



Deliverable 1.2 OBSERVE Horizon Scanning Report

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1 Introduction

The horizon scanning report contains the findings of the OBSERVE horizon scanning phase that was running from June to December 2015. In this phase a set of complementary screening methods was applied¹ to generate a repertoire of emerging topics with potential relevance for the FET unit activities.

The Future & Emerging Technologies (FET) program of the European Commission invests in transformative frontier research and innovation with a high potential impact on technology, to benefit our economy and society. FET provides a unique combination of high risk, long term, multidisciplinary and collaborative frontier research, which lays the foundations for radically new, next generation technologies. It converts proofs of concept into industrial applications and systems.²

This means that topics taken up by FET should be highly radical/transformational, interdisciplinary and potentially beneficial for society and economy. At the same time topics should be situated in the very early stages of innovation trajectories.

Insights from innovation studies indicate that radical breakthrough innovations rarely emerge from basic research in a linear way. Rather, novelty emerges from combinations of changes in diverse corners of socio-technical landscapes. Therefore the OBSERVE team set up an observatory looking at a wide range of frontiers from science and technology to social practices.

Accordingly, findings were assigned to five basic types of change:

- **Solution Idea**

Emerging technological or social innovation or combination of both addressing a certain problem

- **Science and Technology**

Emerging frontiers in science and technology development

- **Challenge/Need**

Challenge or need with long term relevance for society newly emerging or gaining a new dynamics

- **Social Practice**

Emerging change in social practices (new ways of doing) including policy practices

¹ Manual scouting, web-mining, publication analysis, cluster analysis of FET proposals

² <https://ec.europa.eu/digital-agenda/future-emerging-technologies-fet> last accessed 11.02.2016

- **Collaboration**

New formats of collaboration in research and innovation and new constellations of actors collaborating in particular across disciplines

It should be noted that the potential emerging topics reported here are not the final topics suggested for consideration by the FET program. Rather, the OBSERVE observatory forms the basis for the sense making phase where stakeholders and experts will review the diverse set of emerging issues from different realms and combine them into “hotspots” with a potential relevance for FET.

The methodology and lessons learned are discussed in depth in the OBSERVE Methodology Report D1.3. This report presents the emerging changes identified in the horizon scanning phase one by one. In order to preserve the usefulness of this report as a basis for the sense-making discussion we provide only very basic information for each topic. At a later stage the database with the full range of sources will be made available. Also the emerging topics will be distributed in the format of a deck of card as a basis for creative workshops (D 4.3). In the next step this wide range of topics will be synthesised and selected areas of change will be investigated in more depth to provide input to the FET programming activities.

2 Overview Findings

In total, the report presents 171 items to be considered in the OBSERVE sense making phase as emerging topics. Of these items 44 are “clusters” that have been formed by combining observations from a wide range of sources often revealed through the automated web-mining. Figure 1 list these clusters and indicates their “size” by the number of key sources associated with this cluster. In addition however several clusters are supported by the automated webmining in particular: brain research, water/ocean research, robot research, energy/solar, urban systems, food and space exploration.

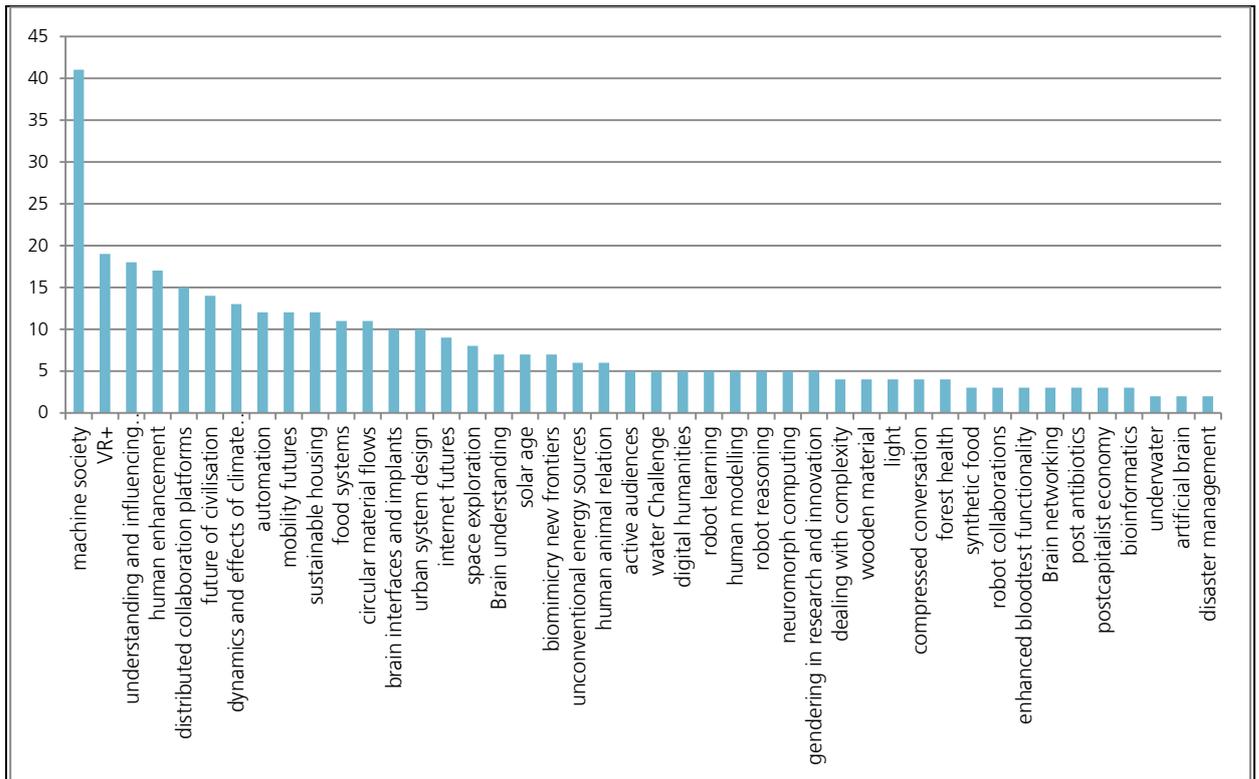


Figure 1: OBSERVE Clusters

Figure 2 shows the distribution of the findings across the different types of change. In total 57 findings are in the realm of science and technology. In addition, 43 S&T developments are explicitly addressing challenges or needs. Furthermore the observatory contains 14 “challenges and needs”, six “solution ideas” and six “social practices” of which seven are directly related to science and technology developments. In line with the selection criteria most of these topics are strongly inter- and transdisciplinary. Also, almost all clusters comprise novel collaboration elements. This is why only relatively few (7) findings remain that have collaboration right at the core.

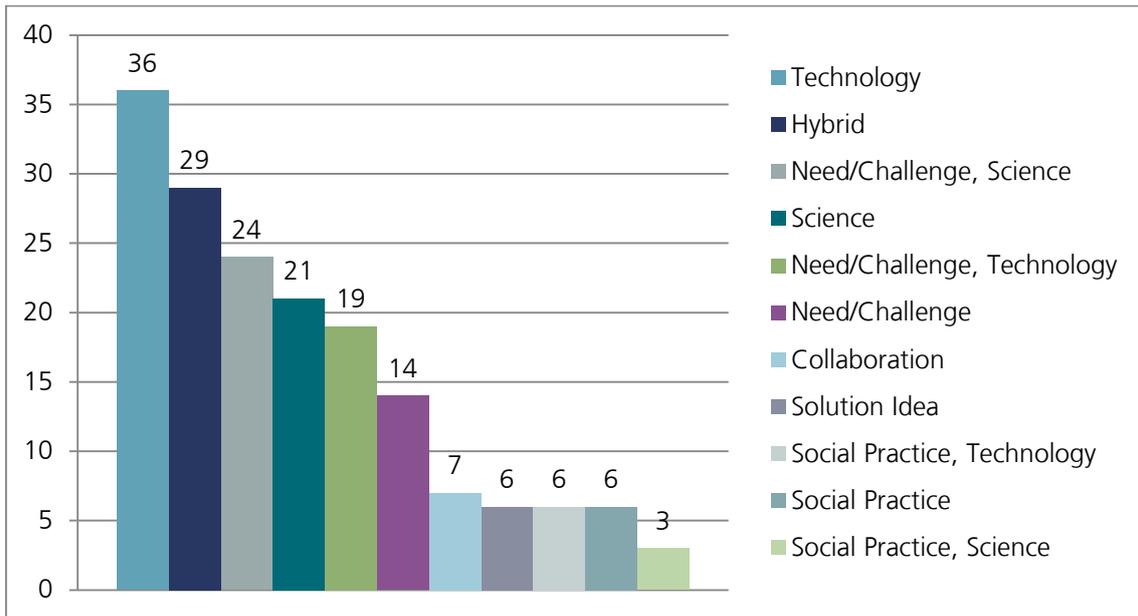


Figure 2: Observe findings by type of change

3 Emerging Topics

This chapter provides short descriptions of the emerging topics sorted by type of change. For each topic we provide to source that initially hinted at the topic. In the case of the 44 clusters listed above this is marked as “several”. In most cases this source is backed by several further background sources often highly renowned scientific journals. The “impact level” describes the type of impact expected from this development. We distinguish the following four levels:

- “Local”: impact in a specific domain (e.g. health)
- “Mid Range” impact across several domains e.g. a new materials with applications in health, ICT and energy
- “Widespread” impact across society e.g. fundamental changes in communication patterns
- “Fundamental” impact on the long-term future of the civilisation.

This classification is by no means an assessment of the relevance or even the relevance for FET. Developments with local impact (e.g. on a certain disease like heart attack) may well be of highest importance.

