Chapter 10: The Promise of Genomics, Robotics, Informatics and Nanotechnologies (GRIN)

Vignette

Net-Log

Malaga, 10 January 2034.

Mixed emotions ravage my soul, if anything is left of it. I now remember almost everything, especially Laura, the most valuable piece of all that was seized from me.

I can no longer continue to evade the truth: I was solely responsible for the accident. I should never have driven in such heavy rain, knowing my own state of health. It is true that up to that point I had never suffered such a severe fainting episode. But on that day, of all days, I should have been more aware than ever of my limitations.

We were on our way to the hospital where I was to receive the Langerhan gene therapy that would finally revert my advanced state of deterioration. A new life, more time to share with her...

And then the emptiness... that inability to remember anything for more than 5 minutes, forcing all those around me constantly to introduce themselves. After the accident I also lost my sight, and they had to amputate a leg. A pacemaker, a hip replacement, hearing aids... I suppose I became a real monster for those around me. But perhaps I did have an inner consolation: my unawareness of what was happening. A living death.

But what am I now, truly? My eyes are nanocameras. My legs made of metal. My body is home to dozens of gadgets, which regulate my blood flow. Even my mind is artificial. They call it a neo-hippocampus, and apparently it replaces a part of my brain that was damaged by the haemorrhage caused by the accident, or my illness… it doesn't matter. And what am I now? Man or machine? Or worse still, what percentage of me is human and how much is not? And my soul? Is that still human?

I suffer now. I suffer the absence of Laura, who was everything. And it may be that my new memory will not help much when I try to stop thinking about her. It would, unfortunately, seem to work very well. On the other hand, though, I must acknowledge that I have been able to meet my grandchildren. With my new eyes and new mind, I can enjoy being with them and then remember every minute together. Maybe I am no longer a burden to others. And maybe those flashes of happiness with my family more than make up for my suffering. I can now help others by recounting my experience in this Biographical Register of Well-being, shared with the whole world. Maybe that is what it means to be human now.

Summary

Have humans reached a turning point in their evolutionary journey? Have humans been preparing the way throughout their history for the advances that will enable them to overcome eliminate previously incurable illnesses this century? Will humans reach immortality by the end of the 21st century?

The "scientific" approach to knowledge about the human body began with the observation of its inanimate anatomy on the dissection tables during the Renaissance

(although there do exist prior records of considerable empirical knowledge, notably among the Egyptians), moving on to knowledge of the organs, then the tissues, later still the cells and their organelles, finally leading us to the code of life stored in our DNA, while opening the door to an era with promising technologies for the manipulation of our bodies at the molecular and sub-molecular level. The same process has occurred in other fields, with reality being gradually broken down to its most basic elements: gene, bit, atom... Whether this degree of ever increasing 'unpacking' of our bodies will translate into ever lasting health, and even immortality as some prominent scientists suggest, remains to be seen.

Regardless of where the ongoing scientific revolution leads, aggressive efforts are being made to conquer chronic diseases by harnessing the power of genomics, robotics, infonomics and nanotechnology. This technological foursome, also known as GRIN, is heralding enthusiastic hordes of innovators devoting their energies to the reverse engineering of existence, working back towards the artificial reconstruction of our selves. Within this great field of integration, referred to by many as the 'grand technological convergence of the 21st century', lay many potentially useful contributions to the fight against illnesses, in particular those currently considered as incurable or chronic and that have resulted from our long life expectancy and longevity. These technologies also promise to alter our relationship with disease, profoundly, and to shape the destiny of our species.

Why is the topic important?

Throughout the final decades of the 20th century, with the decoding of the DNA, the seemingly unstoppable power of computers and the increased ability to manipulate matter at the molecular level, humans started to feel increasingly confident about their ability to eliminate disease and conquer death. At the dawn of the 21st century, however, it is not clear whether this will be possible. At this point, there are more questions than clear answers, particularly in relation to what seems to be an 'inconvenient' adverse effect of our scientific and technological success since the Enlightenment: the high prevalence of chronic diseases, and the associated wave of poly-pathology.

Humans tend to consider themselves as the pinnacle of evolution, thinking that everything that has so far occurred has been 'programmed' to result in them. However, it is also possible that humans are mere evolutionary specks moving along a trajectory that leads to a future without them. Given our capacity to create hugely powerful technological extensions to overcome most of our physical (and increasingly, cognitive) limitations, therefore, it is reasonable to ask: Are we simply transitional elements on the pathway towards a 'post-human' species?

We have known since Darwin that the genetically best-endowed individuals are those with the greatest probability of surviving and reproducing. We humans have, however, succeeded to a great extent in interfering with the laws of evolution.

