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Innovation Landscape and Fields

1.1. From intensive industrialization to intensive innovation: consequences of global business

The years since World War II have been dubbed by some as the Great Acceleration. In a single lifetime, people have seen remarkable advances in medicine, transport, communication and other technologies, which have brought unprecedented economic changes. Today, many people enjoy a standard of living which was once thought impossible. This progress has been made possible combining dreams (science fiction), imagination, needs and technologies. But this was not done without impacting the planet and livings things. Powerered by imagination and often by quick business, some "forgot" or were simply unaware (or did not wish to be aware) of the impact they produced. Sometimes, the effect only becomes apparent after several years of operation. Some discoveries and disruptive innovations attract entrepreneurs who look for something new to explore commercially. For example, Barbara Goldsmith describes frivolous and dangerous uses of radium, pushed by business, just after it was discovered [GOL 05]. Today, a few non-governmental organizations (NGOs) are trying to draw the attention of "consumers" on the possible harmful effects of genetically modified organisms (GMOs), cell phone antennas and nanotechnologies.

Human activities, accelerated by globalization and not governed at the biosphere-level, are pushing the Earth beyond its natural cycles so that the environmental significance of human activities is now so profound that

the current geological era was called the "Anthropocene" epoch [CRU 00, IGP 15]. Is the Earth heading for a point of no return?

Some scientists consider that the effect of changes can be difficult to predict – we might be approaching "tipping points" where sudden and unanticipated climate changes could usher in disastrous results [AMS 12]. Consider, for example, the West Antarctic Ice Sheet. Some researchers believe that with sustained global warming, there is a point where the melt of this ice sheet could be irreversible. This is because ice-cover naturally reflects the Sun's rays. But as the ice sheet thins and shrinks, the ocean below, which is less reflective, is eventually exposed. The dark ocean surface absorbs more heat, which, in turn, leads to greater melting.

Groënland is melting and the surface of the ice is becoming gray. As a result, dark areas are heated more than the bright areas. This phenomenon is known as the albedo effect [DAN 14]. A self-feeding, runaway cycle could be created. The resulting rise in sea levels from the melt water could spell disaster for hundreds of millions of people.

The statements of the American Meteorological Society, 2012, and some others note that "the dominant cause of the warming since the 1950s is human activities" [AMS 12]. Nearly 50% of the land surface has been transformed by direct human action, with significant consequences on biodiversity, nutrient cycling, soil structure, soil biology and climate. In the last 150 years, mankind has exhausted 40% of the known oil reserves that took several hundred million years to generate. More nitrogen is now fixed synthetically for fertilizers and through fossil fuel combustion than it is fixed naturally in all terrestrial ecosystems. More than half of all accessible freshwater is appropriated for human purposes, and underground water resources are being depleted rapidly in many areas. According to the Global Change IGBP[1], humans have dramatically changed the planet and are altering some of the Earth's primary cycles: the water, carbon, nitrogen and phosphorus cycles.

It is also pitting water-intensive businesses such as the Intel Corp.'s China unit and bottling plants of Coca-Cola Co. against growing urban use and the 1.6 billion people in China and India who rely on farming for a living. "Water will become the next big power, not only in China but the

1 http://www.igbp.net.

whole world. Wars may start over the scarcity of water", said Li Haifeng, the vice president at sewage treatment company Beijing Enterprises Water Group Ltd., in a telephonic interview [BLO 10].

"Around 85% of global fish stocks are overexploited, depleted, fully exploited or in recovery from exploitation" [FAO 12], while food is wasted in developed countries due to food business.

Boyan Slat, a young entrepreneur and diver, states that after the Ages of Stone, Bronze and Iron, we are in the middle of the Age of Plastic [SLA 12]. Over 300 million tons of plastic poison the food chain – it is absorbed by fish and birds because its looks like a food. This mess which we have created leads to waste economy, and although it creates jobs for now, we have an obligation to change our behavior. "Change is more important that [sic] money", he said. His crowdfunded company, the Ocean Cleanup, develops solutions to remove plastic from water without capturing the sea life. The collected plastic is then recycled.

Figure 1.1. *Plastic bags on trees closed to mini-marts (source: www.lawntea.blogspot.fr/2012/07/getting-drift.html)*

Despite some alarms having been raised in Europe since the 1960s [MER 11], the French government has only recently ordered to reduce the use of plastic bags in the supermarkets. As a consequence of Evin's law against smoking in closed spaces, French streets are "decorated" with butts simply by stupidity ("brain-off").

Since the Rio Summit in 1992, other climate change summits have been organized; various road maps have been drawn up to deal with the

"planetary emergency" which we now face. One long-standing strategy is sustainable development, which means promoting economic and social growth within the ecological limits of the planet. What have been the results? Sadly, like the global financial debt crisis, the Earth's ecological debt continues to mount unabated. Humans continue to make intensive businesses and consume our planet's resources faster than these can be replenished naturally. Many world specialists and presidents have traveled around the world to debate the planet conditions. Nobody seems to have a realistic and immediately applicable solution for reducing pollution, global warming and educating a new respectful culture. Researchers travel to various conferences and measure the ice without thinking about their contribution to the global warming.

Corporate social responsibility (CSR) and sustainable development were made mandatory with the aim to reduce the environmental impact [MCW 01]. Although many companies display their initiatives on their corporate websites, only a few are seriously practicing it. Numerous reports describe how these companies are applying the ISO 26000 norms, but none, in our knowledge, tried to adapt these norms into their real situation and innovate by proposing adapted key performance indicators (KPIs), including, for example, the impact of all these constraints on business in terms of cost and revenues. The five-dimensional (5D) return on investment (ROI) could be applied for better evaluation of impact [MER 11]. This includes the impact of sustainability actions on business.

In the meantime, the Earth's population has nearly tripled. This means there are many months to feed but also represents a huge global market facilitated by communication technology, e-business and transportation means. The Google business model based on advertisements generates intellectual and visual pollution and is an important theft of time – time to find how to close the advertisement window or 30 s if this facility is not provided. The mass media continue to promote the "to have more and to show" mentality through advertisements and various entertainment programs. "Buy more" and "throw away" are the engines of today's business.

The political landscape has been also changed. The Soviet Union collapsed and nobody, including the European Union, seems to be interested in analyzing the positive and negative sides of this experience, such as multidisciplinary research results, the innovation fields, social system, culture and motivations, long- and mid-term economic and educational

planning and motivation to work. The Soviet Union identity and Russian as a common language were mandatory. Nowadays, the European identity does not exist and English became the world communication language. It would be fairer if everyone learns a new common language instead of privileging one's mother tongue. Esperanto was created by Ludwik Lazarus Zamenhof in 1873 [ZAM 87] with the aim to provide a world communication language that everybody has to learn as a second language. Fascinated by the idea of a world without war, he believed that this could happen with the help of such a language.

The business innovation and quick development of China and other Asian and South American countries, offering the low labor cost, is one of the causes of relocation mainly the USA and Europe, in the search of quick business, with the aim to offer more for less and increase the firms' income. This way of doing increases also pollution in developing countries and the unemployment in Europe and other developed countries. Besides this, we have to recycle products, often of poor quality, made somewhere else and traveling around the world.

Innovation is considered the principal driver of growth by the European and national politics. A plethora of initiatives and experiments in Europe and around the world [MER 11] are not bringing in the expected results. Various "success stories" are available, but systematic feedback, metrics and ROI are still missing.

Innovation can be considered a major contributor to the detrimental effects of humans on the planet because the inventors and designers think about functionality, shape, look and attractiveness, but not about the overall behavior inside the environment. Business people want to sell more; nowadays, a global market is addressed without thinking about the right benefits.

The invention and industrialization of the aircraft, and later the Internet, shortened distances between places and people, created new opportunities for businesses, and was the main trigger of globalization. According to Planetoscope [PLA 14], 80,000 flights per day, or nearly 30 million flights per year, are recorded. Civil aviation generated 2.5% of global CO_2 emissions in 2010. In 2000, the airline has issued 664 million tons of CO_2, or 11.5% of the emissions of the transport sector. Information and communication technologies (ICTs), intelligent traveling and local

development may reduce the number of planes, but not without some impact on aircraft companies' business. The right balance has to be found.

Aircrafts, which are knowledge-intensive products, are still conceived for transportation of people and goods; however, in recent years, efforts have been made in using lightweight technology and optimization software with the aim to reduce fuel consumption and CO_2 emission. The new Airbus A350 is conceived to save 25% of fuel. The alternative fueling is also studied and experimented[2].

Optimization techniques, such as constraint programming, are helpful for route allocation. The choice of aircraft model is made according to the number of passengers or loads. But air transportation companies have their own hub and an intelligent optimizer of travels is still missing. The available "optimizers", such as Kayak, Skyscanner and others, work for their clients and not for travelers.

The automotive industry is focusing its efforts on a non-polluting "car of the future". Peugeot prototyped a hybrid car almost 20 years ago, but the market and governmental incitation was not yet present; however, the main barrier is the energy storage, i.e. the size and capacity of batteries. Today, Hybrid Air, an innovative full hybrid gasoline system, is available commercially. Peugeot confirmed its plans to bring an all-new hybrid car to the market place which will have a zero-emission capability in and around town and the potential to dramatically reduce tailpipe emissions on the motorway. The technology will be officially unveiled at this year's Geneva Motor Show, and is expected to be offered as an option on the B-segment Peugeot 2008 by 2016. Renault, BMW and Toyota are also working on zero-emission cars. However, the concept of car has not evolved since its invention and car designers are not ready for disruptive innovation. A Fantômas car [FAN 64], born from the imagination of André Hunebelle, was an example of what such a car could be.

