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The Latest Medical Devices Used in the Field of Medicine

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Abstract: Have you ever thought about how medical care is delivered? What factors are taken into account before administering treatment or prescribing medications? Progress in the medical device industry has indeed opened up a whole new dimension to personalized health care and improved patient outcomes in the medical field. Initially, the medical device industry was niche with humble beginnings until regulatory guidance was released outlining the general regulatory and quality system requirements that the manufacturers needed to adhere to. In the latest medical devices, which is the area of interest today, wireless technology, sensor technology, indicator lights, and others were added in order to update the old ones. The transformation of the healthcare workplace utilizing medical devices for better healthcare applications has brought many advantages to today's healthcare sector. Medical devices can now be bought from the market with the latest software support. The low energy technology has one advantage, which is that it uses less power. It has been designed in such a way that it can be powered by an electronic battery. The numerical increase in medical devices required innovation and

equally proficient experts who are seamlessly amalgamating medical science with technology. With the growing interdependence of medicine, machine learning, and computer science, several newer medical devices have been conceptualized. Branded equipment showcases defining changes in the domain of new medical devices catering to global hospital and home users. The industry is witnessing a shift from traditional diagnosis and treatments to preventive healthcare using artificial intelligence, IoT, and robotics. The continual evolution of medical devices into the technological domain and focus on the growing interaction and interdependence between medicine and medical devices has made a robust impact on the world.

Overview of Medical Devices in Medicine

Medical devices are integral to healthcare, and their application has contributed significantly to improvements in patient care and public health. Generally, these devices pertain to diagnostic tools to help ascertain the presence or exacerbation of diseases, therapy delivery to reduce morbidity and mortality, efficacy monitoring to guide future decisions, or emerging technologies designed to meet new healthcare needs. Clinical decision-making demands support from medical devices to accurately diagnose diseases such as infections or cancer or to prognose the severity of such diseases. Furthermore, medical devices assist medical professionals with monitoring therapy outcomes. Examples include ventilators in intensive care units or heart implants and pacemakers to manage heart failure. As emerging technologies, medical devices assist in monitoring and responding to physiology in a protective manner. Such examples include the use of hemostats and tourniquets in trauma management. Healthcare systems and everyday treatment options have evolved drastically with the help of distinctly effective medical devices. [1][2]

The early signs and symptoms of diseases can often be unspecific and elusive. The accurate characterization of the disease necessitates diagnostic devices. Medical devices have provided an intricate, detailed report of all aspects of disease trends. There are a multitude of devices used in day-to-day clinical practice, such as microscopes and X-rays, which can detect pathologies at the tissue or cellular level. Over the last two decades, considerable evidence has been generated to establish intense beneficial impacts of medical devices on patient outcomes and healthcare expenditures. Medical devices include a broad range of products, from highly user-interactive low-risk devices to technologies requiring skilled expertise for their operation. They are currently compliant with relevant laws and regulations set forth by governments and enforcement authorities. A governance commission was nominated for the establishment of an international regulatory framework on the sale, promotion, distribution, and use of targeted medical devices. [3][4]

Diagnostic Devices

Medical diagnosis plays one of the key roles in modern medicine. To answer the question regarding the state of health for a given person that will relatively soon influence their future, a non-invasive inspection within the body is first needed. In addition to an external physical examination, patients may also be offered various types of imaging or laboratory tests within the

hospital. While the literature usually focuses strongly on new drugs, the potential of incorporating new diagnostic technologies into medical practice is vast.

There are several technologies that the state of the art has allowed for the examination of the internal body without invasion or exposure to radiation. Their efforts have led to a 'focusing down' of devices to a size that can be included in the clinical work-up as an outpatient, such as at the point of care. This often involves a combination of diagnostic devices. Firstly, there are imaging technologies that inspect inside the body and act non-invasively, having replaced the requirement of X-rays and surgery to diagnose diseases and acute conditions. Laboratory tests form another part of the diagnostic process, turning physical or biological context into measurable quantities that inform how the disease could be treated.