3.1 Hybrid

H 1 Human enhancement

Various technologies, techniques and drugs are emerging, that can enhance bodily functions and in particular cognitive performance (neuroenhancement). There are microchip implants, smart contact lenses which can monitor blood values or advanced prosthetic technologies (bionic eyes, extreme knees...). Severable applications serve to support blind and deaf people to navigate. Biohackers modify themselves with RFID-Chips or other technologies. Science fiction writers envision even more extreme forms by envisaging such as chips that can set emotional mind states or interact with body cells e.g. fighting cancer cells. Also artworks like "Anke" (Hans Op de Beeck): investigate the theme of the enhanced superhuman and the quest for immortality. This trend (in particular cognitive enhancement) could change the way we work, we think or how we communicate.

Source:
Several

Impact Level:
Widespread

H 2 Biomimicry new frontiers

An increasing number of technologies are inspired by biological functions and solutions. One driver of the new momentum for biomimicry is the advance in simulation and freeform manufacturing (3D printing). Current examples of cutting edge biomimicry innovations include smell-guided-navigation, jellyfish inspired locomotion, insect-inspired robot design (vision and movement) and research into animal system behaviour (e.g. ants) that could help us develop the internet – or even understand how cancer spreads. Furthermore, biological principles and characteristics could be used for better computing. There are already many attempts to emulate biologic systems in order to enhance computer chip performance or binary communication processes as well as bioinspired parallel and neuromorph computing. In the 2015 Lift China Conference there was a focus in biomimicry as the next generation sustainability concept.

Source:
Several

Impact Level:
Mid Range

H 3 Active audiences

Through the rise of web2.0 the role of media audiences has been shifting from passive observers of distant events to active participants. In many areas "active audiences" are emerging and sometimes gaining substantial influence. Examples are the rise of vloggers, movie fanediting and personal live streaming. New apps like periscope where audiences become active influencers may transform the way we interact and relate to each other.

Source:
Several

Impact Level:
Local

H 4 Automation

Automation is fast progressing in ever more domains of human activity (medical research; sewing, software managing processes, trash collection, drone ships, automated hiring; automatic ordering/replenishment; robo journalism; science). This comes with a number of social, economic and ecological consequences. Humanity needs to understand and actively shape this development e.g. by controlling the power of algorithms and learning to deal with unexpected events. One of the key challenges will be to build a workable future for all.

Source:
Several

Impact Level:
Widespread

H 5 Circular material flows

Circular economy approaches are on the rise. More and more designers adopt "upcycling" approaches and use more second-hand materials. Waste materials will become increasingly valuable as new technologies offer better ways to extract reusable substances like rare metals from discarded products (waste mining). Several examples for circular economy products emerge. At the same time, Europe only correctly recycles 35 percent of its E-Waste - a radical change is needed here. Also, the global plastic production increases rapidly. Plastics and microplastics in the ocean are causing severe problems.

Source:
Several

Impact Level:
Widespread

H 6 Urban system design

It seems that humanity now faces a watershed challenge: to find a new basis to generate creative economies and quality of life, without destroying the resources on which life ultimately depends. Cities are bound to play an essential role in this transition. They are complex, adaptive systems with their own characteristic dynamics. Several ideas for novel transdisciplinary approaches to urban system and infrastructure design are emerging ranging from citylabs via "tactical urbanism" to urban warfare concepts and low energy urbanization. The issue is emerging with the same intensity in research, web debate and art.

Source:
Several

Impact Level:
Widespread

H 7 Dealing with complexity

Advanced control systems (such as aircraft cockpits) master increasingly complex control tasks. They are however unable to fully deal with complexity and uncertainty of the real world in particular of human behaviour. While the science of complex systems has been around for 35 years now, it has more recently seen a rise of centres and institutes all around the world and is expanding to include more social sciences and sustainability. Several research activities in machine learning are aiming at contributing to this challenge of handling complexity. Examples are emotional recognition used to steer machines, pricing of basketball players based on moving dot analysis and development of mental clones acting in cooperation with ourselves. Further contributions to better understanding the relationships of elements in complex systems are made by research on swarm intelligence, swarm robotics, self-organizing systems, adaptive systems, evolutionary computation, systems biology and affective computing.

Source:
Several

Impact Level:
Widespread

H 8 Disaster management

Globally, the threat of disasters is rising so e.g. the risk of flooding for US coastal cities has risen significantly. This calls out for solutions for better monitoring and management of catastrophes such as e.g. the use of seafloor cables to generate and transmit geological data (smart-cables).

Source:
Several

Impact Level:
Mid Range

H 9 Distributed collaboration platforms

Around the world citizens self-organize to research and address certain challenges such as energy-supply, waste-disposal, weather- and threat-monitoring or bee dying. These "peer2peer" initiatives need platforms to safely collect, manage and process data and resources in a distributed and collaborative way. At the same time technical solutions that allow orchestrating large numbers of distributed specialists at short notice and thereby enable new collaboration and service models such as Application Program Interfaces (API) and blockchain technology are receiving a lot of attention.

Source:
Several

Impact Level:
Widespread

H 10 Postcapitalist economy

Several developments point towards the emergence of new “postcapitalist” economic models with the internet and automation among the driving factors.

Source:
Several

Impact Level:
Fundamental

H 11 Food systems

In the near future we have to produce 70% more food than today without harming the environment. Furthermore the decrease in variety in plant and animal based food (eg rice/apples) is making food systems more susceptible to pests and diseases. Globally dependency on grain imports is on the rise. Production of meat and fish is rising steeply. Technical approaches to food production such as smart floating farms, high-tech urban farming (e.g. vertical aquaponic growing system) and artificial food abound. Another angle is the reduction of food waste. At the same time there is a growing threat from foodborne diseases. Research addressing infection or intoxication caused by pathogenic factors entering into human bodies through food is one of the most dynamic fields in agricultural, plant and animal sciences.

Source:
Several

Impact Level:
Widespread

H 12 Future of civilization

The future of our civilization could be fundamentally affected by developments in different categories.

- 1) Change of nature: 6th mass extinction, dying of butterflies and bees, long term ocean transformation, climate change
 - 2) Developments and technologies: rise of the solar age, living below the sea, in space or supported by artificial life support systems for interstellar flights.
 - 3) Mankind: the rising average of age (nearly 100 soon)
 - 4) Higher risk of collapse through catastrophic food shortages triggered by a combination of climate change, water scarcity, energy crisis and political instability.
- Artwork like David LaChapelle's Utopia: Gas Shell is reflecting on a world where nature reasserts itself in the world.

Source:
Several

Impact Level:
Fundamental

H 13 Gendering in research innovation

The awareness for the need for gender specific approaches in research and innovation in domains like health and communication is growing.

Source:
Several

Impact Level:
Local

H 14 Plant communication

Several studies point out that plants weave complex social relations and can communicate with themselves and with animals. Some argue that their right should be more considered especially in the midst of the Sixth Mass Extinction.

Source:
theguardian, Book: Brilliant Green

Impact Level:
Widespread

H 15 Human animal relationship

The relationship between animals and human beings is changing. Firstly, there is a kind of technical domestication apparent in developments like remotely controlled bugs (biodrones), fish-guiding robots or genetically altered pets. With science increasingly pointing to animal culture and self awareness there is debate on (human) rights for animals and ever more people adopt vegetarianism and veganism. Furthermore, some people modify their body in order to become like animals.

Source:
Several

Impact Level:
Mid Range

H 16 Technological Singularity

The technological singularity is a hypothetical event in which artificial general intelligence would be capable of recursive self-improvement and thereby ultimately surpass human control or understanding. This expectation has long been voiced in Science

Fiction but is also expected and discussed by several researchers. More and more such as physicist Stephen Hawking warn that the development of full artificial intelligence could spell the end of the human race. FET proposals point out that groundwork in fields like ontologies, knowledge representation, computational linguistics and cognitive systems is still necessary.

Source:
Several

Impact Level:
Fundamental

H 17 Internet futures

The internet will change, in a technical and in a social way. Some experts expect that smaller and more specific networks with a distributed processing power will emerge such as e.g. "smart-hotspots". Mobile access points will become more important. Google designer Tom Uglow advocates an "Internet in Things": Bringing the internet into „natural, simple“ things without screens for the time span of fluid information. In terms of content the rise of non human traffic, trolls and abusive behaviour is raising concerns. The artwork Biennale.py (Eva and Franco Mattes) points to the central role of viruses in the future of the internet.

Source:
Several

Impact Level:
Widespread

H 18 Machine society

New forms of machine-human-symbiosis emerge on all levels of society from manufacturing to intimate situations. More and more decisions and activities are done by algorithms and machines (hiring, investment, robo-journalism, poetry, recognition and reproduction of facial expressions, identification). Deep learning further extends the range and depth of human machine interactions. This requires collaborative and interdisciplinary research to reap the benefits, prevent failures and chaos and to counteract risks. Issues like trust and responsibility in hybrid human-machine ensembles need to be explored.

Source:
Several

Impact Level:
Widespread

H 19 Mobility futures

There is plenty of discussion on disruptive changes in human mobility.

The most discussed development is the self-driving vehicle and its interaction with the human. Other emerging concepts are improved solar-powered vehicles, personal balance-vehicles (like segways), vacuum hyperloop-tube for transport and hypersonic-flights. For ships the old approach of wind powering is explored afresh.

Source:
Several

Impact Level:
Widespread

H 20 Solar age

The reinforced search for renewable energy sources forwards the solar technology and solar installations in general. Many advanced technologies and techniques emerge: New designs and materials for solar cells, solar powered devices and monitoring of favourable conditions for solar panel installation (e.g. in space) were key topics in the current debate. Several research fronts in chemistry and material science dealing with solar applications emerged:

- Polymer solar cell: The polymer solar cell has become a hot research topic for the third generation of solar cells due to its advantages of low cost and the capability to be produced in large volumes with the "roll-to-roll" technique.
- Bulk heterojunction polymer solar cells: Bulk heterojunction is a low cost manufacturing technique for polymer solar cells. Studies investigate different polymers and methods to increase efficiency.
- High performance perovskite-sensitized solar cells: Solution-processable -organic inorganic hybrid perovskites- have attracted attention as light-harvesting materials for solar cells with very promising conversion efficiency. Another hot research topic is more efficient, affordable and benign materials for photoelectrodes and photocatalysts for splitting water (solar fuel, artificial photosynthesis).