The concern of energy providers and information technology (IT) application designers is on "clean" and renewable energies, such as wind turbines, solar energy and biogas. Neighbors of wind turbines raised the impact on living in terms of noise. The impact is not yet studied and the business is a priority. Plans involve installing large wind turbine plants on the sea. What is the impact of such plants on sea life?

2 http://www.thenewecologist.com/2010/09/top-10-solar-powered-planes/.

Airplanes and cars cannot exist without complex electronic computer systems. The invention of the computer and the quick development of computer science has had a very significant impact on our lives.

1.2. Computer science, the Internet and mass media

Computers which were initially conceived for calculation now support all fields and activities. "Industry after industry is being transformed by IT-enabled disruptive innovation. These include not only information-based industries, such as banking, media, real estate, and education, but also transportation, agriculture, and health care" [DUB 14].

The entertainment and image industry are a part of this list. Fluidity between Silicon Valley and Hollywood boosted the cinema industry. Using a lot of special effects allowed them to reduce the production cost and increase the attractiveness of the movies. Traditional electronic games were radically improved in terms quality, attractiveness, rapidity and "intelligence". Serious games combining immersion and training changed the traditional way of learning.

Computers in all forms are everywhere and it is often difficult to imagine life without them. Miniaturized, advanced, user-friendly and more intuitive human–machine interfaces, multimedia and the Internet have conquered all the categories of users. The smartphones have became powerful computers in our pocket/hands. The Internet has opened the highway to the world of information and knowledge, amplified commerce, offered distance learning to all, helped people to communicate and become clever in communication in order to become leaders. People share their knowledge through Wikipedia, blogs and social networks. Advertisers have understood the advantages of this tool and all the services it provides very quickly. Every click and "like" is tracked and used commercially.

The Internet and Web 2.0 services may have created a lot of opportunities, but they have also opened a "highway" for cyber-criminality. The terrorists are the intensive users of information and communications technology (ICT). Social networks may be used to build or destroy reputations. Influence on behavior – from bad to good – is one of the most important challenges of the 21st Century; serious games are experimented in facing this challenge.

> Information and Communication Technologies (ICTs) enable us to see the connections between seemingly disparate issues, like transport and energy or health and economic growth, and help us find comprehensive solutions, for example in the European Innovation Partnerships on Smart Cities and Communities and on Active and Healthy ageing. ICTs enhance our quality of life, push productivity and lead to new opportunities for EU citizens and businesses [ICT 13].

Pushed by students, on the one hand, and technology providers, on the other hand, education has become an intensive user of ICT. Politics want it to be "students-centered". However, the educational program is not adapted to changing industrial and economic environments.

To give one example the conquest of the space could not be done without technology. In space, satellites extend the communication facilities on Earth. But since the launch of the Soviet "Sputnik I" in 1957, over 4,500 spacecrafts have been hurled from the Earth's surface, nearly half of which remain in orbit. According to the new book *Orbital Debris: A Technical Assessment*, "only about 10 percent of these devices are still functional; the rest simply constitute space junk, very expensive garbage. But that's just the intentional debris. There are also many tons of 'mission-related' garbage littering the solar system" [HAY 96].

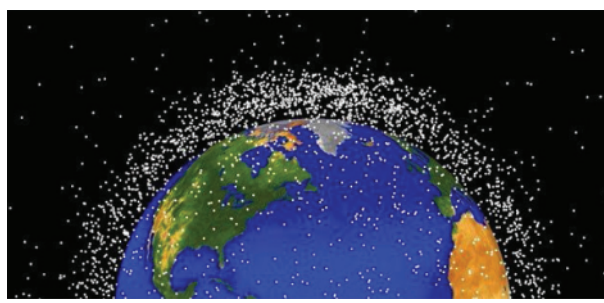

Figure 1.2. *Space garbage (source: smithsonian.com)*

The satellites and the spread of the Internet and mobile devices, smartphones and tablets have led to a veritable deluge of data, further accelerating the move toward the Internet of Things.

According to the IDATE studies, today IT companies have three main business areas: mobile, cloud and big data [DIG 12]. The topics of Digiworld 2013 were connected objects, video as a service, digital malls and digital money, smart city and digital living, future Internet and games. In 2014, they chose "mobility reloaded" as the main topic[3].

Big data offers unified access to information. It allows the large-scale dissemination, analysis and use of data for the benefit of consumers and citizens. Analytics are mainly used to find information in large amounts of data. Other techniques of knowledge discovery, such as neural networks, genetic algorithms, induction or other multistrategy machine learning hybrid tools [PIA 91], are available but underused.

Due to *sensors* and *embedded software*, objects are becoming increasingly interactive. It is possible, for example, to get them talk to each other or switch them on remotely. This radical upheaval opens up the prospect of cost and resource savings. Computer *simulation* makes a direct contribution to an economy's progress in terms of sustainability issues, particularly with regard to environmental protection, the scarcity of raw materials and the emergence of a low-carbon economy. *Smart city* ambition is offering their inhabitants increased comfort, employment and economic development.

The *Future Internet* focuses on new network architectures and more user-oriented services. Among the objectives are: increasing the speed and storage capacity, integration of connected objects, malicious programs detection, machine-to-machine (M2M) communication and Internet-enabled innovation. We could hope for a disruptive innovation, for example biometrics instead of logging and password, but all the projects around the world represent only an incremental innovation.

According to Google Product Manager, their undersea fiber optical cable system needs extra protection because of shark attacks. For that, Google cables are being wrapped in Kevlar-like material to prevent shark bites from damaging the line. Why do sharks seem drawn to the data cables that rest on the ocean floor? Do they feel attacked? Or is it simply because the cables are in their territory?

3 http://www.digiworldsummit.com.

Google has evolved from search engine to many other services related to data collected from users or captured from other organizations (geographic information system, satellites, etc.). Their vision, strategy and innovation attitude have been fruitful – in possession of a huge amount of data they have become the "master of the world" through data, the new capital. Their advertisement-based business model is copied around the world but their ethics should be reviewed – it is impossible to see a video on YouTube without losing 30 s, to search an item or topic without being tracked with the aim to show us over 90% of irrelevant advertisement. Finding in one click the information we are looking for is difficult. The paid advertisements are on the top of the list, as well as various comparators working for companies that pay for the number of clicks on their websites; the users have to spend time to find the right item. In continuous improvement and real-time innovation, they forget the users – they "offer" new services that they think we need.

Social networks, especially Facebook, are another contributor to big data. All these data are stored in data centers that must be powered and cooled. The first European data center of Facebook was established in Luleå, Sweden. Figure 1.3 presents its energetic architecture.

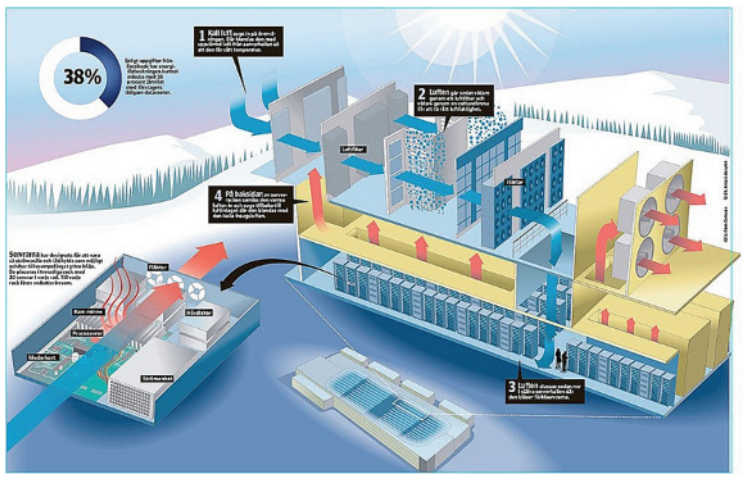

Figure 1.3. *Facebook Luleå data center, Sweden*

This provides Facebook center local job creation and impacts the regional economy. Concerning the environmental aspects, they mention the

availability of cheap, green electricity from hydropower and a cold climate that allows them to use outside air for cooling. It lets them remove 70% of the diesel units for backup power compared to the same facility in the USA. The cold climate also makes it possible to cool the thousands of servers by cold air from the environment. For cooling, Facebook has developed its own technology. This center reuses the know-how and technology of Prineville, Oregon. However, it is certainly warming outside and contributes to ice melting. Another ethic of publishing on Facebook may considerably decrease the need for big data.

Google are said to use 50% less energy than the typical data center. Designed to best use the natural environment and conditions, they use outside air and sea water in cold climates (Hamina, Finland) and reuse water from a nearby water source to stay efficient even in hot, humid summers (Douglas County). They use gray water and clean it by plants. In 2010, they started buying renewable energy from wind farms near their data centers. Google also developed a machine-learning algorithm (artificial intelligence (AI)) that learns from operational data to model plant performance and predict power usage effectiveness [GOO 14].

Energy efficiency of data centers and green IT are emerging as some of the most critical environmental challenges to be faced because of the increasing yet unprecedented trend in digitization of business processes, such as online banking, e-government, e-health and digital entertainment. The worldwide data centers CO_2 emissions achieve about half of the overall airlines' CO_2 emission [GAM 10].

What is the percentage of useful information in these data centers? How many times the same or similar data including the same pictures are registered in different databases? If only we could verify before registering and make link instead of multiple storing of the same object, it will certainly decrease the need for energy, cooling and environmental impact of data centers.