Today, the bearers of defective genes survive and reproduce thanks to scientific advances, allowing for an increase, even in cumulative terms, in the survival rates of specimens that will guarantee the presence of such genes in subsequent generations. Now, the children of diabetics and hemophiliacs may thus be able to live with both diabetes and hemophilia, and yet achieve life expectancy long enough to reproduce and to "gather" even more chronic conditions. Up to less than a century ago, this would have been unthinkable †(1, 2).

As we tinker with nature, however, we are not only slowing down the "trimming" aspects of the evolutionary process, but also accelerating the process from an adaptive perspective. Genetic changes that would otherwise require thousands or even millions of years can today be implemented by means of simple techniques of manipulation at the laboratory or research centre of any moderately sized organization. We are now able to enhance the human body with modifications to an organic function by replacing pieces of DNA or by implanting biomedical devices.

Traditionally, since childhood, we are taught that life is made up of four stages: birth, growth, reproduction and death. Given that most adults have their children before the age of 40, it would be easy to understand that with reproduction we fulfill our essential purpose, the survival *of our genetic information as a species.* From that point onwards, as it happens to all other living beings, all we should have left is the alchemical rebalancing with the environment having reached our point of maximum entropy... our deaths. However, we human have pursued a different path. Thanks to the massive parallel computing power of our brains, we have been able to embark in a relentless pursuit for immortality that is getting us close to the point at which we might be able to surpass many of our most basic limitations (a - Jadad AR, Enkin MW. Computers: transcending our limits? BMJ 2007; 334 Suppl 1:s8): carbon-based units of weak bones surrounded by soft tissue, requiring narrow bands of pH and temperature, in the permanent presence of O_2. Some even conceive a not-too-distant future in which our inventions exceed all of our capabilities, blurring the boundaries between human and machine, blending us into a new single entity, known as the Singularity (3).

This chapter deals with the main forces that seem to be driving this unprecedented evolutionary process at this point - genomics, robotics, informatics and nanotechnologies - which are collectively known as GRIN (b [esta es la referencia 29 actual]- Garreau J. Radical evolution: the promise and peril of enhancing our minds, our bodies—and what it means to be human. New York: Doubleday, 2005).

What do we know about this topic?

Instead of the traditional futuristic archetypes of humanoid robots collecting physiological information from us while using their free time to take care of household chores, technological trends are pointing in the direction of much more complex scenarios in which thousands of interconnected gadgets provide ubiquitous services (4). We are already seeing this through a plethora of projects that promote Ambient Assisted Living (AAL), an area that is receiving considerable attention in the regions of the world that display the longest life expectancy, such as Japan and the European Union (5, 6).

The following is a summary of what is happening in relation to each of the components of the GRIN movement.

The G factor

Today, it is already relatively straightforward to change the structure of a section of DNA in a laboratory, use a virus to introduce it into a cell, and see if it performs a particular function. This technological feat, however, has not translated in the

spectacular breakthroughs in the management of disease that were expected at the time of the decoding of the human genome. Although it would seem that this is just a question of time (c- http://www.futuremedicine.com/toc/rme/5/2), it is possible that given the myriad elements that explain most of the chronic ailments affecting humans, regenerative medicine and gene therapy will only be successful at curing a handful of minor diseases, failing to produce the expected 'silver bullets' that would correct the main sources of morbidity and mortality for single major diseases. The picture is even more dismal in relation to potential gene therapies for multiple chronic diseases.

The R factor

There have also been impressive developments in robotic therapy (11, 12). However, the results are still falling short of the expectations of a few decades ago.

In Metropolis, the famous film of the 1920s directed by Fritz Lang, a futuristic society was divided into two castes, the thinkers and owners who lived on the surface, and the workers of the underground, laboring ceaselessly to maintain the pace of life of their masters. They, ultimately, come into conflict. Maria, the leader of the oppressed, is kidnapped by the masters and replaced by an android replica, with the aim of sowing chaos among the rebels. The humanoid image of this robot then became the popular archetype that has ever since inspired hundreds of researchers into artificial intelligence, viewing the replication of the human form as the logical path to the future. However, this *descendant* vision championed by many has been challenged with compelling arguments.

Many leading experts believe that we should promote the basic conditions required to allow artificial intelligent systems to evolve, spontaneously, learning in a self-organized form, in the belief that once they have surpassed a certain threshold of information processing, intelligent behavior would emerge. The aim, then, would be an attempt to emulate what happens, for example, in colonies of termites, which are capable of manifesting the emergent intelligent behavior that allows them to construct sophisticated ventilation and storage systems, in a way that could not be explained by the arithmetic sum of their individual intelligences. In this case, the transfer of simple short-range chemical messages can generate highly precise coordinated reactions similar to that of neurons interacting through neurotransmission in their synapses.