Finally, social scientists are discussing patterns of life in solar age e.g. new strategies to better use daylight.

Source:
Several

Impact Level:
Widespread

H 21 Space exploration

New ideas and developments concerning outer space abound: life support space suits, space mining concepts, future space shuttle designs with a biosphere on it, outer space villages or nanosats which observe earth from space and an inflatable space elevator. Space related topics are one of the most popular domains on Kickstarter.

Source:
Several

Impact Level:

Local

H 22 Synthetic food

In the face of a looming food crisis artificial substitutes are developed such as a food powder that provides 100% of an adult's daily nutrients. Some experts expect that within 10 years synthetic biology will be able to produce different kinds of food, including meat and drinks at lower costs than today. By manipulating genes, brand-new foods can be created with new properties or flavours. Agricultural biofactories which use glass or plastic vats (bioreactors), and needs only sun or sugar, algae and nutrients, can be located anywhere.

Source:
Several

Impact Level:
Local

H 23 Understanding and influencing human behaviour

Several researchers across disciplines are investigating ways to understand and influence human thinking and behaviour; The field is highly interdisciplinary ranging from AI, NPL, data analytics, game design and neuroscience to sociology, pedagogics and economics. Computational neuroscience in particular aims for a better understanding of the human brain and cognition.

Source:
Several

Impact Level:
Widespread

H 24 Underwater

Several underwater operations are researched and developed. Key issues are underwater: -gardening, -living, -(mini)robots, -cities, -streetview, -radio (graphene), -chemical plants, -charging, -flight, -volcanoes, -farms, -archaeology, - screening radar, -energy (wave/wind farms), materials.

Source:
Several

Impact Level:
Mid Range

H 25 Mixed Realities

We entered the age of multiple realities. Technologies and practices which allow us to see augmented or virtual reality are extremely prominent in the current discourse: 360 degree videos, advanced vr-gaming (Microsoft holo-lense), vr-therapy, a real time

painting 3D-model translator, vr development tools for animations, paint applications for oculus rift and space experiences. Virtualization and wearable computing devices are expected to combine to create a new wave of social technology. The Oculus Rift already allows users to virtually explore real environments from the perspective of a child, and wearable recording devices are beginning to capture the details of everyday life. Developments like the personal headphones which can filter out unwanted noise point to a world where reality will be in the eye (and ear) of the beholder. VR and augmented reality topics are one of the most popular areas on Kickstarter.

Source:
Several

Impact Level:
Widespread

H 26 Robot reasoning

A new generation of robots with cognitive planning and reasoning capabilities is being developed. They can handle uncertainty, act in messy unpredictable situations and carry out creative tasks like participating in a cartoon contest. Furthermore some researchers focus on a kind of artificial consciousness and self awareness - a concept that is highly contested by some philosophers.

Source:
Several

Impact Level:
Mid Range

H 27 Forest health

Forests and woodlands cover about 20% of Earth's land surface, and only a small fraction is undisturbed by humans. There is a need for a "future health care plan". Forests still have an important function in the future, sustaining wildlife, producing timber, sequestering carbon, and performing other services. Tree mortality attributed to drought and heat stress has become a hot topic in environmental science. Studies suggest that at least some of the world's forested ecosystems already may be responding to climate change and raise concern that forests may become increasingly vulnerable.

Source:
Several

Impact Level:
Mid Range

H 28 Brain networking

For the first time scientists have been linking together animal brains with electrodes. University of Washington researchers recently used a direct brain-to-brain connection to enable pairs of participants to play a question-and-answer game by transmitting sig-

nals from one brain to the other over the Internet. Some believe that one day humans will be able to directly share emotions, thoughts, and sensory feedback with each other through synthetic telepathy.

Source:
Several

Impact Level:
Widespread

H 29 Sustainable Housing

Advanced concepts of sustainable and practicable housing are fast emerging. Especially themes like natural materials, zero impact living, safety, movability, environmental fitting, gentrification and social housing are addressed by highly interdisciplinary teams of developers. Examples are the "Energy Positive" house in Wales, sustainer homes and urban campsite in Amsterdam, the future box in Berlin, the Ultra Light Construction Systems developed by MIT POPlab, the movable skip-garden in London and efforts in Indonesia towards buildings that withstand natural disasters.

Source:
Several

Impact Level:
Local

3.2 Technology

T 1 Virtual Personal Assistant Bots

Deep machine learning gives rise to a spectrum of smart machine implementations — including robots, autonomous vehicles, virtual personal assistants (VPAs) and smart advisors — that act in an autonomous (or at least semiautonomous) manner. Apps as virtual assistant such as Microsofts Cortana, Google Now or Apples Siri will get better in recognizing situations and derive individual user needs.

Source:
Gartner

Impact Level:
Widespread

T 2 Rise of the drones

Science fiction novels envision a world where drones of all shapes and sizes will take over a vast diversity of functions such as monitoring, scanning, surveying, transport and spying. Smarter and smaller drones with more functions are one of the most popular areas on Kickstarter.

Source:
Science Fiction Novel: Drohneland

Impact Level:
Widespread

T 3 Plasmonics: From basic research to breakthroughs in high-performance computing and nano devices.

Plasmonics deal with information transfer in nanoscale structures, similar to photonics, by means of surface plasmons. In contrast to photonics, there is no light involved but surface charges are being analyzed in this research field. Being in an early stage of development, plasmonics may contribute to new high-performance chips and nano devices since surface plasmon-based circuits can overcome the size limitations of photonic circuits.

Source:
FET Proposals

Impact Level:
Mid Range

T 4 Energy Harvesting may be the solution for powering small and mobile devices in the future.

Energy harvesting is the process by which energy is derived from external sources (e.g. solar power, thermal energy, wind energy, salinity gradients, and kinetic energy), captured, and stored for small, wireless autonomous devices, like those used in wearable electronics and wireless sensor networks will more and more be powered by energy from kinetic energy, salinity gradients, solar power or thermal energy instead of batteries. The process of making these external energy sources usable for small devices is called "Energy harvesting". Once new and efficient ways of harvesting energy from the environment have been found, more and more mobile devices can be powered by surrounding renewable energy sources. Also, once successful, more and more low-energy electronics may be developed and deployed in a variety of fields.

Source:
FET Proposals

Impact Level:
Mid Range

T 5 In the research field of Microfluidics, interdisciplinary work will yield advanced Lab-on-a-Chip-technologies and other new applications

Microfluidics is a multidisciplinary field intersecting engineering, physics, chemistry, biochemistry, nanotechnology, and biotechnology, with practical applications to the design of systems in which low volumes of fluids are processed for high-throughput screening. Typically, fluids that are constrained to a sub-millimeter scale are moved,

mixed or separated. Thus, processes which are normally carried out in a lab can be miniaturized on a single chip (lab-on-a-chip). Other current applications of microfluidics include inkjet printheads, DANN-chips, micro propulsion and micro-thermal technologies. With the introduction of active micro components like micropumps or microvalves, a whole new range of applications will become possible in the future.

Source:
FET Proposals

Impact Level:
Local

T 6 CMOS technology will stay on the R&D agenda and will continue to boost chip performance and bring about new applications

Complementary metal–oxide–semiconductor (CMOS) is a technology for constructing integrated circuits. CMOS technology is used in microprocessors, microcontrollers, static RAM, and other digital logic circuits. CMOS technology is also used for several analogue circuits such as image sensors (CMOS sensor), data converters, and highly integrated transceivers for many types of communication. Research will continue in this area and new performance output and new applications will come out of these R&D activities in the future.

Source:
FET Proposals

Impact Level:
Mid Range

T 7 Interdisciplinary research to build context-aware robots

Robotics is the branch of electronic and electrical engineering, mechanical engineering and computer science that deals with the design, construction and operation of robots, as well as computer systems for their control, sensory feedback, and information processing. Whereas robots are already in use in production environments and other contexts where simple and fixed tasks need to be done, autonomous, rule-based and context-sensitive “behaviour” is currently the dominant research challenge in robotics. Thus, more research will be needed in the future in the areas of context awareness, embodied cognition, autonomous systems, and human-robot-interaction.

Source:
FET Proposals

Impact Level:
Mid Range

T 8 Bio-sensors: Using plants as environmental sensors and connecting them to sensor networks

Plants can be used as sensors to monitor environmental parameters, such as temperature, humidity, air quality, etc. In the future, the sensing information of plants may be accessed by a technical device and the signal will be transferred over a wireless network. This way, many new applications become possible as data will be available to monitor any environment of interest.

Source:
FET Projects

Impact Level:
Local

T 9 Wireless transfer of electricity

Wireless transfer of electricity is a future vision that interests many researchers

Source:
Book: Technolife 2035: How will technology change our future? ³

Impact Level:
Widespread

T 10 Intelligent combination of sensor-data replaces traditional technologies for authorization, monitoring and observation

Instead of highly visible and electricity-consuming video cameras or pattern recognition computers, sensors tracking motion, noise, temperature, weight, etc. can be used. This requires that the sensors are connected to each other and that their data is being combined in an intelligent way. New network setups and algorithms will be developed which will enable these sensor networks to identify persons, activities and objects with more precision and much less power-consumption than traditional methods.

Source:
FET Projects

Impact Level:
Widespread

T 11 Automated indoor farming

A company in Japan is building an indoor lettuce farm that will be completely tended by robots and computers. The company expects the factory to open in 2017, and the fully

³ Hiltunen, Elina & Hiltunen, Kari. Technolife 2035: How Will Technology Change Our Future? Cambridge 2015

automated farming process could make the lettuce cheaper and better for the environment. For now, the Wall Street Journal reports that the company is still working on a machine that can plant the seeds, and their process still requires human eyes to determine whether a seedling has sprouted.

Source:
Wall Street Journal

Impact Level:
Mid Range

T 12 Self-Propelled particles

Researchers at the University of British Columbia have created the first self-propelled particles capable of delivering coagulants against the flow of blood to treat severe bleeding, a potentially huge advancement in trauma care.