1.2.1. *Example of applying environmental principles*

Bull, a French computer company founded in 1931, applies CSR and sustainable development principles and makes efforts for innovating in computer and software design and reducing the environmental impact of data centers.

> The main challenge for IT companies is eco-efficient IT with economical use of raw materials, low energy consumption and an emphasis on recyclability. IT must also be capable of helping other industries progress more quickly with their own challenges, such as social innovation, business transformation and the quest for long-term prosperity [BUL 13].

Bull offer includes big data, the cloud, green IT and digital simulation. The latter is very useful for creating a "greener" innovation – it allows us to simulate the potential impact before transformation and to virtually try several possibilities to finally choose the most accurate one [MER 11].

Their concern is to increase eco-efficiency of data centers and of control over the environmental impacts, green IT for energy challenges and IT for change in response to sustainability issues. At Les Clayes-sous-Bois (the headquarters), data center calories are now recovered to heat offices at the site. The new modular outsourcing center opened in 2013 is targeting a high level of energy efficiency.

The Bull home eco-designed supercomputer ROMEO was ranked fifth in the world for energy performance in the Green 500 list (http://www.green500.org/).

By designing energy-efficient servers, Bull is committed toward innovation at all levels: components, power supply, cooling and load management. The most environmentally friendly product design involves progress throughout the three major stages of the lifecycle (design, use and recycling). Bull considers that the contribution of product designers and purchasing and logistics managers is key to a successful global eco-design strategy.

The ultra capacitor technology developed by Bull reduces power consumption by 15%. It makes it possible to operate the servers' power modules in the optimal part of their yield curve (40–90%) and to save on energy consumption by the inverters. Bull's various enterprise servers share many advanced energy-saving features, such as dynamic management of the energy envelope of critical applications, dynamic management of the load supply function and the extensive use of low-consumption components.

The Waste Electrical and Electronic Equipment Directive (WEEE) management system is also accompanied by a specific "on-demand service" (ODS), entailing the recovery and resale of customers' unwanted or old products. By giving them a second life as spare parts or complete systems, this service reduces annual recycling volumes and allows older equipment in need of spare parts to be kept in service control operations at its data centers and to generate energy performance indicators. Innovative solutions, such as the water-cooled "cold door" offered by Bull, are designed as an addition to an existing air-conditioning system or as an alternative to installing a new air-conditioning system. The thermal conductivity of water is much greater than the thermal conductivity of air. These doors are situated directly behind the server cabinets, dissipating heat before it is released into the room. With this technology, 600 W can extract 40 kW, compared with 2.6 kW using air alone, and consumption is reduced by half.

Replacing hardware in place for several years with new models can provide energy savings of up to 40%. The consolidation or extreme virtualization of equipment makes it possible to "do more with less", thereby taking the potential saving as high as 60%, if not higher. Their storage system based on massive array of inactive disks (MAIDs) technology enables disks to be turned off independently when not in use, reducing consumption from 40% to more than 60%. Another function automatically adjusts the fan rotation speed depending on the ambient temperature.

Having clients working in several fields, Bull also has experience of making links between seemingly disparate issues, such as transport, energy, health and weather forecast. This experience helps reuse the available software modules and designers' know-how.

In the automotive (and aviation) industry, supercomputers are used to design vehicles incorporating new forms and materials that reduce consumption. At the same time, combustion engine simulation can also be used to reduce emissions. In the energy sector, digital simulation is an essential tool for the transition from the current system using non-renewable resources toward an energy mix based mainly on renewable resources.

The involvement of Bull in health care focuses on patient management and quick diagnosis. The latest technological advances, such as high-performance computing (HPC), big data, M2M, cloud, security and mobility, dovetail neatly with the most crucial health issues: pooling and outsourcing

of resources, development of outpatient medicine and telemedicine, rapid growth in secure storage needs, secure data processing and sharing, patient modeling and virtualization, personalized and genomic medicine, and mass data simulation for medical research.

The connected objects may serve to dynamically control energy consumption and smart grids and optimize and protect urban and road traffic. It also applies to geo-localization, building, home automation, home security, industry and waste management. In the context of a smart city, they experiment digital technology, smart objects and smart solutions to promote new administrative digital services, facilitate access to transport networks and optimize energy consumption. For example, Bull has developed a smart device which, when placed at the front of the train, offers a virtual onboard presence and sends experts detailed information on system behavior, especially along high-risk sections. These telepresence, teletesting, remote diagnostics and telesupport solutions have already been successfully experimented in the next generation of trains. Such remote services are of great environmental importance because they allow acting quickly at a distance, without traveling. Thus, they reduce the carbon footprint and save time and money.

Telepresence ambition is creating a genuine environment, to let people experience an environment even when at, a distance, as if they were in a given place. Several companies now produce moving robots representing a distant person and able to establish a physical presence from a remote location (see Figure 1.4).

Figure 1.4. *Telepresence robot in the office (source: irobot.com)*

In *Cloud* technology, the server's power is shared and it may reduce the carbon footprint, but it is not evident to estimate since there are few studies on it. The UC Berkeley researchers estimated that "if all U.S. business users shifted their email, productivity software, and CRM software to the cloud, the primary energy footprint of these software applications might be reduced by as much as 87%, or 326 Petajoules. That's enough primary energy to generate the electricity used by the City of Los Angeles each year (23 billion kilowatt-hours)" [MAS 13]. NOTE.– this study was sponsored by Google, offering cloud services.

We can certainly improve these results if only we could reduce the amount of e-mails and have an intelligent antispam that learns from user and an automatic advertisment remover. In fact, CRM software contains confidential information about clients (customer capital), and companies are not keen to use cloud for processing. They are afraid to use clouds for processing of their specific activity supporting software because they do not trust the cloud security system.

The Island company GreenQloud[4] is an example of a "smart cloud". They have seized a great opportunity to use local abundant 100% renewable geothermal and hydro energy infrastructure, in a naturally cool climate, and its strategic location as a means to clean up IT and greatly reduce the industry's carbon footprint. They train their users to monitor energy metrics and carbon savings.

In France, in the past 40 years, the population has increased by 10 millions of people. Each family has several devices, but we did not build new power plants because the devices designers make an effort in using low consumption components.

The continuous improvement of electronic equipment, such as computers, mobile phones, TV, in-car electronics, cameras and game consoles, led to reduce the power consumption, but it consumes raw materials and generates a lot of products to be recycled. Too many people focus on technology only and/or on business only. As a result, we often have to change our devices because the hardware, operating system, applications, interfaces, or simply the aesthetics are no longer up-to-date (e.g. Apple).

4 https://www.greenqloud.com.

We are living in a ubiquitous electromagnetic field, both natural and artificial. According to scientific studies[5], our cell phones may cause brain tumors. Today, cell phones, tablets, consoles and other devices are in the living room; this "second" screen is said to be necessary. Many are playing for hours on these devices. Addiction to cell phones [CIS 14], games and social networks is rampant in Generations Y and Z. The workers from Generation Y use three screens. According to the Cisco study, two-thirds have taken phone calls in the car while driving. Many of Gen YZ talk with virtual friends and live in isolation. It is easy to influence them. Social networks, in particular Facebook, as well as online games, have a strong impact on the culture of communication and behaviors – teenagers become addicted and push every kind of information on it, increasing this way a need for storage of data. They have to respect a "code of conduct". Games, in particular violent, brutal, sadistic and bloody flashgames, on the Internet, may seriously influence the young and less young players. Another consequence may be obesity because of the lack of physical activity.

Our smartphones and tablets are manufactured from parts made in the Far East that are then transported thousands of kilometers into the countries buying them. This is due to the savings that companies can make in terms of cheap labor and manufacturing efficiencies. Mining the raw materials and the manufacturing process use up a great deal of energy, and most of it is produced by burning fossil fuels. The coltan (tantalum) industry is worth billions of dollars per year, but the miners, including children, work in very bad conditions. Some of the smartphones' companies, such as Nokia and Sony, are collecting obsolete devices from the users. Some try to educate the users. The European Imaging and Sound Association (EISA) launched the Green Awards (http://www.eisa.eu/green.html). Their objective is to promote a "green attitude" in their member companies.

Sims Recycling Solutions in Eindhoven recycles 60,000 tons of electronic waste annually, a third of which is in the form of monitors and televisions, and plays a leading role in reusing of components such as computers or telephone equipment that are not yet at the end of their lifecycle.

5 http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones.

Figure 1.5. *Electronic devices to recycle (source: http://eco18.com/minimize-electronic-waste-to-help-protect-the-environment/)*

The most efficient process within the company is an automated machine, which is able to recover almost 100% of metal and glass from a conveyor full of TV's and monitors. The recycled glass is so clean that it is re-usable for new televisions. Also, plastic recycling is becoming more sophisticated achieving levels of almost 85% recoverability. Besides material recovery, enormous energy savings are achieved. In relation to the energy necessary to recover metals, savings of about 60% are achieved in recycled zinc and lead, 62–74% savings in steel, 85% in copper and up to 95% in aluminium. Sims[6] Recycling Solutions has collection systems for consumers, manufacturers and professional users.

All this human and electric energy can be used to eco-design and produce locally the smart and scalable devices (Lego™-like devices) with the aim to reduce the environmental impact.