As these two currently opposing strands evolve, an intermediate pathway represented by advances in so-called "human-machine interfaces" is evolving; the very same approach that has guided the development of tools capable of overcoming our limitations (e.g., pulleys, cars, planes, computers). Today, the boundary between biological and artificial is becoming blurred. Advanced surgical techniques are now beginning to be used to incorporate cybernetic creations as extensions to our own biological structures, bordering in many cases on what some still view as science fiction. Chronic illness associated with the loss of limbs following accidents, in particular in traffic incidents and the workplace, are being managed with highly sophisticated controllable myoelectric prosthetics and re-nervation techniques (13) which may soon incorporate haptic interfaces capable of providing a sense of touch. Cognitive robotic innovations are also being spurred by advances in functional magnetic resonance imaging, which allows careful observation of neurological activity in areas affected by neurodegenerative conditions or by strokes.

The I factor

Information and communications technologies represent more than simply another piece in the jigsaw being outlined here. They are essentially the glue that binds together the GRIN complex and underpins its potential.

The power of online social networks has been expressed clearly during natural disasters (14). As official information management systems were rendered ineffective by Hurricane Katrina, members of the public were able to generate, in a matter of hours, an online repository of resources and database of victims, allowing thousands of people to locate their relatives swiftly (15).

Similarly, many patients who were previously left to endure in solitude the daily consequences associated with chronic diseases are now beginning to join forces, supporting each other as "prosumers" (16,17) or as e-patients (18).

In addition to the growing level of patient emancipation afforded by social networks, another powerful shift in the way in which humans create and manage knowledge is being caused by hybrid webs or "mash-ups"(19). In essence, this involves something like "a pinch of this and a dash of that" in order to extract and blend different functional elements of disparate applications into a new set. As a result, it is now possible to blend electronic health records, large databases of demographic data, online maps and powerful statistical tools to create dynamic spatial representations of the distribution of diseases in a population, and their associated risk factors (20).

Another wave of change is being nurtured by the unprecedented wave of technological convergence that is ushering the age of mHealth (mobile health), heralded by mobile telecommunication devices connected to the Web. This is leading to the emergence of powerful telehealth solutions designed to improve the quality of life of people living with chronic diseases and to optimize the use of limited resources (d - http://www.iom.edu/~/media/Files/Activity%20Files/Global/GlobalCVD/Jadad_mHealth_IOM_090717_website.ashx).

Unfortunately, little is known about the value of this veritable renaissance to reduce suffering for people living with multiple chronic diseases.

The N factor

Nanotechnologies, which allow the manipulation of matter at its smallest scale, are giving birth to an area already known as ‘Nanomedicine’, a hybrid of the physical and biological sciences that promotes the interaction between the human body and different materials, structures or devices which operate on a nanometric scale.

The most important aspect of nanotechnologies lies not only in the manipulation of matter itself, but the potential derived from the radical change undergone by the physical and chemical properties of matter when working at such scale (21): electrical conductivity, color, resistance or elasticity (22).

At present, the application of nanomedicine focuses on three major transversal strands, irrespective of the pathology that may be targeted (23):

- *Nanodiagnosis*, comprising the development of analysis and imaging systems designed to detect illnesses at the earliest possible time, both in vivo and in vitro. A promising area of work focuses on nanobiosensors (24) minute tools that combine **biological receptors** (a cell, a fragment of DNA or protein) capable of detecting the

presence of a substance, with **sensors or transducers** capable of measuring any related reactions;

- *Nanotherapy*, the controlled release of drugs, through systems able to deliver drugs exclusively to the affected areas or cells in the body, hoping to achieve maximum therapeutic effects with minimal or no adverse events. Exciting work is being conducted on innocuous biodegradable nanoparticles (25), which can carry drugs and then be effectively eliminated by the kidneys once they have performed their task (26);

- *Nanoregeneration*, the purpose of which is the repair or replace damaged organs or tissues. Carbon nanotubes (27), for instance, are being created to build replacement limbs with levels of performance that exceed those of their natural counterparts.

Unfortunately, the knowledge available on the role that nanotechnologies play in the management of multiple chronic diseases is scant.

What do we need to know?