Some of these laboratory tests have been developed into individual diagnostic devices that the clinician makes use of while the patient is present; these so-called point-of-care devices have spanned various industries and testing applications for diagnosis or evaluation. Results can happen in as little as 10 minutes and may facilitate shorter visit times to hospitals or clinics and earlier decision-making. Although there is a need for a large quantity of clinicians to be trained, a combination of such imaging technologies and laboratory tests is currently used to understand the complete patient picture. It has been more difficult to create a so-called 'integrated' approach because of the challenges in combining technologies, the requirement for the simultaneous presence of a large number of the newest clinicians, and a lack of leadership in identifying needs. Health services also lack a structure to request integrated technologies for given problems. The potential of a combined multi-technology panel would give the clinician more time to evaluate the patient and greater confidence that the diagnosis was accurate. One prospect is to centralize this clinical system, as integrating new technologies will also be complex and time-consuming in addition to changing the system. Moreover, health professionals are increasingly time-poor, and to convince the profession to adopt a new testing system, patient benefits, cost-effectiveness, and better outcome data are also required. [5][6]

Imaging Technologies

Imaging technologies have become integral tools for physicians in diagnosing and managing diseases. Traditional imaging methods such as X-rays can only detect bone and very dense abdominal abnormalities when the X-ray beam passes through the body. As a result, soft tissue abnormalities in organs such as the liver, the kidney, and parts of the brain could not be visualized with X-rays. Imaging evolved further to computed tomography (CT), which detected and showed the abnormal density in the body, and magnetic resonance imaging (MRI), which had superior soft tissue contrast to CT. MRI has shown abnormal physiology with magnetic soft tissue property changes, superior to CT imaging. CT, MRI, and functional nuclear medicine imaging are now widely used in visualizing different organ systems of the human body. Positron emission tomography (PET) was later added to the families of CT and MRI. These advanced medical imaging modalities provide valuable information to guide management decisions, for example, in the treatment planning of cancer patients or the guidance of a catheter during interventional radiological procedures. For neurology, MRI is the imaging modality of choice as it is safe, non-ionizing, and superior to CT in detecting ischemic changes in the brain when a patient presents with a focal neurological deficit.

Advanced digital technology improved the quality of the imaging system with less ionizing radiation. Digital subtraction angiography (DSA), 3D computed tomography in cardiac angiography (3D cardiac CT) imaging, and 3D pulmonary imaging are a few examples of advanced imaging applications and virtual reality. This served as an advanced medical observation tool to not only view the anatomical shape of the organ interior in a monochrome 2D and 3D display but also select a particular tissue region of interest and display them in various colors as per the parameters. After digital imaging was widely accepted, many computer applications were developed to 3D reconstruct the data obtained from 2D scanned images. The commercial software

and systems introduced to diagnose problems in the coronary arteries and heart, and to measure ejection fraction in the pulmonary and renal arteries, measure the heart wall endothelial function in addition to its benefits, were also used clinically. However, many other technologies and advances were made for imaging and medical imaging, which helped doctors read and interpret the diagnostic images from radiology and cardiology procedures as per the disease being treated or managed. [7][8][9]

Newer applications such as preprocedural planning, virtual biopsy, enhancements of molecular imaging with new isotopes and ligands, new hardware and software developments in medical imaging such as 4D digital imaging, time-resolved angiography (MRA), and 8K to 16K video imaging, and virtual reality neural feedback are the trending and new nano and miniaturized imaging technologies in developing clinical techniques, diagnostic devices, organ-sparing treatments, and advanced surgery. The field of teleimaging and artificial intelligence in digital imaging is booming lately. Access to computer technology combined with imaging and telemedicine could provide essential diagnostic equipment to underserved third world countries. Artificial intelligence is being used to interpret digital 2D and 3D images by incorporating deep learning algorithms, training computer systems to interpret the photographs of diseases that doctors provide for input to learn. In the future, it could reduce human error, improve workflow, reduce costs, and overall interpret complex 2D and 3D radiology and cardiology images more accurately in near real time with limited error. [10][11]

3.2. Laboratory Tests and Point-of-Care Devices

Laboratory testing provides crucial medical data to diagnose, prognose, and further classify the condition to tailor proper treatment. Laboratory tests are mainly divided into two categories: hematological tests and biochemical tests. Hematological tests evaluate blood cells and plasma elements that are involved in the blood clotting process. In contrast, biochemical tests are done on plasma or serum samples and measure the level of analytes or serum biomarkers. Both types of analyses are currently performed by automated or semi-automated instruments. The complete list of laboratory tests ranges between 600 and 700.