1.2.2. *Artificial intelligence*

For many, AI means robots. For more than 50 years now, AI has developed methods and techniques that are now embedded into many decision support systems, diagnostic and simulation tools, educational software, innovative electronic commerce, data, text and image mining tools, creativity "amplifiers", robots and drones, etc., mostly not eco-designed [MER 11, MER 13a]. Nevertheless, the way of thinking, the methods and the techniques are still not taught and not integrated into IT, probably

6 http://www.simsrecycling.com/.

because of two different ways of thinking. IT limits to data and information processing, whereas AI is about "knowledge" thinking and problem-solving. From the very beginning, robots were conceived to copy human intelligence. It was, and still is, a challenge to build an AI device as intelligent as human, or even more so. There are some useful robots designed to help humans as industrial or surgery robots; these robots are able to diagnose and fix complex equipment in places that are difficult or dangerous to access, such as control and monitoring cabinets, nuclear power plants or high-voltage stations. Robots have been designed to take care of elderly people, to help them train their memory to take pills or simply as companions, while the number of unemployed people is high in many places. Other robots play with children because their parents have no time to play with them. Many of them move to metropolises and there is nobody to take care of their parents living in small towns and villages. Dancing or playing football robots are just a challenge for research. During the Fukushima disaster, the very famous Japanese robots were not able to manage the damaged nuclear plants.

Robots are used in the industrial plants, hospitals, at home and in the office.

Figure 1.6. *Surgeons performing Da Vinci Robotic Surgery at Wesley Medical Center in Wichita, Kansas (photo: Wesley.ehc.com)*

A recent study has found that patients who have robot-assisted surgeries on their kidneys or prostrate have shorter hospital stays and lower risk of post-op complications but their bill is significantly higher.

In a Swedish TV series, "Real humans[7]", the hubots (human robot) can decide and replace humans in decision-taking. It is not a science fiction; it may happen. Few researchers are trying to understand the laws of the nature and deepen our knowledge of the brain. Do we really want robots to take control of our lives? Can today's research think about the future of humanity? Asimov [ASI 42] defined 3 laws for robots:

– a robot may not injure a human being, or, through inaction, allow a human being to come to harm;

– a robot must obey the orders given to it by human beings except where such orders would conflict with the first law;

– a robot must protect its own existence as long as such protection does not conflict with the first or the second law.

Are these laws considered by robots designers today? Some researches focus on the implementation of "real" agents, having unfriendly behaviors to express the real society. Is such research relevant, while there is a lot of criminality in movies, games and in real life?

Figure 1.7. *Diagnostic of Millau viaduct performed by drone (source: Eiffage CEVM/Foster + Partners/DIADES)*

7 http://realhumans.arte.tv/fr.

Drones were conceived for military purpose and they now carry out supervision and monitoring, security, tracking, picture taking and delivering (e.g. Amazon). The diagnosis of the tallest bridge in the world, Millau Viaduct, is made possible by drones. The diagnosis of buildings and other constructions, thermal diagnosis and crops fertilization are also performed by drones [BOU 12, FPD 14]. A Reaper Drone localized the Air Algeria plane that crashed in Mali in 2014.

The fact that Google bought the drones-maker Titan Aerospace is not insignificant. Drones also serve a military purpose that targets people, not always terrorists. How can a drone tell the difference between a terrorist and normal citizen? Daniel Byman (Professor in the Security Studies Program at the Edmund A. Welsh School of Foreign Services at Georgetown University) states that drones offer a comparatively low-risk way of targeting terrorists while minimizing collateral damage [BYM 13].

Despite the focus on robots and drones, all AI techniques will be used to help people in their work and activity, and not to replace them [MER 11].

Ambient intelligence represents a vision of the future where we will be surrounded by invisible technological means, sensitive and responsive to people and their behaviors, which will deliver advanced functions, services and experiences. It combines the concepts of ubiquitous technology, intelligent systems and advanced user interfaces [AMI 14].

Ambient intelligence intends to provide personalization of services according to the users' preferences, for example tracking the user of a smartphone to suggest they buy or visit objects available in their area. Multiple connected devices are embedded into the environment, adapting to, and anticipating the needs of, the users. Some claim that it is a human-centric vision of the future, while in the majority of cases it is used to make tracked people buy products or services (clothes, shoes, restaurants, hotels and travels).

This kind of application will avoid considering the user as a machine to buy. Offering the targeted services, corresponding to the user's real needs could be of great importance. The main goal of intelligent matching is to save us time and gain opportunities. Smartphones and future devices embedded with machine-learning techniques will learn from real-time

interactions with the user and not from navigation (too many errors) or a published profile only.

Ambient intelligence without invasion of privacy represents a long-term vision for the European Union Information Society Technologies Research program with the aim of bringing together researchers across multiple disciplines: computer science, social science, physics, biology, engineering, design, architecture and philosophy. A strong multidisciplinary and collaborative approach is the key requirement for large-scale technology innovation and the development of effective applications[8].

A *cyber-physical system* (CPS) is a system of collaborating computational elements controlling physical entities. Such systems can be found in aerospace, automotive, chemical processes, civil infrastructure, energy, health care, manufacturing, transportation, entertainment and consumer appliances. This generation is often referred to through embedded systems. In embedded systems, the emphasis tends to be more on the computational elements, and less on an intense link between the computational and physical elements.

1.2.2.1. *Security systems*

With growing threats such as terrorism, all kinds of attacks and thefts, the demand for global security is growing. There are two ways to fight this scourge: build sophisticated security systems or influence human behavior. The global security systems include central monitoring systems (CMS) for buildings, airports, schools, parking, city control and home automation. CMS works on an alarm-trigger principle. The alarm signal is transmitted to the central monitoring station; the controller will ascertain the nature of emergency and initiate action such as contacting the police, an ambulance service, the fire department or dispatching a response team to the emergency site. Camera records are analyzed to identify the offenders. AI techniques may help in image mining. The alternative solution is to educate society with the aim of preventing crimes.

1.2.2.2. *Innovation at home*

The early development of home automation appeared in France in the 1980s. Miniaturization and availability of high-performance communication

8 http://ec.europa.eu/programmes/horizon2020/.

services (ISDN, digitalization of networks and Minitel at home) influenced the emergence of innovative systems-oriented communication and exchange inside the housing and outwardly thereof. An effort to bring more comfort, security and usability in housing management has guided the early days of home automation. Its popularity has been increasing greatly in recent years due to much higher affordability and simplicity through smartphone and tablet connectivity. Today, it may include a centralized control of lighting, heating, ventilation and air-conditioning, appliances, security locks of gates and doors and other systems to provide an improved convenience, comfort, energy efficiency and security. The Internet of Things facilitates taking control of all connected objects from outside using a smartphone. The challenge for companies is to install this automation in every home and successfully create a viable ecosystem with standards widely disseminated to ensure an interoperability between systems, while offering simplified interfaces via solutions in line with our daily usage. What services can these technologies provide that may significantly improve our daily lives? Do we really need a fridge that is able to order milk?

Home automation for the elderly and disabled can provide an increased quality of life for individuals who might otherwise require caregivers or institutional care.

1.2.2.3. *What is still missing?*

In our knowledge, the majority of ICT companies are still not involving the final user in their innovation process; by consequence, much of the available software and products are not intuitive or really user-friendly. Service providers via the Internet, such as railways and others, change their user's interface, without asking them; sometimes a new version is radically different from the previous version and the users find that they are lost.

Search engines lack relevancy and flexibility. Ecosia is supposed to be an eco-engine, but it also adopted the advertisement-based business model. The users need an effective way of searching instead of pushing tracking-based advertisement.

The users of Microsoft, Google, Ecosia and others have to set a search language, which will limit the results of search to the chosen language. The words completer is useful, but it only works in one language; the users need to change the settings each time they change the language. The program

should recognize the user's language (he/she may speak several languages) and adapt. The SMS assistants should also evolve.

A majority of software designers implement "trees thinking". For example, the BMW navigation system includes a voice interface following tree logic, instead of allowing a direct access to a given function.

Intelligent antispam is still missing. Equipped with AI techniques, it could learn to accept or reject e-mails. We receive a huge amount of e-mails because of automatic, and unfiltered, sending.

Computer access control by log-ins and passwords will be replaced by biometric recognition system.

Three-dimensional (3D) *printers*, invented in the 1980s, are able to print a 3D object of almost any shape from a 3D model or other electronic data source primarily through an additive process in which successive layers of material are laid down under computer control. 3D printers, which may be considered as industrial robots, allow rapid prototyping in many areas. Organic and printed electronics become a reality. The Technology Partnership Vista has the ability to 3D print a wide range of both inorganic and organic matter, including plastics, metals, ceramics, enzymes and biological cells [MOL 13]. According to Design News, rocket engines, airplane components, human cartilage and carbon composite production-grade parts are 3D printed [DES 14, LIP 13]. The decreasing price of 3D printers now allows their use in areas such as design [STA 14] or in kitchens[9].

1.3. Medicine and biotechnologies

Electronics, information processing and AI have greatly influenced the extraordinary progress that has been made in the field of medicine. Internet has facilitated the exchange of medical data and experiences. Health care practices are now supported by electronic processes and communication (e-health). Many hospitals have constructed a knowledge-flow connecting patients, doctors and other stakeholders based on patients information and their treatments, health information systems offering an electronic agenda for appointments, as well as medical research survey for medical staff. Services such as telemedicine, including distance diagnosis and monitoring,

9 http://www.naturalmachines.com/.

and surgery are now available. Sensors allow to continuously monitoring a patient's vitals.

The Internet's quick access to the patients' data is useful in an emergency, but it may also be used maliciously.