Some of the key questions that require careful consideration (although they may be unanswerable) are:

- Are multiple chronic diseases the inevitable price that we must pay for our greater longevity?
- Does the level of complexity associated with most multiple chronic diseases exceed the capacity of GRIN technologies to offer tangible solutions?
- Even if we could eliminate chronic diseases through GRIN technologies in the mid- to long-term, will we be able to use innovations to mitigate their impact in the short-term?

What innovative strategies do we need to fill the gap between what we know and we need to know?

Harnessing the power of emerging GRIN technologies will require a careful balance between the inevitable super-specialization inherent to them and the need to create system-wide responses to the challenges associated with multiple chronic diseases. Consequently, it will be necessary to nurture truly inter-disciplinary skills among clinicians, policy makers and managers.

It will also be essential to develop ‘bridge technologies’ and powerful incentives to promote the efficient flow of knowledge across the boundaries of each of the technological domains. Thus, knowledge management tools and managers will act as the central pillar of the sustainable reuse of information, the average lifespan of which will continue to shorten.

In addition, new business models and ethical frameworks will be needed to bridge, in radical ways, the gap between bench and society, enabling real-enough-time adoption of scientific breakthroughs.

New methodologies will also be essential to enable clinicians, managers, policy makers and the public to make informed decisions at a speed that could match the pace of technological innovation (28).

For GRIN technology theorists, humans will soon be able to gain more than a year of life expectancy in each chronological year, thus bringing immortality within reach before the end of the 21st century (e-). Others believe that the same technological prowess that gave birth to GRIN technologies has given us the capacity to destroy our very sources of survival, thus turning us into a suicidal species that will unlikely survive to see the end of this same century (f - Wright R. A short history of progress. New York: Carroll

& Graf, 2005; g - Diamond J. Collapse: how societies choose to fail or

succeed. New York: Viking, 2004). As the future is impossible to predict, all we can do at this point is hope for the best, while becoming as receptive as possible to innovations that could help relieve the pain, anxiety, fear, sadness and despair that are caused by multiple chronic diseases. As for the rest... we shall see.

A concluding trans-humanist vignette (Year 2090)

Noospheric time: n-point 7.

Confederal Regulatory Synchroconference.

Speaker: Citizen AB8456780-John.

Ladies and Gentlemen,

I address you as the General Director of Cohabitation Policies for our Confederation, having been mandated by our sovereign Global Parliament to draw up the definitive proposal for the Communion Treaty intended to bring to an end almost a decade of disputes and disagreements among the various human matrix species which have jeopardized the peace we inherited from our Sacred Parentals.

We believe that all our sub- species without distinction - ***the reborn, the virtuants, the cognitives*** *and, of course, the* ***descendants*** *- contribute incalculable value to our global society as a whole. Our diversity, which has been enshrined in the charter of our Matrix Constitution, has allowed us to live in peace for decades, having left behind the unfortunate wars of the past, thereby guaranteeing our planetary cohabitation and the future of our cognitive colonies.*

We believe that the ***reborn*** *represent the living essence of our past. They lived in other times and their will to endure led them to fight against their destiny, rightly believing that they could be cryogenically preserved until the advent of technologies sufficiently advanced to correct their defective organic endowment. They are now enjoying our modern way of life, while acting as the guardians of our ancient conscience and the active voice of our past.*

We believe that the ***virtuants*** *also enable us to guarantee the permanent safekeeping of our ancestral human values, preventing non-regulated emergent cyber-conduct, without giving up the divine spirit of their forebears. We value the strength they displayed when they took the* ***great singular leap*** *and transfer their metacognos into cyberspace.*

We believe that our ***cognitive*** *brethren are the valid extension of our greatest scientific achievements. Surpassing the biological limitations of our ancestors, they represent the indefatigable force facilitating the well-being of all, undertaking productive labor along with their responsibility for the conquest of new worlds, thus*

bearing the burden of extending the essence of human knowledge throughout the universe.

And as I stated at the outset, and without overlooking while nonetheless moving on from the unfortunate conflicts of recent years, no one can question the purity of our ***descendant*** *brethren. When the* ***Framework Validity Act*** *ruled that all those who had borne eradicated hereditary illnesses must give up the right to continue procreating, thereby being prevented from taking the* ***great leap****, the aim of the Founders was specifically to keep alive our own biological history, while granting them the absolute guarantee of eternal survival, and vesting in them the same rights as those held by the other constitutional species. Any other option would have served to undermine the Great Ecosystem or deny the enshrined rights of our* ***cognitive*** *brethren, who saw so much emotional blood spilt when the now long-since vanished* ***spiritualists*** *attempted to reduce them to inanimate matter. It was at this point that the* ***right of intellectual equivalence*** *with any other human species was established, and although this did not mean their forsaking the capacities achieved, nor were they permitted to surpass their restricted natural limitation, since we are all ultimately the descendants of the same father science and the same mother earth, to whom we once again extend our most emotional recognition.*