Additionally, with the classical use of automated techniques in the laboratory setting, a growing trend is represented by in-house and point-of-care tests. This kind of testing provides the capability to obtain clinical test results, formerly restricted to the laboratory setting, right at the patient's side. The transmission of results to the responsible physician is rapid, in most cases within minutes from the collection of a biological sample, allowing rapid decision-making. The benefits of point-of-care testing involve treatments that require a rapid decision and a quick result, such as the prescription of antibiotics, the control of blood sugar levels, or cardiac tests during mass events. Then, POC tests represent the best option for health professionals working in rural areas. In this context, a large number of laboratory devices and analytical devices have been identified that correctly belong to the category of POC laboratory, though they are commonly marketed under the names of wearable devices, electronic noses, and others. The interest in POC testing devices is currently increasing due to significant advancements in microanalysis technologies over the last decades. Indeed, innovations in chemistry and technology have often driven the development of analytical platforms, with miniaturization and automation, combined with the development of portable devices, being particularly dominant. Analyzing such devices in medical diagnostics, glucose measurement technology, for example, underpinned the invention of blood glucose meters that are widely used by diabetic patients to self-monitor their glucose levels. The reason why many people are excited about the potential of POC testing devices is that they avoid the need to send samples to a large, expensive, and sophisticated centralized laboratory. It is an approach that has already opened up the analysis of blood to anyone with US$1 within reach of a duty device. Therefore, there is a clear need for POC testing because clinicians demand updated and relevant clinical data from patients at the point of care. This is because many point-of-care tests are based on the same biochemical protocols used for the analysis in central laboratories. However, fundamental differences can lead to complications and other potential issues in the use of POC

testing devices in diagnosis. There is, indeed, vast literature on POC testing. However, instead of evaluating the appropriateness or cost-effectiveness of the use of POC testing, this review focuses on discussing the utility of different platforms with POC testing in practice. We identify the possible ways mentioned above that correspond to three distance-related objectives: home health, emergency room, and humanitarian care. This review summarizes the major POC testing devices currently in use and defines their limitations within a clinical and prognostic manner. [12][13]

Therapeutic Devices

A wide array of medical devices exists that are not developed for diagnosis; these medical technologies focus mainly on treatment. Surgical instruments and tools have been important throughout the history of medicine since they are smaller and less invasive, with the ability to assist during a broad variety of medical procedures. Innovations in surgical tools have therefore been revolutionary. Such devices often need to have precision cutting or suturing mechanisms for safe and successful procedures. Although, within early history, many of these devices were very simple, such that the tools were simply an extension of the human hand, the technological development of recent decades has been more than incredible in this area. Within the surgical devices market, many large corporations develop these, and as with most other fields, prices from procurers popularly drive competition, such that new devices will often be combined with an affordable cost.

Drug delivery: These therapeutic devices have been at the center of quite the revolution. Today, physicians and patients can depend upon them to provide consistent as well as non-uniformly administered medication daily or as and when needed. These systems have been developed in many forms, such as electronic pumps, implants, inhalers, and even injectables. Though they are continuously improving, they continue to face the challenge of patient adherence to correctly using the devices. This is relevant since making usage automatic, much like eating or drinking, is essential. The undisputed leader within this arena remains implantable long-acting reversible contraptions designed mostly for pregnancy prevention—a female choice that lasts in typical use for up to 8 years. Some emerging trends within this area include more smart implant drug delivery devices, where improved patient engagement may never be all that far off. Management ingredients are also finding increasing therapeutic delivery applications since they are proving to decrease adverse side effects for various pharmaceutical drugs. [14][15]