Source:
Futuristech Info

Impact Level:
Local

T 13 New sensors to measure ocean acidification

Ocean acidification describes the decrease in the pH of the Earth's oceans due to the uptake of carbon dioxide (CO₂) from the atmosphere. New sensors for data gathering are being developed. XPRIZE has awarded a large sum for development of sensors for acidification.

Source:
Scientific American

Impact Level:
Local

T 14 Terahertz communication enables a new range of wireless applications in the future

In May 2012, a team of researchers from the Tokyo Institute of Technology set a new record for wireless data transmission by using Terahertz-rays and proposed they be used as bandwidth for data transmission in the future. The new devices will use a so called resonant tunnelling diode (RTD) in which the voltage is decreased as the current increased, causing the diode produce waves in the terahertz band which enable data transfer rates of 3 Gigabits per second. The demonstration was twenty times faster than the current Wi-Fi standard. Research still has to be done, especially in the fields of adaptive antennas, frequency comb to unleash the potential of the invention.

Source:
FET Proposals

Impact Level:
Mid Range

T 15 Research in the field of photonic crystals may lead to a superior-performance optical computer.

A photonic crystal is a periodic optical nanostructure that affects the motion of photons in much the same way that ionic lattices affect electrons in solids. Photonic crystals occur in nature in the form of structural coloration—and, in different forms (one-, two- or three-dimensional), promise to be useful in a range of applications. Photonic crystals can, in principle, find uses wherever light must be manipulated. Existing applications include thin-film optics with coatings for lenses. Two-dimensional photonic-crystal fibers are used in nonlinear devices and to guide exotic wavelengths. Three-dimensional crystals may one day be used in optical computers with superior performance. The related research field are silicon photonics, spectroscopy, optoelectronics, GaN, integrated optics, optomechanics, and photonic integrated circuits.

Source:
FET Proposals

Impact Level:
Mid Range

T 16 New kinds of sensors (biosensors, lab-on-a-chip, smart textiles, etc.) and their smart connection will give us a new level of control over our surroundings.

The reason why the Internet of Things still seems to be distant promise today is that there is not enough smart and connected data available. Thus, research needs to be encouraged in the area of sensing devices and technologies to analyze and exploit the data collected in the various fields. This research includes new kinds of biosensors, lab-on-a-chip technologies, wireless sensor networks, remote sensing, environmental monitoring, smart textiles and RFID.

Source:
FET Proposals

Impact Level:
Mid Range

T 17 Fully autonomous production organism

If industry 4.0 becomes bigger and more connected, this could mean the end for industrial production as we know it. In science fiction it is envisaged that all production is accomplished by an artificial organism that works fully autonomously.

Source:
Herr aller Dinge

Impact Level: Fundamental

T 18 Brain interfaces and implants

There is a lot of current R&D effort at the intersection of neuroscience, biotechnology, and computer science directed at developing interfaces to the brain. The topic was one of the most prevalent in the webmining. Examples for research activities on interfaces are memory chips to improve the memory performance, brain controlled bionic devices and a brain reading technology that helps violinists to play again after a heavy accident. For implants new developments in 2015 included soft devices to deliver drugs in the brain and syringe-injectable electronics.

Source:
Several

Impact Level:
Local

T 19 Advances in robotics will be achieved by combining biology, material science and computer technology

To build robots is an interdisciplinary venture by nature. In the future, efficient and broadly applicable robots will be available because research has successfully combined insights from biology (robots inspired by plants, octopus or insects, swarms of robots with emergent behaviours) and material science (evolving and shape-changing robots) has successfully mapped those advances into information systems.

Source:
FET Projects

Impact Level:
Mid Range

T 20 Neuromorph computing

Several sources from webmining and manual scouting point towards novel developments in neuromorph computing in particular circuits formed after the human brain such as memristors. Some expect that these will allow designers to create devices with memory systems that function more like a brain. A third development is in the use of optical fibres for mimicking the human brain in neural networks. Some researchers point out ethical issues in dealing with future "digital brains".

Source:
Several

Impact Level:
Local

T 21 Bacteria-robot model systems

In a recent paper a Virginia Tech scientist used a mathematical model to demonstrate that bacteria can control the behaviour of an inanimate device like a robot. In agriculture, bacteria-robot model systems could enable robust studies that explore the interactions between soil bacteria and livestock.

Source:
DEEPSTUFF.ORG

Impact Level:
Local

T 22 New materials for robot parts

New materials for robot parts enhance robot capabilities: Autonomous and soft materials enable changing of shape, artificial skin and muscles and thus allow for more flexible movement and functions.

Source:
XPRIZE

Impact Level:
Local

T 23 Robot to robot collaborations

Communication and collaboration between robots without human interference is possible now. In science fiction self governing robot swarms have long been imagined.

Source:
Several

Impact Level:
Mid Range

T 24 Robot learning

One of the most discussed topics in the field of robotics in 2015 was new ways of deep robot learning including learning from watching, reading and playing and storing through "thought vectors".

Source:
Several

Impact Level:
Mid Range

T 25 Robots will become more human-like as their vocabulary comes closer to that of real humans

Currently, computational intelligence is restricted to lexical descriptions found in dictionaries. But with current results from brain research from clinical studies and neuro-imaging, a complete inventory of words, their emotional valence and perceptual properties will become available. However, it takes a combined effort of neuroscientists, cognitive scientists, lexicographers and computer scientists to harness this new source.

Source:
FET Projects

Impact Level:
Local

T 26 Spintronics: New principles for new, ultra-high capacity storage devices.

Spintronics is a research field of nano electronics and deals with the study of the intrinsic spin of the electron and its associated magnetic moment. Spintronics differ from older magnetoelectronics, in that spins are also manipulated by magnetic fields and not by electrical fields alone. One promise of this research field which is at the same time basic research and applied research is that with the help of the special principles, storage devices with much higher capacities may be developed in the future.

Source:
FET Proposals

Impact Level:
Mid Range

T 27 Insights from cognition research and biology may enable better Ambient Intelligence (Aml) systems

Context awareness and activity recognition are key components of the vision of Ambient Intelligence (Aml). A common problem is that activity recognition can only be achieved in narrowly defined sensor configurations. Bringing together insights from biology, machine learning and control theory will allow new systems which take advantage of sensing modalities that happen to be available, rather than forcing the user to deploy specific, application dependent sensor systems.

Source:
FET Projects

Impact Level:
Widespread

T 28 non-invasive brain influencing

The webmining revealed two new approaches to for influencing brain cells without physical interfaces one is through sound waves and another through magnetic stimulation (using nanoparticles).

Source:
The Guardian, BBC

Impact Level:
Local

T 29 The combination of scientific advances in nanotechnology, optics and spintronics with conventional electronics will lead to new computing and switching devices with superior performance.

Advances in nano-electronics, nanoscale integration, optical signal processing and spintronics are currently being combined with existing electronics (chipdesign, switching technology, storage technologies) in order to increase performance or to build all new devices based on new principles. In the future, the incremental improvements from these combinations and inventions may turn into disruptive changes in computing and high-speed applications.

Source:
FET Projects

Impact Level:
Local

T 30 Quantum technology will move from basic research to applications

Quantum technology today is in an early stage of its development and research is often characterized by theoretical reflections. However, the promises concerning future applications are manifold and are not limited to the quantum computer. Instead, the expected applications range from secure communications, highly sensitive sensors to other breakthroughs in the context of data processing. For some researchers it is clear that the 21. Century will be the century of quantum technology.

Source:
FET Projects

Impact Level:
Widespread

T 31 Cancer-detection in real-time

New insights in hyper-spectrography, advanced mathematical methods and the combination of available data on more than 200 kinds of cancer make it possible to discriminate between healthy and malignant tissues in real-time. This information may be used by medical doctors during surgical procedures.

Source:
FET Projects

Impact Level:
Local

T 32 Use recently discovered graphene characteristics to produce better switches, lasers, chips, etc.

Graphene has many extraordinary properties which are being studied worldwide, and especially in the FET Flagship on Graphene in Europe. Currently there are many applications being developed and tested and in the future, graphene may trigger a new generation of better electromagnetic switches, lasers, broadband chips and so on.

Source:
FET Projects

Impact Level:
Mid Range

T 33 Quantum Computing: Combining advances in quantum technology and photonics to realize a quantum computer

Instead of binary digits that are used in conventional digital computers, quantum computers use quantum bits (qubits), which can be in superpositions of states. Quantum computers are still in an early stage of development but if realized, they may be able to efficiently solve problems that no classical computer would be able to solve within a reasonable amount of time. One approach to advance the development is to combine quantum technology and photonics.

Source:
FET Projects

Impact Level:
Local

T 34 Smart materials will be used to provide shape-changing mobile devices and other interfaces

Smart materials are designed materials that have properties that can be changed in a controlled fashion by external stimuli, such as temperature, skin contact, voice, moisture, electric or magnetic fields. In the future, mobile devices may change their appearance for example when a call or a message is being received. Also, other Human-Computer-Interfaces can change their shape, appearance and functionalities according to outer circumstances.

Source:
FET Projects

Impact Level:
Local

T 35 Faster computers and newly available massive data hold the key for problems deemed too difficult to solve in the past

Many scientific undertakings like formalizing tacit knowledge, simulating complex organ functions or mapping evolutionary developments in biology were once considered too complex either because there was not enough data available or the computing capacity was not sufficient to run the necessary programs. With increasing computation power and the availability of new mass data which is often made automatically available by new devices many old problems can now be solved.

Source:
FET Projects

Impact Level:
Widespread

T 36 Micromotors will be built into nano-scale micro-electro-mechanical systems (MEMS) and enable new lab-on-a-chip systems to biomedical implants.

Researchers from different disciplines (physics, biology, medicine) have teamed up to integrate micromotors into MEMS. Once successful, this combination will allow a wide range of applications such as new lab-on-a-chip systems, pumps for micro-fluids and tuneable filters, tuneable lenses or filtering substrates for biotechnology, tissue engineering and regenerative medicine.

