposable buffer—telomere. After many divisions, telomere is exhausted, and cells start to lose vital genetic information, which leads to cell death. On a group basis, we see slower regenerative speed as one age. In this sense, exercise kills. (Exercise force cells to speed up division) But to be fair, most people die of chronicle diseases, heart attack and so on. Very few people die of exhaustion of regenerative power of cells. (Alzheimer, on the other hand, appears to be the lack of regenerative power of neurons.) Adding artificial telomere to prevent cell decay is doable, and has already been successfully done on lab mice. The process is similar to gene therapy described above. However, at the moment, the therapy has the side effect of increasing the chance of cancer. So it is probably decades away from human trail.

Let us pause for some humanitarian thinking. You are familiar with the evolutionary viewpoint; it is not surprising that you should argue that the finite length of telomere is giving human an evolutionary edge. Death is necessary for adaption, and it is true for all living things. That is until gene therapy alters the paradigm. In the wild, when environment changes, new generation with the right mutation has a better surviving chance. In nature those species that never die (a type of jelly fish), or live for thousands of years all have low fertility (or survival rate for babies) and high tolerance to outside changes. Human has past the test --we can change the gene of adults (though not widespread practice, yet) , not to mention that technology has already made the specie more adaptable than most species on Earth. The problem is fertility, or the population bomb.

The trend is good, at least in the developed world. One source interpolates that about 20% of adults will never get married in year 2030. Many will marry late or choose not to have children. Those who have children, tend to focus on one egg rather than a basket. (Working mothers in America spend more time taking care of children than housewives in the 1950s) Nevertheless, population keeps on growing, mainly in the developing countries. Population bomb has in fact ignited many wars in the past, and it is not unimaginable that it will continue to do so. We have to deal with the population bomb, either by keeping expanding our capability to venture into the unknown, or witness how wars and starvation keep population in check. Chances are, over the long term, both effect will be felt.

Back to technologies, we now turn to neuroscience.

If a person's body decays reasonably slowly, to the degree that only his brain is functional, he would still have human like conscious or self-awareness. Over time he would develop certain behaviors and personalities that are often observed with the blind, the deaf and other disabled groups. Despite of disability, their brain functions are largely unimpaired. In fact, recent experiments show patients are perfectly capable of regaining skills if artificial eyes, ears and limbs are connected (even when remotely connected), even after being disabled for decades. This tells you how adaptable human brain is.

By being adaptable, it is possible to replace every body parts with mechanical substitutes. It is not ideal, but a desirable work-around before stem cell enabled transplant technologies become widely accessible. Research is far ahead in this bio-electronic direction, as exemplified by the FDA approved electronic eyes that I mentioned earlier. Non-intrusive brain scan technologies (MRI, EGG, MEG,TES, Positron emission tracer, Deep brain simulation. I bring up the names just to show you the extent of progress, in case you are stuck with the memory of MRI being the most advanced scanning technique.) are helping us probe deeper and resolute finer details of brain's inner working. As of last year, researchers have learnt to locate specific neuron group for specific memories. They can pinpoint the group of cells that are responsible for your memory about, say your ex, or a painting, or anything else. They can use precision tool to destroy those cells to erase a particular memory. It is difficult though, because memories tend to have many copies spread around the brain, and mixed with other memories. So, to eliminate one particular memory, not only several shots need to be administered, but also there are some side effects. Note, the side effect is not an intrinsic property of the brain function, but a byproduct of the limited resolution of our apparatus. In other words, if we can improve brain scan technology to the resolution of individual cells, it might be possible to identify cells that are responsible for the smallest unit of memory. Ah, what is a unit of memory? We do not know yet. That means, we might even learn how memory is ultimately comprised of.

Even before that understanding is realized in the lab, there have already been practical applications tested. For example, researchers could copy electronic signal from a mouse's brain when it is learning to navigate through a maze. The electronic pattern is then reproduced and simulated when the mouse seems to have forgotten how to walk the maze. This electric shock works as a strike of inspiration, the mouse immediately relearnt what is forgotten. While we do not know how the electronic signal is interpreted and converted to memory, it is clear now deep brain-machine interface is do-able. Another experiment used MRI scan and Artificial intelligence to establish correlation between pictures (in a database) and brain signal patterns. After finding tens of thousands of correspondence, researchers could reverse mapping to tell roughly what you are thinking (or dreaming). An inexpensive version of brain-machine interface technology using EGG is already commercially available, as gaming consoles. Don't worry yet about brain hacking. Human skull shield electric signal almost completely. It requires deep brain implant or powerful MRI to invade one's privacy.