Surgical Instruments and Tools

Surgery involves the utilization of a special range of instruments, from minor day surgery to complex emergency operations. There are different categories of surgical instruments, such as tissue forceps, scissors, and hemostatic instruments; retaining retractors or holding instruments; dilating instruments for resilient tissues or bone; visual instruments for direct imaging; electrosurgical and laser cautery instruments; vibratory instruments; minimally invasive instruments; and many others. All such instruments have both advantages and limitations and are suitable particularly for specific surgeries and tissue types. For example, electrosurgical scalpels are useful in slow dissecting movements through tough tissue, but they can ignite flammable facemasks. There are also continuous developments in the shape, function, and power sources of operating tools. Robotic surgical systems, for example, nowadays allow entirely intracorporal designs and 3D imaging in a variety of sizes submerged in different body cavities. Many minimally invasive surgical tools are rigid and, apart from a minority, have many potential technical restrictions. To reduce any complications, surgeons need optimal training in effectiveness and cooperation with these tools. Rigid flow, tremor filtration, and the reflection of tool force and natural rotation of the patient could be built into the tools to mitigate the influence of tremor. For the patient, it is necessary to minimize suffering. Patients may suffer because of anatomical conditions, postoperative adhesions, accidental organ damage, long operation times, anesthesia complications, and preoperative anxiety. Different perioperative approaches can reduce patient suffering related to surgery.

Minimally invasive surgical instruments reduce organ damage, decrease exudate, increase the benefits of results statistically, and decrease the length of hospital stays. However, it is important for surgeons to maintain high standards throughout the improvement of equipment and technique and for the government not to withdraw funding programs such as minimally invasive cancer therapies prematurely. It is also crucial to ensure that regulators guarantee that individual instruments follow the therapy's desired criteria and do no damage to the patient, similar to any other medical tool. The development of tissue holding tools, in which the grip can be controlled independently, would also be beneficial. This could alter the tension on a kidney blood supply autonomously during a liver operation, raising the blood flow to an area of a vital target organ. The use of a natural-shaped, wristed holding tool would also represent an advantage if mechanically feasible, as this could produce minimal torque by the restraint on a major blood-supplying vessel. It will be preferable if the feeling of force and palpation feedback can also be engineered into the new holding instrument. Such instruments could greatly change the potential in clinical practice. Standards for the design of medical instruments, in general, are governed by regulatory bodies which require potential harm to be minimized and evidence provided that acceptable quality and RAM have accurately recorded their effects on new equipment before human trials are conducted. A concept has begun to be implemented, which requires patient safety to minimize the potential for human error. The technology was used to prevent wrong-site surgery, for example, when the power tool for surgical bone cutting was navigated by GPS, showing the surgeon the exact location of the hand structure in real time and warning him if there was a wrong instrument movement. Many advanced surgical tools and instruments are equipped with various smart and innovative sensors, which can also provide the surgeon with real-time feedback. [16][17]

Drug Delivery Systems

There are various methods of drug delivery, including oral and intravenous therapies, which lead to systemic drug distribution and effects, and transdermal, subcutaneous, and intrathecal methods, which limit drug exposure to certain body regions. The selection of drug delivery modality depends on the therapeutic strategy, patient-specific characteristics, and disease type. Fast-developing biopharmaceuticals and personalized therapeutics are pushing the frontiers of targeted treatments that rely on tailored drug delivery systems. The aim of the development of sophisticated drug delivery systems is to increase drug effectiveness, minimize side effects, and improve patient quality of life. The oldest methods used in drug delivery systems are considered to be implantable devices and smart pumps. Implantable devices are generally designed as drug-reservoir systems that provide chronic treatment with medication. Smart pumps are battery-powered devices connected to the ICT and contain software that allows for programmable drug delivery according to solitary, set, and changeable treatment regimens. Even though landmark milestones have been reached in drug delivery system production, problems in drug delivery, such as dosage compliance or the usage of natural barriers, still continue. The development of new methods in drug delivery is essential in this respect. Nanotechnology offers a new approach to the production of drug delivery systems. This is expected to facilitate the production of new drugs with better efficacy, fewer side effects, and better drug targeting in various clinical conditions. Drug delivery systems using nanotechnology are essentially in clinical use, and various clinical trials regarding their use are in progress. Nevertheless, as with other novel drug delivery systems based on nanotechnology, translating results from bench to bedside in a short time period by employing product development designs is not enough.