Source:
FET Projects

Impact Level:
Local

3.3 Science

S 1 Emerging research front: Analysis of dynamic and static behaviour of functionally graded material

Functionally graded material is a new type of non-uniform composite material. In this type of material, the abrupt interfaces of traditional composite materials are replaced by a continuous gradient of a changing material component. Studies in this emerging research front develop analytical and numerical methods to investigate static and dynamic behaviour of these materials.

Source:
Research Fronts 2014⁴

Impact Level:
Mid Range

S 2 Synthetic DNA

After decades of research, organic chemists succeeded in synthesizing artificially enhanced DNA with two synthetic nucleotides called P and Z. The new nucleotides even outperform their natural counterparts. When challenged to evolve a segment that selectively binds to cancer cells, sequences using P and Z did better than those without. Biotechnology company Synthorx has taken the next step towards creating truly synthetic life. A team of scientists successfully incorporated two synthetic nucleotide bases into the DNA sequence of a strain of E.coli bacteria.

Source:
Wired

Impact Level:
Widespread

S 3 Quantum squeezing

As described in a paper in Science, researchers at the California Institute of Technology have come up with a way of observing and even controlling quantum motion by cooling a small (but not quantum-small) device to a temperature of almost absolute zero (or as absolute zero as it gets), the point at which the only remaining forces come from quantum fluctuations.

Source:
Motherboard

Impact Level:
Local

S 4 Molecular communication

Use of molecules for communication has been successfully applied by scientists in a very basic setting. This could be useful for cases where electronic transmission fails (e.g. communication between robots in disaster recovery or in-body communication).

Source:
The Economist Technology Quarterly

⁴ RESEARCH FRONTS 2014: 100 TOP RANKED SPECIALTIES IN THE SCIENCES AND SOCIAL SCIENCES. The National Science Library, Chinese Academy of Sciences, Thomson Reuters IP & Science. The Joint Research Center of Emerging Technology Analysis. December 2014

Impact Level:
Local

S 5 Physicists set a new fiber-optic quantum teleportation record

Researchers at the National Institute of Standards and Technology (NIST) have bested the previous quantum teleportation fiber-optic distance record four times over, achieving a span of 100 kilometres. While physicists have teleported over farther distances in free space—via open-air laser beams, that is—the ability to transmit information across vast spans using fiber-optic cabling offers a new degree of practicality to quantum-based networking e.g. for distributing keys in future quantum encryption schemes. The accomplishment is described in the current issue of *Optica*.

Source:
Motherboard

Impact Level:
Local

S 6 Timekeeping mechanism of human brain uncovered

A group of neuroscientists from MIT and Columbia University may have the beginning of an answer on how the human brain keeps time. In a paper published this week in *Current Biology*, they describe how the lateral intraparietal cortex (LIC) region of the brain helps it to both interpret and reproduce time intervals, e.g. keep the beat, as it were.

Source:
Motherboard/Current Biology

Impact Level:
Local

S 7 Microbiomes

Microbiomes have become the focus of intense study and public interest. The trillions of microbes that live inside the human body play important roles in health, from fighting diseases to maintaining a balanced immune system. The White House is considering increasing its support of research into the workings of these microbial communities.

Source:
The New York Times

Impact Level:
Widespread

S 8 Emerging research front: CRISPR/CAS Genome-editing technology

The CRISPR/CAS Genome-editing technology is considered to have great potential due to its many advantages to previous methods. It has been successfully applied to

many studies of plant and animal behaviour. Since 2013 this field has become extremely active very fast.

Source:
Research Fronts 2014

Impact Level:
Widespread

S 9 Research front: Synthesis of pillar [5/6] arenes and their host guest chemistry

Pillar[n]arenes are a fast-growing research topic in supramolecular chemistry. Originally the focus was predominantly on pillar[5]arenes; however, now more and more studies on pillar[6]arenes are being performed. According to Wikipedia Pillar[n]arenes have been shown to have potential applications in molecular machinery, sensing, nanoparticle synthesis, artificial transmembrane channels, controlled drug delivery, construction of porous materials for gas/guest absorption, organic light-emitting materials, and ionic liquids.

Source:
Research Fronts 2014

Impact Level:
Mid Range

S 10 Measuring Imagination

By attempting to quantify a person's imagination, neuroscientists and psychologists at the Imagination Institute (a non-profit based at the University of Pennsylvania's Positive Psychology Center) hope to bring forward an alternative to traditional IQ-oriented standardized testing in a multimillion-dollar research effort funded by the John Templeton Foundation.

Source:
TED

Impact Level:
Local

S 11 Research front: Graphene and graphene oxide in biomedical application

Graphene is expanding its range of applications beyond electronic and chemical toward biomedical areas such as precise biosensing through graphene-quenched fluorescence, graphene-enhanced cell differentiation and growth, and graphene-assisted laser desorption/ionization for mass spectrometry.

Source:
Research Fronts 2014

Impact Level:
Local

S 12 Artificial brain

The webmining revealed two breakthrough moments in artificial brain development. Japanese researchers have formed a cerebrum like structure from embryonic stem cells. Researchers at the Institute of Molecular Biotechnology (IMBA) in Vienna created brain organoids from adult skin cells. Both groups hope for insights in brain behaviour and especially mental diseases.

Source:
MIT Technology Review

Impact Level:
Mid Range

S 13 Emerging research front: Synthesis of functional gold nanorods

Gold nanorods have received much attention due to their unique optical and electronic properties which are dependent on their shape, size, and aspect ratio. Studies in this emerging research front of materials science look at the synthesis of these materials.

Source:
Research Fronts 2014

Impact Level:
Mid Range

S 14 Emerging research front: Metal organic materials with optimal adsorption thermodynamics and kinetics for CO₂ separation

The energy costs associated with the separation and purification of industrial commodities, such as gases, fine chemicals and fresh water, currently represent around 15 per cent of global energy production, and the demand for such commodities is projected to triple by 2050. The challenge of developing effective separation and purification technologies that have much smaller energy footprints is greater for carbon dioxide (CO₂) than for other gases; Papers in this emerging research front investigate the optimization of metal organic materials for this purpose.

Source:
Research Fronts 2014

Impact Level:
Mid Range

S 15 Emerging research front: Synthesis of copolymers by direct arylation polycondensation

Copolymers are promising as basis for organic semiconductors with favourable characteristics e.g. for solar cells light-emitting diodes and transistors, sensors, and displays. Direct arylation represents an economically attractive and ecologically benign alternative to the traditional methodologies for synthesizing these polymers.

Source:
Research Fronts 2014

Impact Level:
Mid Range

S 16 Emerging research front: Magnetically retrievable nanocatalysts

The concept of “Green Chemistry” has emerged as one of the guiding principles of environmentally benign synthesis. The preparation and the use of nanoparticles (NPs) in organic synthesis has become a subject of intense investigation, in particular, magnetic nanoparticles (MNPs) which offer advantages in clean and sustainable chemistry as they can be non-toxic, readily accessible, and retrievable. Additionally, the activity and selectivity of magnetic nano-catalysts can be manipulated by their surface modification.

Source:
Research Fronts 2014

Impact Level:
Mid Range

S 17 Emerging research front: Photoinitiated polymerization and Photoinitiators

Much progress has been made in the past 10 years in the preparation of complex and nano-structured macromolecules by using photoinitiated polymerizations. A number of applications emerge in the field of biomaterials, surface modification, preparation of block and graft copolymers, and nanocomposites.

Source:
Research Fronts 2014

Impact Level:
Mid Range

S 18 Bioinformatics

Bioinformatics is an interdisciplinary field that develops methods and software tools for understanding biological data, especially in genetics and genomics. Common uses of bioinformatics include the identification of candidate genes and nucleotides which aims at a better understanding of the genetic basis of disease, unique adaptations, desirable properties (esp. in agricultural species), or differences between populations. Bioinformatics contributes to advances in synthetic biology biomimetics, supramolecular chemistry and other subfields. As such, researchers expect bioinformatics to provide major tools and methods to solve basic questions of biology and genetics. Using bioinformat-

ics for prediction of protein structure and nucleosome positioning is emerging as a research front in the biological sciences.

Source:
Several

Impact Level:
Widespread

S 19 Brain understanding

The webmining revealed a number of research insights on the way the brain works emerging in 2015. A particular focus was on memory but also on spatial mapping, timing, vision, decision making, emotional experience assignment, social prediction, hearing, tinnitus, pattern recognition and aging.

Source:
Several

Impact Level:
Widespread

S 20 Nanolattices

Strong, lightweight, and recoverable three-dimensional ceramic nanolattices are being developed at the University of Cambridge. Some expect that these materials could revolutionise a wide number of applications from battery electrodes to growing bones. The bottleneck is the large scale production of the material.

Source:
MIT EmTech 2015

Impact Level:
Mid Range

S 21 Research front: Synthesis and application of graphene quantum dots

Graphene quantum dots (GQDs) represent single-layer to tens of layers of graphene of a size less than 30 nm. Due to exceptional properties such as low toxicity, stable photoluminescence, chemical stability and pronounced quantum confinement effect, GQDs are considered as a novel material for biological, opto-electronics, energy and environmental applications (Wikipedia). GQD synthesis and application has received strong attention in materials science and chemistry

Source:
Research Fronts 2014

Impact Level: Mid Range

3.4 Collaboration

C 1 Digital humanities

New collaborations and interactions between social sciences and humanities on the one hand and computer sciences on the other are fast emerging. One of many examples is the use of sensory postcards in ethnography.

Source:
Several

Impact Level:
Local

C 2 Multi-disciplinary simulation research

There is a call for better modelling, simulation and visualization of complex multi-disciplinary systems such as turbulent aerodynamics. At the same time philosophers and social scientists point to the societal transformations associated with simulation based technology.