Technological innovation has also changed operating theaters; robots and laser are currently being used for surgery [SAT 06]. Virtual autopsy helps students learning medicine. Technology enables the detection of serious illnesses in the initial stages (X-rays, MRI and ultrasonography). However, the art of thinking and making the right diagnosis is vital. The next step for the medical research is to find the cause of death.

Transplantology also made progress through experimentation. Organs that can currently be transplanted are the heart, kidneys, liver, lungs, pancreas, intestines and thymus. Tissues include bones, tendons (both referred to as musculoskeletal grafts), corneas, skin, heart valves, nerves and veins. Worldwide, kidneys are the most commonly transplanted organ, followed by the liver and then the heart. Cornea and musculoskeletal grafts are the most commonly transplanted tissues. Organs are also the subject of business and, at worst, part of black market trafficking traffic. Some artificial organs are now created, such as the bioprosthetic heart conceived by the French company Carmat [CAR 14], pancreas [GON 14] and lungs.

Despite these advances, we still have to cure cancers, diabetes, Alzheimer's and other serious diseases that we have generated by globalization, our activity, our way of life (working in stress, bad eating, physical inactivity and smoking), immersion in electromagnetic field, poor quality of air and water, as well as by the massive use of pesticides and fertilizers [BEL 04]. By eating chemically "improved" food, many people develop food allergies. The increase in serious infectious diseases transmitted by humans, animals and insects is alarming. The Ebola virus is one example, which killed over a thousand people in recent months. As the natural reservoir of Ebola viruses has not yet been proved, the manner in which the virus first appeared in a human at the start of an outbreak is unknown. However, we can make the assumption that the first patient became infected through contact with an infected animal. The virus can be transmitted to others by direct contact with the blood or body fluids or by exposure to objects (such as needles) that have been contaminated with

infected body fluids. An experimental treatment is currently being tested on these effected.

Older diseases such as tuberculosis, which we have eradicated in the past, can reappear. The growing population needs more doctors to fight serious diseases, but many of newly trained doctors prefer to settle in big cities, which increase the shortage of doctors in rural areas and already devitalized regions. As such, a need for first-level remote diagnostic increases, while the current educational system is not adapted to create more doctors, combined with a social security system that has less money.

Except the people who still use ancestral and holistic knowledge, for example the Chinese traditional medicine or homeopathy, we practice fixing instead of preventing. Understanding the interest in association with the alternative and allopathic medicines may reduce medical costs, which are very high in France. Deepening out knowledge of diseases and new drugs to treat them helps save or extend lives. But the knowledge of our body, the prevention, and the use of plants to cure the "easy" illnesses is not a part of school curriculum.

1.3.1. *Human spare parts and augmented human*

Repairing and enhancing humans has been the subject of many dreams and utopias. This issue, which is of both sociological and philosophical interest, is now taking a new direction in the field of health care equipped with technologies, especially those of AI. The distance between repairing and improving is disappearing. Regarding normal human enhancement, underpinned by the idea of repair/augmented human, Goffette suggests, as a part of "anthropotechnie", the idea of an "ordinary human" improved by absorbing medicines or by surgery [GOF 06, BAT 13].

Therefore, if initially new mechanisms are aimed at overcoming deficient functions of the diseased, why not also to enhance his/her capacity and expectancy of life – as suggested by transhumanists? Are we trying to reinvent human as underlined by Besnier [BES 12]? Attempts to discuss these questions have been far from consensual.

Initially, mechanical and electronic human "spare parts" were conceived to improve the life of people with disabilities after an accident or in individuals born with a disability.

We are also able to enhance human capabilities ("augmented human") through technology for increased well-being. Human enhancement is any attempt to temporarily or permanently overcome the current limitations of the human body through natural or artificial means. Some bioethicists restrict the term to the non-therapeutic application of specific technologies such as neuro-, cyber, and nanotechnologies and genetics.

Figure 1.8. *Oscar Pistorius at Beijing Olympics, 2008*

An alternative way is to discover and develop our natural possibilities, including those of the brain, as foreboding, intuition, communication and action at distance or energy feeling and transmission. Today, if someone has a capacity that science has not yet discovered and that cannot be measured, we consider him/her as a "sorcerer".

1.3.2. *Ambient assisted living*

The aim of ambient assisted living is to use ICTs to develop new products and services to offer a better life to older and dependent persons. Such services require some physical equipment to be connected using various networks and controlled by specific software. Besides these technological solutions, security, privacy and acceptance will be considered to ensure that the proposed solutions fit the requirement of older and dependent persons, as well as the needs of the people who care for them (professionals and family). This field is interdisciplinary and requires collaboration between the future users, computer science and IT as well as from the social sciences. Ambient assisted living involves technologies such as sensors, specific equipment, robotics, user interaction (multimodal interfaces) and simulation platforms. Preserving privacy and ensuring security are the basic points for its implementation.

Ambient assisted living offers intelligent environments (devices and automated services) for the elderly to allow them live independently in their own homes, and to assist people with special needs. More sophisticated environments can adapt autonomously, proactively and context-sensitively to their activity. Sometimes, these individuals just want some company and may prefer that someone simply comes to see them.

1.3.3. *Biotechnology*

The OECD defines biotechnology as "the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" [OEC 05].

Biological processes are exploited for medical, industrial and agricultural purposes. Traditional biotechnology such as fermentation is very old – for years, we have used the biological processes of microorganisms to make useful food products, such as bread and cheese, vinegar and beer, and to preserve dairy products. Horticulturists combine pollen for more beautiful flowers; gardeners transplant trees to get better fruits. The concept of biotechnology encompasses a wide range of procedures for modifying living organisms according to human purposes, going back to domestication of animals, cultivation of plants and "improvements" to these through breeding programs that employ artificial selection and hybridization.

Modern biotechnologies appeared at the end of the 20th Century, following the scientific discovery of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). They include proteomics (large study of proteins) and genetic engineering, animal cell culture, biochemistry, cell biology, embryology, genetics, microbiology and molecular biology. Genetic engineering is the direct manipulation of an organism's genome. Biotechnologies depend on knowledge and methods from outside the sphere of biology including bioinformatics, bioprocess engineering, biorobotics and chemical engineering.

Since the mid-1990s, the field of transgenesis is the most publicized and still expanding field. Transgenesis is the process of introducing an exogenous gene, called a transgene, into a living organism so that the

organism will exhibit a new property and transmit that property to its offspring (see Figure 1.9)

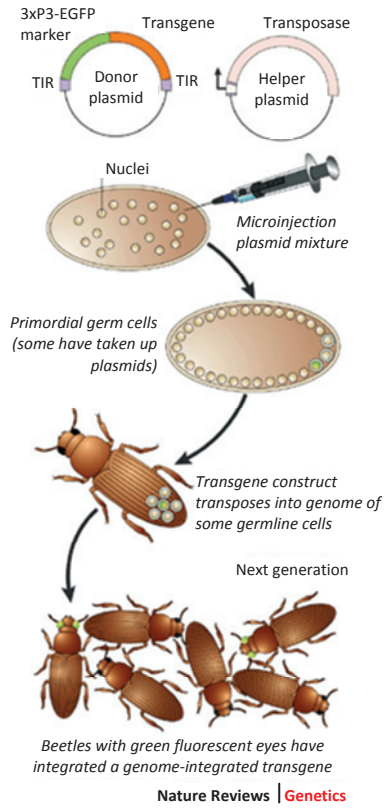

Figure 1.9. *Principle of transgenesis from [WIM 03]*

Techniques based on transgenesis became the basis of biotechnology, which is now based on the new tools for decryption of genomes, whose primary purpose is the creation of new commercial products of interest through:

– genetic modification of organisms, such as grain, to give them the characteristics they do not have, for example, resistance;

– genetic modification of other bodies to make them "useful" for man, for example the creation of goats by integrating into their genes a genome of

spiders in order to extract from their milk the fibers that can be used for textile production.

Genetic modification is not a new concept. It was probably Mendel (1866) who initiated genetic and selective breeding with the aim of improving the resistance of vegetables [MEN 66]. The profound significance of Mendel's work was only recognized over three decades later, on the turn of the 20th Century with the independent rediscovery of these laws.

There are several categories of biotechnology according to the fields of application:

– *red biotechnology: research related to medicine and medical processes* – the designing of organisms to manufacture pharmaceutical products such as antibiotics and vaccines, the engineering of genetic cures through genomic manipulation and its use in forensics through DNA profiling;

– *white biotechnology: research related to industrial processes* – it involves the use of enzymes and organisms for the processing and production of chemicals, materials and energy including biofuels;

– *green biotechnology: research related to agriculture processes* – it involves the use of environmentally friendly solutions as an alternative to traditional agriculture, horticulture and animal breeding processes;

– *blue biotechnology: research related to marine and aquatic processes* – it involves research on the application of molecular biological methods to marine and freshwater organisms for creation of new cosmetics, medicines, aquaculture, agri-food, etc.;

– *black biotechnology: research related to bioterrorism* – it involves research on all aspects of bioterrorism related to military, police, surveillance and counter terrorism;

– *gray biotechnology: research related to the environment* – it is divided into two areas: biodiversity maintenance and contaminants removal [ELS 14].

In Europe, "*yellow biotechnology*" is added to the list for the treatment and removal of pollution.

Moreover, biotechs are ranked in more explicit categories "*healthcare biotech*", "*agrifood biotech*" and "*industrial biotech*".