In short, over the past few decades, neuroscientists learnt to simulate first emotion, then muscle modulation, and lastly memory and sensation, roughly in that order. One area that we do not have definitive understanding is the process of thinking. Hopefully we will in the next decade. Before that time comes, a dying person could have his memory downloaded and preserved for future use. But let's not be narrowly minded. When a whole life of memory can be downloaded and uploaded to anyone, it will become hard to define who is whom. Think about it, every night you go to sleep knowing that brain shut down to sleep mode for 8 hours. Every morning when you wake up, you can only remember a small portion of yesterday's occurring. Question: How do you know you are the same person from yesterday? You don't. Let's push it a little further. Someone got hit by a car and went into coma for a few days. When he wakes up, he not only loses the sense of time, but also inevitably loses a large chuck of memory. How can he be sure who he is? Mostly likely, he would suffer from some kind of confusion for a while but regain "conscious" over time. The process is akin to the one I explained in previous email on the topic of brain splits patients. The illusion of 'self' is an intrinsic function of the brain. There are countless psychology experiments that show you can put ideas into one's mind (by the primitive hinting methods practiced by psychologists) and the subjects tend to take the ideas as their own when asked to recall them. In the process, their memory gets twisted to fit the story. If the coma patient received an operation to erase his own memory ENTIRELY and replaced with someone else memory, would he notice during the time at the hospital? Unlikely. I know there are some Hollywood movies with such plots, but they tend to have writers who are too keen on drama , too short on understanding of how brain works. The transplanted memory is now the ONLY memory of the patient. Do you know anyone who goes at length to disprove his only memory when evidences show contradiction with memory? Not many for sure, and the pain and discipline required is great even if it is just a small matter at stake. Plus, the discipline in thinking is embedded in memory. So the patient who looks out for clues is investigative because the implanted memory is filled with investigative experiences, rather than the other way around.

Now, imagine, the entire life of memory from your father is uploaded to your brain one night during your sleep (let's for now assume it does not cause overload). You would wake up resembling the guy in coma, furiously working out what happened, and in the process twist the facts like the psychological experiments' subjects, inventing theories to explain why there are two personalities and life history in one mind. Without any scientific understanding of what happened, you might go crazy. With proper understanding, you can be at peace with it. Yet memories are not merely information, they shape habits and personalities. So over time, you would probably pick up some of his habits, etc.

Well, enough of drama. Scientists never intend to transplant a cat's memory into a dog. Ideally they would just create a replica, whether it is a bio-clone or a cyber-clone, and copy and paste the entire brain's information (not just memory). If it is a perfect bio-clone, the person would hopefully experience no rejection, probably feeling like waking from a nap. Reality is never that perfect though. We may not be able to develop a brain that is blank, or create 100% match, or something else. But brain can cope with most of the glitches. Like someone waking up from coma realizing he lost a limb, he copes. Personalities will change because of changed social status and so on, but you cannot deny the continuity of individuals.

Back to the sentence "do not be narrowly minded". Life experience, ideas, beliefs are passed on from one person to another, through books, lectures and casual chats. In a sense, one person is never entirely himself. He is rather a coherent collection of memories. The more well read the person is, the more "hybrid" he tends to. An ability to download and upload memories directly is simply a leap forward in accuracy and speed for this type of "fusion". If brain has unlimited capacity (which is not true) to absorb memories and fuse them with the existing memories, there will be no sense in distinguishing you from me, him from her.

Well, that was a thought experiment that has profound implication. But, once again let us return to the narrowly minded goal of prolonging an individual's life. The reason I flirted with the idea of shared memories is because the human life form must change if immortality is to be achieved. The carbon based biological structure may work fine on Earth, given we could solve the telomere problem and cancer and Alzheimer and whatever comes after. But what about else-where? What if some other superior form came around?

OK, let's confine ourselves to what is already known. We know machines are better at certain tasks, both mentally and physically. We cannot convert ourselves entirely to machines because we have not yet figured how the flesh works. But even before we come to full realization, it doesn't hurt to merge the flesh with the digital and the mechanical in minor ways. This can be done by ex-skeleton, limb transplant, bionic sensory devices (e.g. eyes, or contact lens), wireless connected brain-machine interface. Maybe better solution would arise in genetics that helps to achieve the same effect without foreign silicon parts. Prolonging life and enhancement of capacity comes hand in hand, because the ability to survive in disaster reduces mortality rate.

While aging society brings many challenges, an un-aging society brings more social problems that are unprecedented. For example, how to ensure the old are sufficiently innovative to offset the lack of new born, how to deal with the conflict between people who choose different evolutionary path, etc. These are again social resistance.

Xxxx

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