Source:
FastCoexist

Impact Level:
Widespread

C 3 Urban catalysts

Architects and designers around the globe are adopting a new mode of intervention into urban development called tactical urbanism. At the core is the use of micro interventions that function as catalysts for change. A creative and resourceful appropriation of the city's conflictual conditions expressed in terms of informal urban objects and habitats.

Source:
Vienna Biennale/MoMa

Impact Level:
Local

C 4 Biomanufacturing

Living organisms such as viruses are genetically modified to create materials e.g. for semiconductors or batteries. Biomanufacturing has advantages such as non toxic, low energy. Medical applications are also explored (e.g. finding and fighting tumours). With the development of pharmaceuticals and artificial organisms, new biology-based processes will do things that only machines have previously done. For example, scientists have recently been able to modify cells to act like fully functional computers.

Source:
The Economist Technology Quarterly

Impact Level:
Widespread

C 5 Rising interest in traditional medicine

There is rising interest from science, society and companies in investigating traditional medicines such as recipes from monasteries.

Source:
iKnow weak signal database

Impact Level:
Local

C 6 The human brain in the digital society

Researchers reflect on the question how the digitalisation of society affects the human brain. As an example some speculate that autistic behaviour patterns may be becoming more prevalent in the digital society

Source:
Discover Society Journal

Impact Level:
Widespread

C 7 Astronomy and geology collaborate

Geologists have found iron 60 in a rock sample from the sea floor. This has given new insights on the dying of supernovas. The link between geology and astronomy is little exploited yet but could be more relevant in the future.

Source:
Intelligent Life

Impact Level:
Local

3.5 Needs and challenges

N 1 Global Challenge: Global ethics

Global challenge: How can ethical considerations become more routinely incorporated into global decisions? Unethical decisions (like economical ones) are mostly independ-

ent from ethics. Collective responsibility for global ethics issues like waste handling is needed.

Source:
State of the Future

Impact Level:
Fundamental

N 2 Global Challenge: Energy demand

Global challenge: How can growing energy demands be met safely and efficiently? Renewable sources and innovative ways to produce energy are essential to reduce related CO2 emissions.

Source:
State of the Future

Impact Level:
Widespread

N 3 Global Challenge: Transnational organized crime

Global challenge: Problems of organized crime show themselves in many views: drugs (trade), trafficking, corruption, cyber-criminality. The total organized crime income could be over \$3 trillion. We need global strategies!

Source:
State of the Future

Impact Level:
Widespread

N 4 Global Challenge: Education and learning

There are a lot of research projects to understand the brain: brain diseases, enhancement, computer designs, new brain-computer synergies. These outcomes should be included in education and learning.

Source:
State of the Future

Impact Level:
Widespread

N 5 Global Challenge: Global foresight/decision making

Global challenge: Decision makers need tools to analyze, synthesize, and make good decisions. We need collective intelligence systems, that we may know, what is truly

significant and to create synergies among brains, software, and information for securing agreement to make necessary changes.

Source:
State of the Future

Impact Level:
Widespread

N 6 Noise pollution in sea threatens whales

The noise of ships can be more than annoying to whales – it can be deadly. The amount of noise can desensitize the whales over time, making them more likely to swim into the path of a ship – with possibly fatal results.

Source:
BBC Futures

Impact Level:
Local

N 7 Data vs. Intuition?

With ever more data available the question arises how to strike the right balance between data and intuition in decision-making. Data seems the way to go; but data can only go so far. Data-driven decision-making relies on intuitions about what to measure and why; it tends to overweight things because they are measurable; and data sees only the past, the future involves guesswork.

Source:
Intelligent Life

Impact Level:
Widespread

N 8 Universal software bug

Integer overflow, essentially meaning that numbers are too big to be stored in a computer system, can cause severe malfunction such as in the case of the failed Ariadne 5 rocket launch. This problem is often neglected by programmers.

Source:
BBC Futures

Impact Level:
Mid Range

N 9 Threat of “space weather”

The threat of space weather is more and more important because our life has a strong dependence on satellites. The UK government has developed a Space Weather Preparedness Strategy. Understanding of the mechanisms at play is still poor.

Source:
DEEPSTUFF.ORG

Impact Level:
Widespread

N 10 Decline in solar activity by 2030

A new model of the Sun's solar cycle is producing unprecedentedly accurate predictions of irregularities within the Sun's 11-year heartbeat. The model draws on dynamo effects in two layers of the Sun, one close to the surface and one deep within its convection zone. Predictions from the model suggest that solar activity will fall by 60 per cent during the 2030s to conditions last seen during the 'mini ice age' that began in 1645.

Source:
Science Daily/Royal Astronomical Society

Impact Level:
Fundamental

N 11 Spectrum overcrowding

Several experts warn that our hunger for wireless data is threatening to crash our communication networks.

Source:
BBC Futures

Impact Level:
Mid Range

N 12 Mental illness controversy

Some critics argue that the upsurge in mental disorder is pushed by pharmaceutical industry. Meanwhile the real underlying causes of behavioural problems and human misery are often left untreated. Others argue that human suffering will never be eradicated but evidence shows that pharmaceutical drugs have improved the lives of millions around the world.

Source:
Intelligencesquared

Impact Level:

Widespread

N 13 Pandemics strategy urgently needed

According to Nathan Myhrvold at Bill Gates Global Good Lab, strategies for pandemics are lacking globally. The lab is working on some aspects of this such as effective protection suits.

Source:
Intelligent Life

Impact Level:
Widespread

N 14 Particle pollution may be the main cause for brain degenerative diseases

Scientists have collected evidence that particle pollution may be the main cause for brain degenerative diseases. A recent study in the peer-reviewed journal Environmental Health and Technology estimated that we could avoid two million deaths globally by cleaning up the world's air.

Source:
Mother Jones

Impact Level:
Widespread

3.6 Needs and challenge & science

N&S 1 Prevent/repair heart attack

Heart disease is the leading cause of death across the globe. Research is underway for preventing or repairing heart-attacks with new technologies like biodegradable microstructures to repair heart tissue and injection of exosomes from stem cells to induce self-repair.

Source:
Science Daily, Gizmag

Impact Level:
Local

N&S 2 Yeast that makes opiate-like molecules out of sugar

A strain of yeast engineered in a lab was able to transform sugar into a pain-killing drug — called hydrocodone — for the first time. And a second strain was able to produce thebaine, an opiate precursor that drug companies use to make oxycodone. The findings, published in Science, could completely change the way drug companies make

pain-relieving medicine. Unfortunately, it may also open the door to less positive outcomes, like "home-brewed" heroin.

Source:
The Verge

Impact Level:
Local

N&S 3 Antibacterial bio-microfilm

Infections from medical implants are rare but they can still occur. To guard against this infection risk, scientists have developed a thin, silver-coated biofilm to prevent bacteria adhering and surviving on the device. Silver has good antibacterial and antifungal properties. As well as silver, antimicrobial peptides, including catestatin, are included within the chemical matrix. The findings are published in the journal *Advanced Healthcare Materials*. Practical applications are expected in a couple of years.

Source:
Trends der Zukunft

Impact Level:
Mid Range

N&S 4 Brain cell transplantation

Lorenz Studer, Director of Memorial Sloan-Kettering Cancer Center's Center for Stem Cell Biology and new MacArthur Foundation "genius" grant recipient is exploring transplantation of cells generated from embryonic and induced pluripotent stem cells to heal e.g. Parkinson's disease.

Source:
Washington Post

Impact Level:
Local

N&S 5 Nano needles in regenerative medicine

In a trial with mice described in *Nature Materials* nanoneedles prompted parts of the body to generate new blood vessels; idea: help damaged organs and nerves repair themselves and help transplanted organs thrive.

The nanoneedles are tiny porous structures that act as a sponge to load significantly more nucleic acids than solid structures. This makes them more effective at delivering their payload. They can penetrate the cell, bypassing its outer membrane, to deliver nucleic acids without harming or killing the cell.

The nanoneedles are made from biodegradable silicon, meaning that they can be left in the body without leaving a toxic residue behind. The silicon degrades in about two days, leaving behind only a negligible amount of a harmless substance.

Source:
Kurzweil Accelerating Intelligence

Impact Level:
Local

N&S 6 Water based nano bacteria shields

Water particles could provide a powerful airborne shield against bacteria (including antibiotics resistant ones).

Source:
The Economist Technology Quarterly

Impact Level:
Local

N&S 7 Organic flow batteries

Research has shown the possibility of a new type of flow battery resting on organic molecules (quinones). This may revolutionize battery technology and form the missing piece of the renewable energy jigsaw.

Source:
The Economist Technology Quarterly

Impact Level:
Mid Range

N&S 8 Bioprinting

Building living tissues with a 3D printer is advancing. Organ printing is still a long way off though.

Source:
The Economist Technology Quarterly

Impact Level:
Local

N&S 9 New methods for drug delivery inside the body

New ways to deliver drugs inside the body are being researched:

- Capsuled microneedle patches travel to the intestines via the stomach.
- Selfrepairin hydrogel carrying drugs can be injected through needles.
- From fine coils of silicone tubes inserted into the body drugs are forced out through osmosis.

Source:
The Economist Technology Quarterly

Impact Level:
Local

N&S 10 Decline of microscopic plant-life in oceans

The world's oceans have seen significant declines in certain types of microscopic plant-life at the base of the marine food chain, according to a new NASA study. The research, published in *Global Biogeochemical Cycles*, a journal of the American Geophysical Union, is the first to look at global, long-term phytoplankton community trends based on a model driven by NASA satellite data.

Source:
Science Daily/NASA/Goddard Space Flight Center

Impact Level:
Widespread

N&S 11 Spontaneous regression

After a few cases of unexpected regression of tumors scientists are looking to the underlying biology of so-called "spontaneous regression" to hunt for clues that could make these rare cases of self-healing more common. One line of research for replicate spontaneous remission in a cure is infecting patients with dengue fever.