This progress is expected, hoped, and sometimes feared, in the fields of nanotechnology, bioinformatics and nanobiotechnology. It could, for example, allow for a scheduled production of nano- or microcompounds or biomolecules with new health risks, both environmental or geopolitical, if abuses or misuse of these new opportunities is done.

Nowadays, biotechnology plays an important role in the field of health care and in the innovative industrial processes. It has an emerging role in the areas of environment, agriculture and food.

Currently, there are more than 250 biotechnology health care products and vaccines available, many for previously untreatable diseases. More than 13.3 million farmers around the world use agricultural biotechnology to increase yields, prevent damage from insects and pests, and reduce the impact of farming on the environment. More than 50 biorefineries are being built across North America to test and refine technologies to produce biofuels and chemicals from renewable biomass, which can help reduce greenhouse gas emissions.

Cloning and "improving" human and animals raises ethical, political and economic issues. It is difficult to predict the long-term impact of genetic engineering because of complex interactions. At this stage, a simulation of the impact may help in understanding; however, it requires knowledge from related fields. As after the discovery of radium [GOL 05], some new companies are exploring commercialy the research results without considering the possible consequencies.

1.4. Nanotechnologies

The Greek word "nano" means dwarf. It is also a physical measure, 10^{-9}, used in electronics. Nanotechnology is the manipulation of matter on an atomic, molecular and supramolecular scale. It explores the special properties of matter that occur below the given size threshold. Potential industrial and military applications pushed the USA, the European Union and Japan to invest a lot in research and applications of nanotechnologies. They are now entering the phase of construction of many products for their advanced properties as more resistant concrete, self-cleaning paints and glass, and acoustic insulation. The expected benefits seem huge but their

safety remains to be demonstrated (see http://www.batiactu.com/edito/les-nanomateriaux-se-repandent-dans-le-batiment-38128.php).

Nanomaterials are also used in textiles mainly to provide stain-resistance or antibacterial properties as well as for the so-called "lotus effect": the nanocoatings, such as Teflon-like substances, form bonds with the textile so that little nano-sized molecular hooks attach to the fabric of the garment and the hair-like structures repel the liquids like the lotus leaf.

The term "nano" can be found in many cosmetic products, including moisturizers, hair care products, makeup and sunscreen (see http://www.nanowerk.com).

According to, Janez Potočnik, the European Commissioner for Science and Research:

> Nanotechnology is an area which has highly promising prospects for turning fundamental research into successful innovations. Not only to boost the competitiveness of our industry but also to create new products that will make positive changes in the lives of our citizens, be it in medicine, environment, electronics or any other field [HUL 08].

"Nano" is a technology which has unique intrinsic properties and therefore offers numerous possibilities of applications because it is unique in its properties and provides an alternative to other technologies. This natural phenomenon is not yet fully understood and must be studied further; therefore, research in this field is essential.

As for each new discovery, the standards to be met before the commercialization of products have been introduced very late as well as the controls on products potentially containing nano. Two points of control should be introduced:

1) check if products contain "nano";

2) mandatory evaluation of benefits and risks (medical, the real exposure according to the actual wear of the building material, etc.).

In research laboratories, the precautionary principle should be applied when manipulating nanoparticles. This was introduced late and the lab's staff is responsible for checking that it is implemented or not.

According to Gaelle Offranc Piret, a researcher at INSERM/CEA Leti: "the danger may come from what we do not know yet. It is vital to move faster in understanding the phenomena such as interaction between energy and matter in the universe, reactions of biochemistry/biophysics in/between living systems, etc.) for better protection. For now nanos (often materials or molecules that we assemble) are not active. We control them and we activate them just for a very specific function."

Nanomedicine, the European Technology Platform[10], is an initiative led by industries and set up together with the European Commission. Their members wish to accelerate the development of medical nanoproducts and foster connections between laboratories, companies and investors. They address serious diseases such as cancer, atherosclerosis, diabetes and arthritis. Nanomedicine for the eye aims at developing effective drug therapies and reducing health cost related to aging, such as macular degeneration, diabetic retinopathy, glaucoma and dry eye syndrome. Other groups work on nanomedicine for combating infections from antimicrobial-resistant bacteria and on tissue engineering.

1.4.1. *Biological risks of nanoparticles*

Biological risks of nanoparticles, which were raised by Michael Crichton in his book *The Prey* [CRI 03], are studied by *Échange et Coordination Recherche-Industrie* (ECRIN) in France, as well as by Sara Linse [LIN 14], Christophe Brechot and others.

When nanoparticles enter a biological fluid (blood, lung fluid, etc.), their surface is rapidly covered by a corona of proteins. This corona defined the biological safety or risk of the nanoparticle because it is the particle with its corona that the biological system responds to. The research of Sara Linse's team in the Center for Molecular Protein Science has shown that the corona around many nanoparticles is remarkably specific and contains a small number of proteins, and their relative surface concentration is very far from a random representation of their relative occurrence in the body fluid. They studied how the corona composition changes over time, or when the nanoparticle travels from one body compartment to another. They have developed a methodology to identify the nanoparticle-associated proteins, to measure their interaction parameters and to study nanoparticle-induced effects on protein aggregation and function. Their findings at the molecular

10 http://www.etp-nanomedicine.eu.

level are related to testable assumption involving function that may be perturbed at physiological level.

Christophe Bressot, a researcher at *Institut National de l'Environnement Industriel et des Risques* (Ineris), works on the impact of nanomaterials: "the risk evaluation formula is simple: exposure multiplied by toxicity. In the absence of exposure there is no risk, as if the toxicity were nonexistent. In the case of nanomaterials, the toxicity is unknown. The challenge is to reduce exposure, in particular by inhalation because it is a main entry point to the body".

All the particles smaller than 4 μm affect the pulmonary alveoli. The entire population would thus be exposed: the industrials involved in production, consumers of a finished product and the environment during the end of life of products. Researchers point out the absence of data related to the risk of the skin contact or the ingestion of nanoparticles [BAT 14].

Nanotechnologies are used and experienced in all kinds of fields: automotive, electronics, construction, pharmaceutics, biomedicine, cosmetics, textile and food [MON 08].

A growing, enhanced and longer living population represents many mouths to feed and many individuals do not have any time to play chef due to a multitude of various promptings in addition to their usual work. ICT adapts, anticipates or creates new needs. Supermarkets were created to let us find everything in the same shop, as well as to buy more. The latest trend is a digital mall. What more can we buy and eat?

1.5. Agriculture and food industry

According to Pyarelal, secretary of Mohandas Gandhi, the late spiritual leader of India, "the Earth provides enough to satisfy every man's needs, but not every man's greed".

Quick business and human avidity have been a very strong engine in the industrial production and transformation of traditional food. On the pretext that it is necessary to feed more people, many initiatives aiming at producing more were launched. For example, extremely modern giant farm Gemeente

Westland[11] in the Netherlands intensively produces fruits, vegetables and flowers using renewable energy and fully automated gathering and logistics, as well as artificial fertilizers, lighting and trucks for delivery. They are proud of being such an innovative center, generating jobs and growth for local people.

As food is not managed at the level, planetary specialists believe that we need to produce more food. Global competition imposes low prices to meet the criteria of purchasing power. As a result, the central purchasing for supermarkets requires the low prices, the farmers are poorly paid for their work and they grow farms to produce more despite the quality. As they have to produce more big and good-looking products, they use chemically treated seeds, fertilizers and pesticides to fight against more resistant and self-adapting harmful insects and diseases. The more sophisticated farming equipment is also polluting. The animals in the large farms have little space and they are fed growth hormones and antibiotics.

The practice of monocropping, such as cereals, on only one large surface, leads to land degradation and proliferation of pests. Artificial fertilizers and strong pesticides pushed by chemical giants increase pollution and cause serious diseases. This is definitely not a sustainable solution. Researchers work on how to improve the effectiveness of crops and eradicate various pests using genetic engineering, and others study natural methods. Our ancestors practiced crop rotation, used natural fertilizers and mastered the art of vegetables association to avoid harmful effects, such as planting the carrots alongside the leeks to avoid carrot fly and worm leek. These old rules, created from our ancestors' observation, are known and practiced by producers of organic food.

We observe that food waste is highest in countries with "sell and buy more" attitudes. After fast food, the fashion of processed dishes and drives was introduced under the pretext that people work more and have no time to prepare food. The "modern human" feeds himself/herself with fast food, processed food and drinks sodas while working, watching TV or playing games, and becomes fat because of their sedentary lifestyle. Drugs and a lot of services are readily available to make you slim. Many practice self-medication – drugs are available and often cheaper online.

11 https://www.gemeentewestland.nl.

The quality of the water we drink is increasingly polluted and must be cleaned (another business). It contains many chemicals such as pharmaceutical, nanoparticles, pesticides, insecticides, processed food "improvers", flavor enhancers, and artificial fertilizers which are difficult or impossible to clean. Fish and other living beings in ecosystems absorb these chemicals and are poisoned. Research and innovation can provide new methods to clean water, such as laser or membranes, and sometimes rediscover natural cleaners, such as plants.

Genetically modified seeds (GMSs) are pushed by business giants. The paradox is that farmers are not allowed to grow their own seeds; they have to buy GMS seeds from giants such as Monsanto. As a result, the GMS space is growing (see Figure 1.10).