As mouthpiece for the cryospheric will, we must regulate as follows:

Our ***descendant*** *brethren must accept the will of the planetary and Martian majority and give up their claims to use the submarine colonies to create an independent and isolated society, thereby separating themselves from the remaining humans through our most beloved. They are the essence of our species and a living testament to what we were and whom we so respect and venerate. It may be that the former term* ***diseased****, applied for so long to their species, represents to a greater extent man's conquering achievement in replacing illness with a full life. We cannot separate ourselves from them, and their descendancy has always been guaranteed by the historic and definitive consolidation of the* ***Clone Reformancy****. Nor can we in anyway accept the restitution of their reproductive capacity, as we would otherwise be reactivating the now obsolete mechanisms of recombination.*

Let it be so, if this be the parental will.

References

1. Estudio Económico y Social Mundial 2007. El desarrollo en un mundo que envejece. Departamento de Asuntos Económicos y Sociales. ONU. Nueva York, 2007.

2. Swain H. Las grandes preguntas de la ciencia. ¿Todavía evolucionamos? Crítica. Barcelona. 2003. Pag. 251

3. Kurzweil R. The Age of Spiritual Machines: When Computers Exceed Human Intelligence. 2000. AND Kurweill, Ray. The Singularity is near. Penguin Group. 2006.

4. Sweta S, Upkar V. Enabling ubiquitous patient monitoring: Model, decision protocols, opportunities and challenges. Decision Support Systems; Feb2009, Vol. 46 Issue 3, p 606-619

5. http://www.aal-europe.eu/

6. http://www.revistaesalud.com y http://www.i2bc.es

7. Predicciones. 1999. Edit. Taurus. Pag. 41.

8. Asensio M. El primer borrador del genoma se presenta en sociedad. http://www.prbb.org/quark/20/020068.htm

9. Barondes S. Los próximos 50 años: El conocimiento humano en la primera mitad del siglo XXI. Los fármacos, el ADN y el diván del analista. Pag. 336.

10. Kurzrock R. Chronic myelogenous leukemia in chronic phase. Current Treatment Options in Oncology. Volume 2, Number 3 / junio de 2001. Pag. 245-252.

11. Costello AJ. Installation of telerobotic surgery and initial experience with telerobotic radical prostatectomy. BJU International; Jul 2005, Vol. 96 Issue 1, p34-38

11. Costello AJ. Installation of telerobotic surgery and initial experience with telerobotic radical prostatectomy. BJU International; Jul 2005, Vol. 96 Issue 1, p34-38

13. http://www.ric.org/research/centers/neca...

14. Lorca J, Jadad AR. ¿Salud 2.0? RevistaeSalud.com.Vol 5, No 19 (2009)

15. Palen L, Liu SB. Citizen Communications in Crisis: Anticipating a Future of ICT-Supported Public Participation. CHI 2007 Proceedings Emergency Action.

16. Tapscott D, Williams AD. Wikinomics: How Mass Collaboration Changes Everything. Kindle Edition, April 19, 2007

17. http://www.patientslikeme.com/

18. "Gimme My Damn Data!". E-patient Dave DeBronkart*, Society for Participatory Medicine, Nashua, NH, United States Medicine 2.0 Toronto. 2009.

19. Scotch M; Yip KY; Cheung KH. Development of grid-like applications for public health using Web 2.0 mashup techniques. Journal of the American Medical Informatics Association (J AM MED INFORM ASSOC), 2008 Nov-Dec; 15(6): 783-6

20. Lorca J. Diario de Sevilla. Registro de salud en línea. 6 de Marzo de 2008.

21. Samitier J. Presentación del Lanzamiento Público de la Plataforma Española de Nanomedicina. 2005.

22. http://158.109.66.48/biosensores/biosens...

23. Lechuga Gómez LM. La revolución de la nanomedicina. Sedisa. 2008.

24. http://158.109.66.48/biosensores/biosens...

25. Park JH, Gu L, et al. (2009). "Biodegradable luminescent porous silicon nanoparticles for in vivo applications." Nat Mater.

26. http://www.cronica.com.mx/nota.php?id_no...

27. http://www.nanowerk.com/news/newsid=1274...

28. Kurzweill J. The Singularity is near. http://singularity.com/aboutthebook.html...

29. Garreau J. Radical Evolution: The Promise and Peril of Enhancing Our Minds, Our Bodies and What It Means to Be Human