Source:
BBC Futures

Impact Level:
Mid Range

N&S 12 Post antibiotics

Hazards concerning antibiotics or antimicrobial resistance are real. The malaria parasite for instance has a new resistance to malaria-drug and this spreads over South and East Asia. Bacteria that are immune to antibiotics might actually be deadlier than bacteria that aren't. Researchers might be able to bring back old, drug-susceptible strains. Some bacterial species really are weakened by the resistant mutation.

Source:
Several

Impact Level:
Widespread

N&S 13 Emerging research front: Control and treatment of schistosomiasis in Africa using the drug praziquantel

Schistosomiasis is a chronic parasitic disease caused by parasitic flatworms called schistosomes, which is prevalent in tropical and subtropical areas with poor sanitation,

especially in Asia, Africa, and Latin America. Studies address treatment mainly of African children with the drug praziquantel.

Source:
Research Fronts 2014

Impact Level:
Local

N&S 14 Water challenge

Water and especially clean water is becoming a scarce resource in ever more areas as climate change threatens water security. We need global strategies to prevent this or deal with it. Water was one of the most addressed topic in 2015 tweets. Issues were water: -generation, -cleaning, -recycling, -pollution, -splitting, -based energy generation, - saving and -quality monitoring as well as measures dealing with droughts. Ways of measuring the quality of oceans, coastal and transitional waters is becoming an important topic in ecology. The utilization of aquatic biological communities to assess the ecological status of European surface waters is emerging as a research front. Artists such as Maarten Vanden Eynde have (plastic reef) point towards the rise of plastic debris in the ocean - a topic that was also highly prominent in the webmining.

Source:
Several

Impact Level:
Widespread

N&S 15 Research front: Models for predicting potential distributions of species

Species distribution models (SDMs) that help to estimate the development of ecological niches of species and their preference for habitats are an increasingly hot research area in environmental science with many practical applications.

Source:
Research Fronts 2014

Impact Level:
Mid Range

N&S 16 Research front: Atmospheric aerosol nucleation and growth

The formation and growth of new atmospheric aerosol particles has become an important research area in geosciences in recent years.

Source:
Research Fronts 2014

Impact Level:
Local

N&S 17 Research front: Newly emerging psychoactive substances (new designer drugs)

New psychoactive substances (new designer drugs) such as herbal marijuana alternatives, like K2 or Spice and synthetic cathionones (“bath salts”) have been emerging in many countries. These drugs often have adverse effects, which range from minimal to life-threatening that are little known by health care providers and the public. In biological sciences the investigation of these substances in particular their effects and detection methods has become a hot research front.

Source:
Research Fronts 2014

Impact Level:
Mid Range

N&S 18 Research front: Human disease analysis using Genome Wide Association studies

Genome Wide Association Studies (GWAS) apply genetic statistics to analyze human diseases. Further developing these methods including analytic tools and software has become an important research front in the biological sciences.

Source:
Research Fronts 2014

Impact Level:
Widespread

N&S 19 Research front: Electrode materials for sodium-ion batteries

In chemistry and material sciences interest has soared in electrode materials for batteries to enable new qualities such as longer life and cost effectiveness.

Source:
Research Fronts 2014

Impact Level:
Mid Range

N&S 20 Research front: Functional metal organic frameworks

Metal-organic frameworks (MOFs) are one type of solid porous materials formed by the self assembly of metal ions or ion clusters and organic ligand complexes. MOFs have the merits of a rich composition and structure, a large specific surface area, adjustable pore sizes, and a modifiable skeleton. MOFs have been widely applied to multiple aspects of absorption and separation, hydrogen storage, chemical sensors, fluorescence, catalysis, and biological medicine. Currently, more than 6,000 new structures are reported every year. MOFs have become a hot research front in the field of chemistry.

Source:
Research Fronts 2014

Impact Level:
Mid Range

N&S 21 Research front: Graphene-based photocatalysts

Graphene-based photocatalysts have been attracting ever-increasing research attention in chemistry and material science. Applications of GR-based nanocomposites in photocatalysis, range from degradation of pollutants, selective transformations for organic synthesis and water splitting to clean hydrogen energy by converting solar energy into chemical energy.

Source:
Research Fronts 2014

Impact Level:
Mid Range

N&S 22 Emerging research front: Supercapacitors based on nanoporous carbon electrodes

Supercapacitors are electricity storage systems with high power performances. Light-weight, low-cost supercapacitors with the capability of rapidly storing a large amount of electrical energy can contribute to meeting continuous energy demands and effectively levelling the cyclic nature of renewable energy sources. The excellent electrochemical performance of supercapacitors is due to a reversible ion adsorption in porous carbon electrodes. Studies strive to understand the molecular dynamics of such electrodes. Supercapacitors and other energy storing materials were also a prominent topic in the webmining.

Source:
Research Fronts 2014

Impact Level:
Mid Range

N&S 23 Emerging research front: Enhanced Visible Light photocatalysts

Photocatalysis is a science of employing catalyst that is utilized for speeding up a chemical reaction that requires or engages light. A photocatalyst is defined as a material that is capable of absorbing light, producing electron-hole pairs that enable chemical transformations of the reaction participants and regenerate its chemical composition after each cycle of such interactions. Papers in this field investigate ways to enhance photocatalysts that work in visible light.

Source:
Research Fronts 2014

Impact Level:
Mid Range

N&S 24 Effects of climate change

The dynamics and effects of climate change are still not well understood. While some threats such as rising sea levels are already widely discussed other aspects like rise of wildfires, superstorms and effects on soil bacteria are less explored. Researchers worldwide point to the increasing likelihood of yet unknown catastrophic events and recommend acting now. The following research fronts emerged in this context:

- Effects of ocean acidification on marine ecosystems: The way oceanic uptake of anthropogenic carbon dioxide (CO₂) is altering the seawater chemistry of the world's oceans.
- Greenland ice sheet dynamics: The dynamics of Greenland's ice sheet is an increasingly hot topic of research in geosciences.
- Global sea level change: The 42 recent top papers addressing global sea level change are the most highly cited in all geosciences implying that this issue is a major research front in this field.
- Regional climate models: Increasingly climate anomalies happen on a regional scale (eg disaster of icy rain and snow in southern China in 2008). Development of models to simulate the regional dynamics of climate change (including on city level) has become an important scientific front in geosciences.
- Model analysis of non-CO₂ greenhouse gases: Aerosols and gases other than CO₂ (eg. Methane, sulfur dioxide) have not been thoroughly considered in current climate models. In this context a new research front emerged: shifting timing of plant activities in response to global change.

Source:
Several

Impact Level:
Widespread

3.7 Needs and challenge & technology

N&T 1 Reversible heat pump for energy storage

A reversible heat pump promises a cheap way to store renewable energy on the grid. The pump consists of two silos filled with gravel connected with argon filled pipes.

Source:
The Economist Technology Quarterly

Impact Level:
Local

N&T 2 Decentralisation of energy supply

Big utility companies are finding that small, local solutions might be the future of energy. Through small investments in GSEP (Global Sustainable Electricity Partnership) projects, these high-voltage utilities are experimenting with generating energy from renewable feed stocks available locally, such as biogas, hybrid wind-diesel micro-grids, solar powered water pumps, mini hydro power.

Source:
FastCoexist

Impact Level:
Widespread

N&T 3 Electric bio rocks save coral reefs

Electrically charged steel shapes have been implemented in Indonesia to evoke growth of coral reefs.

Source:
BBC Futures

Impact Level:
Local

N&T 4 Energy from oxidation in human bodies

In this novel smart-cells exist which supply themselves with energy from a oxidation-process via ATP-molecules (Adenosintriphosphat).

Source:
Science Fiction Novel: Der unsichtbare Killer

Impact Level:
Local

N&T 5 3D printed emergency shelter

This novel describes an igloo-like emergency shelter made of hexagonal components through 3D printing.

Source:
Science Fiction Novel: Der unsichtbare Killer

Impact Level:
Local

N&T 6 Hyperconnected Sustainable Planet (IoT)

Demos Helsinki has identified 10 principles to guide development towards a hyperconnected, sustainable planet.

Source:
Our World United Nations University

Impact Level:
Fundamental

N&T 7 Carbon nanofibres made from CO2 in the air

Scientists in the US have found a way to take carbon dioxide (CO₂) from the air and make carbon nanofibres. The team says it can be "scaled up" and could have an impact on CO₂ emissions, but other researchers are unsure.

Source:
Motherboard

Impact Level:
Mid Range

N&T 8 Quantum computing challenges cryptography

The US National Security Agency announced it would be abandoning the cryptography algorithms it has used since 2005 for fear of the coming quantum computing revolution. "Our ultimate goal is to provide cost effective security against a potential quantum computer," the agency wrote on its website.

Source:
Motherboard

Impact Level:
Widespread

N&T 9 Extraordinary advances in facial recognition cause huge privacy issues

Extraordinary advances in facial recognition raise severe privacy concerns. Privacy activists mass-quit U.S. government committee on facial recognition privacy.

Source:
The Intercept Blog Unofficial Sources

Impact Level:
Widespread

N&T 10 Fast HIV detection

Current methods for detecting the antibodies that indicate HIV infection are agonizingly slow and cumbersome. However a new DNA nanomachine developed by an international team of researchers (and funded, in part, by the Bill & Melinda Gates Foundation) could shorten the process to a matter of minutes. The DNA-based nanomachine is designed and synthesized to recognize and bind with a specific target antibody, even within biologically-dense and complex samples like blood. When these "machines" do bind with the target antibody, the joining causes a structural change that generates a little burst of light. A test that used to require hours of careful, complex and downright expensive prep-work could now take as little as five minutes. And the sooner that doctors are aware of the infection, the sooner they can start treating it. What's more, these nanomachines can easily be customized to detect a wide variety of antibodies.

Source:
Wired

Impact Level:
Local

N&T 11 Enhanced bloodtest functionality

Several tweets captured in the webmining addressed the growing use of bloodtests with fast DNA sequencing for disease detection (Liquid Biopsy). Specifically for the detection of cancer and brain diseases breakthroughs were reported.