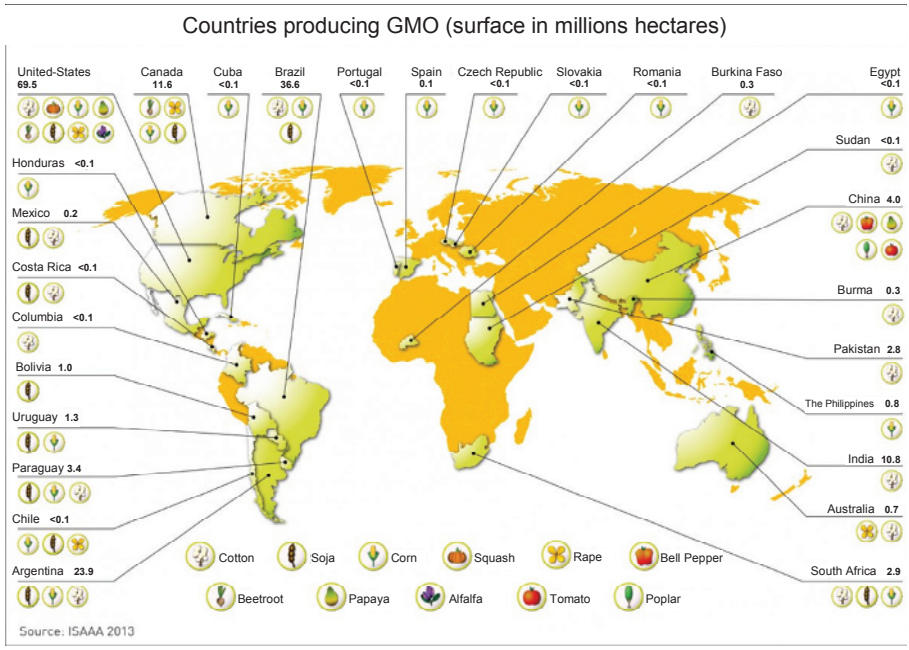

Figure 1.10. *GMO in the world (source: http://www.europabio.org/news/map-global-status-commercialized-gm-crops)*

Industrial food contains a lot of chemicals and technological innovations are improving the efficiency of the extraction of oil; the taste, smell and color are chemically improved.

According to Seignalet [SEI 12], the "pollution" of food was developed in the 20th Century due to the industrialization of food production, motivated by quick revenues. For example, the industrial mode of preparation of oils has three main disadvantages: persistence of harmful substances, such as hexane, which is impossible to eliminate totally, saturation of a part of unsaturated fatty acids and transformation of unsaturated fatty acids *cis* to *trans*. The overall process is described in detail by Chapell [CHA 98].

Ingestion of trans fatty acids can cause hypercholesterolemia, atherosclerosis, obesity, resistance to insulin in diabetes and coronary acute. The deficit in polyunsaturated fatty acids (*cis*) affects the functioning of cell membranes and unbalances the metabolism of prostaglandins (substances that act as cell regulators), which influences inflammatory and immune reactions.

Professor Henri Joyeux, a French oncologist, confirms the existence of a direct link between the quality of food and health [JOY 14].

We can observe that the nature is becoming more "aggressive" – insects such as wasps, ants and mosquitoes are proliferating due to lack of predators. Plant growth is suffering and disease is flourishing – only weeds survive. Large number of insects are eating our fruits and vegetables. As trees and plants are "traveling" due to globalization, insects and plant diseases are also moving around the world. For example, the Asian hornet kills honey bees already decimated by pesticides and *Paysandisia archon* kills palms in the south of France.

Some French researchers at the French CIRAD are working on sustainable agriculture. RITA, the recent initiative for the Antilles Islands, is building a network for sharing knowledge and practices in sustainable agriculture ecosystems, including ancestral knowledge [RIT 14].

Initiatives such as the National Sustainable Agriculture Coalition[12] publish the guidelines for the whole agriculture ecosystem [KRO 14]. Their mission, among others, is to encourage new and existing farmers to transition to sustainable and organic production practices enable producer access to local and regional food systems and increase consumer accessibility to sustainably produced foods. The knowledge from our past may be extremely useful.

The aim of European Initiative for Sustainable Development in Agriculture (EISA) is "to develop and promote Integrated Farming throughout Europe. Integrated Farming is a sustainable system, which helps farmers improve the way they farm for the benefit of the environment, the profitability of their business and social responsibility, including all important aspects of sustainable development".

> In modern times, they (farmers) have been greatly helped by scientific research and innovation, sound professional education and high quality advisory services. They are well informed about the best crop management methods, how to manage livestock efficiently with high welfare standards, and effective ways to manage their land and natural resources. However, sustainable agriculture as practiced through Integrated Farming means much more than just applying the right amount of fertilizers, feeding animals properly or keeping crops healthy. Integrated Farming is based on a holistic (whole farm) approach, on science-based management and on the optimal blend of experience and innovation in a continuous pattern of "planning, evaluation, and improved management" [EIS 12].

Even naturally grown food may be contaminated by surrounding pollution. Fish and seafood absorb industrial toxic chemicals circulating in the seas and rivers. These include mercury, dioxins and other man-made chemicals that are known as Persistent Organic Pollutants, such as polychlorinated biphenyls and polychlorinated terphenyls (PCBs/PCTs). Some are recognized as carcinogenic, for example endocrine disruptors.

12 http://sustainableagriculture.net.

Once again, we need to find a balance between research satisfaction, business from innovation, growth and impact on living and the environment. It would be beneficial to have a sensor able to detect chemical components in food and the freshness of the products to eat.

1.6. Knowledge city, smart city, green city and wise city

The idea of a "knowledge city" likely appeared from the 2003 Helsinki meeting of Entovation network. En2polis[13] was defined as a physical and virtual space where world citizens worked together sharing knowledge, experience and innovation. The following year, the event "Knowledge Cities, Knowledge Regions, Knowledge World" was held in Monterrey, Mexico. Since then, many initiatives around the world have flourished. IBM launched its "Smarter planet" offer in 2010, re-packaging their products to eco-applications such as energy optimization or water management.

A european program on Smart Cities begun in 2010 [EUR 10b]. The initial idea was use "digital technologies for better public services for citizens, better use of resources and less impact on the environment"[14]. The main objective is to bring more ICTs to budding metropolises. The European program focuses on zero-energy buildings, optimized heating, cooling and energy as well as sustainable mobility. Other Smart City programs are devoted to intelligent or green buildings, providing useful information to citizens and to their well-being and environment. In this "game", the winners are still the same – large companies such as IBM (Smarter Planet), CISCO (Smart Connected Communities) and General Electric, while in Europe we have many smart companies.

The very new initiative ‚Wise City, also involves large companies, while there are many start-ups having a "lego" solution; such a project just needs an architect able to explore the best of each player and influence the local development. The Wise City Hong Kong project[15] was initiated by the French Chamber of Commerce, Dragages – the affiliate of Bouygues Construction, a global leader in the building, Alstom – a global leader in the world of power generation, power transmission and rail infrastructure – BYME

13 http://www.entovation.com/group-alliance/en2polis.htm.
14 http://ec.europa.eu/digital-agenda/en/about-smart-cities.
15 http://www.wisecity.hk/partner.

Engineering (HK) Ltd and, a specialist contractor in all mechanical and electrical services and an expert in energy performance.

A city can be considered as "smart" when it wisely manages its tangible and intangible capitals, such as intellectual and social, traditional and digital communication, natural resources and quality of life, and innovates continuously for the sustainable success of all participants. They learn from the past (e.g. accumulated knowledge) and from each other, solve day-to-day problems and improve their capacity. This implies a new kind of governance, involvement of citizens in public policy and the smart use of ICT.

Smart city ranking has become a new "smart" business. Governance, economy, mobility, environment, living and people are among the indicators to define which city is the smartest.

For example, in Japan, companies such as IBM, Panasonic, Tokyo Gas and Accenture are focusing on making solar energy a more crucial element in suburban planning. Is it enough to be a smart city? Giffinger *et al*. [GIF 07] state that a smart city can be ranked using six axes: regional competitiveness, transport and digital economics, natural resources, human and social capital, quality of life and participation of citizens in the governance of cities. The main objective is urban growth and development.

To face the economic crisis, cities and territories have to optimize their functioning and reduce their costs. Smart city is an intensive user of ICT, intelligent technology, big data, connected objects and others. The majority of big cities are equipped with video cameras with the aim of reducing the criminality. Intelligent image mining systems can help to monitor what is happening.

The exodus of people looking for jobs from village to town, from a "poor" country to a "rich" country and the human desire to govern more territory impulsed agglomeration in France and megalopolis in the other countries. In fast developing countries, such as China, this phenomenon is spectacular. But this exodus of populations to the big cities causes a decay of villages, small towns and regions. Their revitalization is a big challenge for the 21st Century.

To preserve our planet, biodiversity and quality of life, do we really need to have more and to become bigger? What alternative is there to more technology, more companies, more business and bigger cities?

Some citizens and architects act on the concept of green city – the buildings are conceived or transformed to include a part of a garden. This idea is not new – small gardens on balcony or on the roof have already been installed by habitants. Green building is not only about energy efficiency [LEG 14], or using "green" materials, but also about producing food by citizens transformed into farmers. In France, we had *jardins ouvriers*, or workers' gardens, where small surfaces are offered for rent. *Feng shui*, the ancestral method to achieve physical, moral and intellectual fulfillment, was applied among others to plan the town of Suzhou [XUY 00], but it is still practiced for the quick development of megapoles. The Japanese also have a long tradition of zen and gardens, which they try to preserve.