Source:
Several

Impact Level:
Local

N&T 12 Privacy preserving technologies

There may be a huge emerging demand for products such as the Indie Phone that are explicitly designed to preserve privacy. Key concepts are homomorphic encryption and differential privacy.

Source:
The Economist Technology Quarterly

Impact Level:
Widespread

N&T 13 Personal Heating

One way to keep warm is to heat people rather than expending energy heating the empty buildings. Several systems are possible.

Source:

The Economist Technology Quarterly

Impact Level:
Local

N&T 14 Optical implants

Ideas about optical implants emerge in science-fiction. Nerve cell-prosthetics which translate a digital optical input in biological data or implants which replaces organs are thinkable. Furthermore there could be laser-implants transmitting additive information direct to the visual nerve via a laser-stimulus.

Source:
Books: Die eiserne Karawane; Replay

Impact Level:
Mid Range

N&T 15 Unconventional energy sources

A lot of new unconventional technologies and ideas to extract and produce energy emerge: Wind-turbines under bridges, geothermal energy (eg from volcanoes), shock-absorber, biomechanical-energy, underwater wind farms, energy from temperature differences in water or from salt content (blue energy), a lamp that gets its energy from a gravity mechanism, tidal energy, wave energy, energy from algae, energy from waste/sewage (through graphene seebeck effect), ocean thermal energy conversion, energy from spores, energy from dry ice/sublimation heat engine, energy from vakuum, energy from space, energy kites, energy from electromagnetic waves (through meta-materials), copying energy strategies from animals (dark eaters), nuclear fusion (new designs), energy from surface tension.

Source:
Several

Impact Level:
Widespread

N&T 16 Motion microscope

Structural information about the inner characteristics of an object has been derived from an extremely precise video. This technology allows contactless, non invasive analysis („a motion microscope“ amplification of tiny motions).

Source:
TED

Impact Level:
Local

N&T 17 Big data supported crisis management

Data collected from sms sent to a crisis hotline has been used to optimise intervention strategies. Similar big data analytics strategies could be used by policy schools, social workers and law enforcement to better handle spikes in crises.

Source:
TED

Impact Level:
Local

N&T 18 Invisible human impact

HeHe (Helen Evans & Heiko Hansen) studies the effect on the environment of clouds resulting from human activities linked to the production and consumption of energy. The work Fleur de Lys illustrates the otherwise invisible radioactive cloud from a nuclear power station after an accident. The exhibition presents the work in section III "an endangered planet".

Source:
Exhibition: A brief history of the future

Impact Level:
Local

N&T 19 Self-tracking pill

A new drug-device was accepted for review by the Food and Drug Administration. Buried inside the pill is a sand-sized metal grain. When the pill reaches your stomach, your stomach acids form a circuit with the metal, powering up a microchip. Soon, the entire contraption will dissolve, but in the five minutes before that happens, the chip taps out a steady rhythm of electrical pulses, barely audible over the body's background hum. The company says it's the first in a new generation of smart drugs, a new source of data for patients and doctors alike. But bioethicists worry that the same data could be used to control patients, infringing on the intensely personal right to refuse medication and giving insurers new power over patients' lives.

Source:
The Verge

Impact Level:
Local

3.8 Social Practice

SP 1 Cycling Futures

The bicycle is emerging as a central component of urban and avantgarde lifestyles. Several of the most advanced concepts in city planning and mobility are centering on the bicycle. Highly interdisciplinary research is exploring ways to establish cycling centred city transport systems.

Source:
Monocle

Impact Level:
Mid Range

SP 2 Time as money

Artist Gustavo Romano carried out a series of actions in public spaces utilizing a monetary system based on units of time (Spot#1. Lost time refunded, Spot#4 Buying time, Time Notes). Offices and other performances have been set up in many cities of Europe, America and Asia. The actions refer to different local and global issues: the exchange systems, the over-employment and unemployment, the increasing virtualization of the economy, and the existential relationship of the human being with his own lifetime.

Source:
Exhibition: A brief history of the future

Impact Level:
Fundamental

SP 3 From design inspired by nature towards nature inspired by design

Designer and architect Neri Oxman is leading the search for ways in which digital fabrication technologies can interact with the biological world. Working at the intersection of computational design, additive manufacturing, materials engineering and synthetic biology, her lab is pioneering a new age of symbiosis between microorganisms, our bodies, our products and even our buildings.

Source:
TED

Impact Level:
Mid Range

SP 4 Compressed conversation

Some researchers expect that digital communication will change the nature of our language so e.g. the use of irony and sarcasm is on the rise as people try to get across

more meaning in less words (e.g. in twitter). Emojis are increasingly used in digital conversations.

Source:
Several

Impact Level:
Local

SP 5 Scientists share their embarrassing #fieldworkfail stories

When scientists step out of the lab, things don't always go to plan. Researchers share their most embarrassing #fieldworkfail stories on Twitter.

Source:
the guardian

Impact Level:
Local

SP 6 Cognitive overburden through perpetual evaluation

Much of today's software casts the user in a role of perpetual evaluation from which it's relatively easy to escape (with one or two clicks) but impossible to reject all together. This may be a taste of what seems likely to become a potentially overwhelming routine feature of daily life in the near future. Each individual act of evaluation is trivial but the aggregative cognitive burden likely isn't.

Source:
The Sociological Imagination

Impact Level:
Widespread

3.9 Social practice and science

SP&S 1 Bugs not drugs

Increased understanding of the microbiome-the community of microorganisms in our bodies-is challenging our long-running obsession with antibacterial measures. New approaches to staying healthy will be based on balancing the ecologies of microorganisms: think "bugs, not drugs." Indiegogo-funded uBiome is already helping people better understand their germs by sequencing the bacteria in their bodies.

Source:
Institute For The Future IFTF

Impact Level:

Widespread

SP&S 2 Treating phantom pain with a mirror

Mirror therapy helps to cure phantom pain of amputees. It works by providing visual feedback to the brain about a functional arm rather than a missing limb, and this changes the central maladaptive reorganisation back to normal. In neuroscience the phenomenon is little understood.

Source:
BBC Futures

Impact Level:
Local

SP&S 3 Freakthinking

The books Freakonomics and SuperFreakonomics have been worldwide sensations, selling tens of millions of copies. They have come to stand for challenging conventional wisdom using data rather than emotion. Questions they examine are typically: Which is more dangerous, a gun or a swimming pool? How much do parents really matter? Why is chemotherapy prescribed so often if it's so ineffective? (authors, Steven D. Levitt and Stephen J. Dubner)

Source:
Intelligencesquared

Impact Level:
Widespread

3.10 Social practice and technology

SP&T1 Wooden material on the rise

Wood as a renewable resource becomes a more and more popular eco-friendly material to build things and houses.

Source:
Several

Impact Level:
Local

SP&T2 Modelling the human

Technical abilities increasingly allow artificial imitation of the human body or behaviour. These imitations are used for testing human related artefacts. Developments include:

Artificial/3D printed skin, chips that mimic human organs, real looking animated human flesh or artificial nerve cells.

Source:
Several

Impact Level:
Local

SP&T3 DIY printing of circuits

Instructable offers a tutorial that will teach you how to modify your average inkjet printer to be able to print electrically conductive circuits. This technology is fairly new but can provide a faster and safer prototyping option for DIY printed circuit boards. This project also acts as an introduction to the larger field of printed electronics.

Source:
Instructables

Impact Level:
Mid Range

SP&T4 Smart dust

Nano-cells on your skin simulate an environment for your body in a haptic way. In addition they can simulate visual and auditive inputs.

Source:
Science Fiction Novel: Das Cusanus-Spiel

Impact Level:
Local

SP&T5 Implants that store and transfer data

Prosthetics or implants which store, process and transfer data in many ways emerge in science fiction. These implants could be interconnected and also linked with a global net. In this scenario complete surveillance could be permanent.

Source:
Accelerando

Impact Level:
Local

SP&T6 Bio patent conflicts - who owns your body?

A conflict between bio-engineering patent holders and the growing community of independent bio-hackers on "who owns your body" is emerging.

Source:
The Awl

Impact Level:
Local

3.11 Solution idea

SI 1 Local energy production will power the smart grid

As the smart grid begins to take shape, a big push is emerging for more localized energy production. The idea is to deploy cheaper and more climate-friendly solar, wind, and fuel cell technology at the neighbourhood scale, with smart routing and storage. Watch for widespread decentralization of energy grids as digital intelligence and renewable energy technologies drive power production to the edges of our networks.

Source:
Institute For The Future IFTF

Impact Level:
Widespread

SI 2 Moss walls for air cleaning

To clean and filter the air from nitric oxide and fine dust within cities, moss walls are tested in Oslo (Norway). The so called “city trees” transform the pollution to biomass.

Source:
Trends der Zukunft

Impact Level: Local

SI 3 Cleaner-fish keeps salmon healthy by eating lice

Scotland's salmon farming industry has begun farming a new type of fish, specifically to keep salmon clean from parasites. The Scottish Aquaculture Innovation Centre, is working with University of Stirling scientists and seafood company Marine Harvest to breed cleaner wrasse. These are fish that feed on a common and pervasive salmon parasite called sea lice.

Source:
BBC Futures

Impact Level:
Local

SI 4 Long term preservation of knowledge

The Long Now foundation is creating a library readable for 10,000 years. Rosetta is a physical archive—a 3.5-inch disc made of nickel, with 13,000 pages micro etched onto its surface. The disc does not depend on hardware or software to be read, only magnification, thus obviating the need to keep up with rapidly changing technology or the looming “digital dark age.”

Source:
American Libraries Magazine

Impact Level:
Fundamental

SI 5 Long-term timekeeping

The Long Now initiative is establishing a clock that would still be readable for 10,000 years.

Source:
American Libraries Magazine

Impact Level:
Fundamental

SI 6 Bee highway

The city of Oslo is in the process of developing a "bee highway" for the pollinating insects, offering them a safe route through the city complete with food sources, resting spots, and places to live.

Source:
The Verge

Impact Level: Local