Figure 1.11. *Qatar green building (source: http://arabbrains.com)*

Citizens' initiatives, such as "vegetables to take for free", contribute to greening and feeding at the condition that those who take also plant for the others benefit. A list of other French initiatives can be found at http://creativite-et-territoires.org/.

The 2020 objective of Hong Kong is to become a Wise City[16]. Theoretically it means they the city intends to use collective knowledge in an intelligent way, although this is not clearly mentioned in their website.

16 http://www.wisecity.hk/project.

1.7. Tourism and business travel

While the invention of the airplane amplified tourism, the present availability of low-cost flights has boosted this mass tourism. Many tourists are not respectful to nature; they just go to the beach, dive and prefer to use cars for short distance, instead of bikes or walking. These activities, added to those of the islanders, wanting to have more, increase pollution and destroy natural ecosystems and biodiversity [BER 09]. The awakening comes from wise local people, wanting to preserve their beautiful environment [KOH 14a], but often business wins. Some technological applications, such as e- and m-tourism, are tried to spread knowledge about a local ecosystem, influence the behaviors and disseminate the responsible and eco-tourism [CON 12].

European programs encourage mobility through various opportunities such as Erasmus, students, PhD and scientific exchange (Marie Curie Actions[17]). The student and professor exchanges have a positive impact on their social life, which lets them learn about new culture and a new language, gain knowledge and network to find partners for applying to EC programs or jobs.

The ICT offers a very good quality of videoconferencing and other distance communication tools, but paradoxically, it has not decreased the business travels. Numerous scientific conferences and other professional summits and forums make people travel around the world, more than before. European prescriptions on mobility for job also push to travel. A compromise needs to be found. A solution is certainly in the right managing of skills on European level (knowledge base of talents). Smart mobility projects are devoted to optimize travels and invent new, clean transportation. But we also have to use our intelligence to decide what is the best solution. Intelligent travel optimizers may help; they are still to be designed.

1.8. Fashion victims

The fashion industry is one of the most creative and innovative industries. Textile and textile techniques are beyond their usual playground, and new

17 http://cordis.europa.eu/fp7/people/home_en.html.

textiles are also inspired by ancestral raw material and are also integrating nanomaterials and sensors. Nettle, hemp, linen and wood are back. One of the last natural textiles is Tencel® produced from wood. The textile techniques are now widely applied in the airline industry to make fuselage for aircraft. Smart carpets control cleaning robots via radio frequency identification (RFID) (Vorwerk), transform harmful substances into harmless steam and carbon dioxide (duraAir). Two-layer textiles such as Transtex, that wicks away sweat and evaporates moisture, was initially used by athletes. Geotextiles made from steamless woven tubes are ground stabilizers in construction. Intelligent-wear (I-wear) textile integrates a solar power heating, flexible keyboard (ski gloves) and sensors [TEX 09]. Technological progress has lightened and improved the performance of firemen clothes and those of astronauts. Sport clothes are also light efficient.

Textile properties are improved with nanotechnology. They control odors, provide ultraviolet (UV) protection and are water and dirt repellent or self-cleaning. Nanoparticles of cyclodextrin, aluminum oxide, silver, silicon and vanadium dioxide provide the desired effect.

The *Centre Européen de Textiles Innovants*[18] was founded in 2012 "to enable businesses to fully benefit from the prospects offered by textile materials and by technologies of new fibres and nonwovens; to provide them with the best in textile innovation so as to rethink or to create products".

Sensors and other devices are now embedded in textiles to measure our vitals or protect us. A tailor-made bulletproof suit uses carbon nanotube material to create a lightweight and flexible body armor, capable of stopping small arms ballistics. Microsoft diversifies to lingerie – they develop a "smart bra" to monitor stress and discourage emotional eating[19].

Technology has also changed the profession of textile. However, technology must be associated with design and fashion to make new products attractive.

Paris was always a capital of fashion, but today the French and Italian models are copied and counterfeited, bringing a prejudice to coveted brands.

18 ceti.com.
19 http://www.wearabledevices.com.

Figure 1.12. *Wearable devices (source: http://www.wearabledevices.com)*

The quick business and avidity changed the human values and ethics. At the global level, there are too many products to sell – the marketing strategy is to offer "new" product instead of reusing, repairing and remanufacturing.

As a result, in France alone 600,000 products/year are not sold, including 22 million of clothes. Paradoxically, we design products needing long transportation which we then throw away or recycle. It is true that recycling creates jobs, but it is also energy- and water-consuming and polluting. The design, production and distribution of clothes involve many professionals and ensure jobs, mainly in China. However, many clothes and bags are produced in Italy by Chinese workers in aim to label them "Made in Italy". Chinese are the owners of a large number of shops in Europe. Intelligent wearing also includes "remanufacturing", i.e. creating new from the old [GRZ 57].

The gathering of clothes is among the latest trends of social innovation. Collected clothes are given or sold at a very low price to the homeless and the poor. We give them what we do not want, instead of helping them to find a job, develop useful skills and start a company.

1.9. Responsible innovation?

The described innovations not only produce an impact on ecosystems and human health, but also influence the change of moral principles, ethics and behaviors.

> If innovation is essential for the survival of any organization in a global and competitive market it can not be separated from the notion of responsibility. This is the challenge of innovation-manager who ensures reconcile at the same time the need to stimulate innovation while incorporating the necessary measures to ensure that the effects of our actions are compatible with the permanence of a lifetime authentically human on earth [JON 85].

The incredible paces of technological and scientific innovations that directly or indirectly affect humans raise questions of responsibility. Whether applications, accessories connected to our bodies, or even entirely artificial organ transplants, companies offer us so many ways to improve esthetically, physically, intellectually and even genetically. The growing impact of these developments on our consumption, our needs, as well as our health and human nature, leads us to pose new questions. It is no longer whether we can do but what we do. When the range of possibilities expands, and the exact impact on our lives is unknown, who returns it to decide whether a project should be developed or not? What are the responsibilities of organizations in the development of these offers? In France, the precautionary principle is applied, but it is also a considerable barrier for research.

Sustainable development focuses on recycling; it allows not only reusing the raw materials, but it also has an economic and environmental impact. Recycling influences the design process. How to influence intelligent buying, remanufacturing and reusing at all levels?

In developed countries, we observe a large number of critical diseases and species extinction [BER 09]. The impact on humans and other living beings health is growing, but it remains difficult to demonstrate the cause of effect in a short time because of the time scale. For example, French scientists have studied the influence of the smartphone on the human brain over a period of 5 years and they concluded that in 5 years there is no impact, while other researchers say otherwise [SAR 13].

Compared to nature, where everything recycles, everything we do has an impact, but the majority of us are not concerned with the consequences.

1.9.1. *What alternative?*

a) b)

Figure 1.13. *a) Leaf blower and b) sweeper in Ueno Garden Tokyo*

There are still some commercialized “innovations” , for example a leaf blowers that are less effective than old methods, energy consuming and polluting (air and noise), making people lazy physically or “thinking” instead of the user (switching off the brain).

What is the impact of the activity presented in Figure 1.13? The impact of activity in Figure 1.13(a) is not efficient and polluting. In Figure 1.13(b), cleaning the park with a broom will certainly be less polluting and more efficient. The physical work is beneficial for health. The individual doing this work is an older Japanese man and this activity allows him to be useful, get a salary, move and have contact with nature and other people. Such a solution is certainly better than a nursing home.

This search for the simplest solution is a basic principle of innovation intelligence. In the 1960s, the Fisher Pen Company invested $1 million to create the space pen. They patented a pen that could write upside-down, in freezing an boiling conditions, and even underwater or in other liquids, and offered the AG-7 “Anti-Gravity” Space Pen to NASA in 1967 and the agency decided to use it on spaceflights. The total expenditure on the Space pen research was very expensive, while the Russian astronauts continued using a simple pencil.

Motivation can be both an engine of innovation and a barrier. Researchers are motivated by recognition and awards, while companies are motivated by revenues. The principle of scientific publications and evaluation of researchers is among the most difficult to change because it involves the change of existing systems that became inadequate with the reality [MER 11]. Researchers are pairwise evaluated only for publications in a given field. Technology transfer, entrepreneurship or influence of their research on the progress of other fields are not taken into account. Such a system is contradictory with the challenges and expectations of innovation. In this context, the evaluation of impact is not easy because it involves distant fields from the original area. In our recent project dealing with eco-design, the convergence of the fields such as design, sustainability, knowledge management and innovation was difficult. Actually, each field has a specific vocabulary and way of thinking. It takes energy and time to build common references, and sometimes it does not work.

Related barrier is the thinking limited to a given field, resulting from specialization. The last European Commission Program Horizon 2020 put

emphasis on multidisciplinary projects. To address the set of challenges, a combination of knowledge from several areas is vital. However, the majority of proposal reviewers are mono-field specialists. As a result, the innovative projects combining several fields are rejected.

Considering the social position rather than the value of the brain may prevent innovation. The knowledge economy is supposed to generate values from our individual and collective knowledge. The main barrier in developing this economy is the psychological barrier – it is a strong culture of context instead of the value of the brain. Very often, people ask about a company instead of asking about the given person's knowledge and experience.

Certainly, we need technological progress, but it should help us in our work and make life easier without deteriorating our conditions and the environment. Searching for the simplest solutions and taking into account the consequences from the beginning are vital. Open Systems Science [TOK 10] considers the "neighbors" of a given science that may have an impact on balanced solution. The challenge is also to use and combine the past and today's multidisciplinary knowledge and "intelligent technology" to invent sustainable products, services and methods taking into account the 5D impact. Do we really need to grow to be happy?