Innovative new drug delivery systems have recently started to attract great regulatory attention. One of the key challenges remains getting new systems through clinical trials to enable them to reach the market. New systems often open new therapeutic areas for drug products that have already been approved by regulatory agencies, but new systems can present unknown side effects when given alongside familiar drugs. Regulatory agencies require new systems to undergo comprehensive clinical trials before they are granted approval. Regulatory agencies have thus far

advised that the number of clinical trials a system has to complete in order to be proven secure should depend on the novelty of the system in terms of pharmaceutical innovation. There is currently no regulatory strategy in place for approving the clinical trials relevant to making the product usable by doctors, and that is the purpose of the present study. To develop this regulatory strategy, we planned to study the clinical trials conducted in the European Union for new systems, comparing the clinical trials for new systems with the clinical trials for the same active ingredients, and stating that there were previously authorized doses in the guise of conventional formulation products. In this study, we included clinical trials conducted in humans. [18][19]

Monitoring and Tracking Devices

Those devices are fundamental for patient care and management. On one hand, they contribute to real-time monitoring of vital signs and other health parameters. In case of an abnormal value of these vital signs, an immediate response can be arranged, which could be of vital importance. Telemetry is a main feature in many of these devices, but many are mobile health devices used also to follow chronic diseases, where they play an important role in the so-called ambulatory telemedicine or telehealth. Finally, as an evolution of mobile health, we recently observed the emergence of what we name telemonitoring or teletracking, as classic telemedicine forces patients to connect the device to the telemedicine system and to wait for instructions. In telemonitoring, patients are able to connect the monitoring device to their mobile phones and to engage in usual activities, including physical activities, as was the case in classical telemedicine.

Moreover, complete wearable devices have appeared in the form of smartwatches from main providers. Smartwatches are not just for notifications, music, or fitness; manufacturers have included many sensors for personal health. All these wearable monitoring and tracking devices aim to empower patients to take care of their own health. In addition, recent research showed that some WBANs for patient monitoring in chronic diseases have been able to make early detections of some health issues. The main challenge for these wearable monitoring devices is data accuracy and the interpretation of the collected data to provide meaningful and trustworthy alerts, so false alarms should be limited, and patients are alerted only when needed. Other challenges include the image of acceptance by the patient and, last but not least, patient privacy. Integrating different types of sensors and processing data from different body areas is an increasing trend to have a complete picture of the patient's health. As all monitoring devices show their lack of consideration in isolation, we already have some sensors implemented on smartphones. The use of artificial intelligence within smartphones, wearables, and also in the cloud for deciding when to alert the patient to provide valuable information is expected to become future technology. [20][21]

Emerging Technologies in Medical Devices

In the last 30 years, there has been rapid development in the field of medical devices. New technologies are emerging, reshaping the way doctors take care of patients and the way patients are treated. If we look at the current situation, the most commonly used technology in medical devices is telemedicine, which helps reduce the burden on specialists and remove hurdles related to long waiting periods. Technological advances in robotics and artificial intelligence are changing the nature of many surgical procedures. For example, robot-assisted surgeries have helped older women expand their options and are considered safe for both the surgery and the surgeon. 3D printing, which allows for individual treatments and innovations in developing countries, can be used to print a variety of devices in personalized medicine, such as implantable medical devices, which can be produced rapidly on a shorter scale. Because this technology is commercially available, and operational and biological parts are not as good as the mass produced by technicians, they are used less frequently when an expedited clinical trial is viable.

Many experts agree that cybersecurity will become important in the development of medical devices, some of which are related to artificial intelligence, IoT capabilities, and communication potential with other equipment to accelerate the development of data collection, therapy software, and firmware in medical devices. IoT-capable medical devices can provide doctors with valuable

data about patients, such as cardiac service information using implantable clinical devices that utilize home glucose readings to track and provide feedback. This, in principle, can promote early intervention in patients during common digital health treatments. All medical devices must be checked for one or more years before they are certified and can be used in various countries. Rapid advances in technology will make the medical device market change quickly in the coming years beyond what we can imagine now.

Technological advances can change the way we design medical devices, the way healthcare is delivered, and the way patient devices interact. They can also be used to treat and cure diseases that are no longer manageable today. Researchers and practitioners can use new information, and data can be collected and used for diagnosis, therapy, or future applications. Many of the latest medical devices can be customized to ensure bio-safety. Many of them can be linked and treated based on consent, which can present potential challenges in terms of regulatory and personal safety. Managing the personal and ethical implications of this emerging technology is also a difficult and unknown area. Some argue that countries can regulate the use of medical licenses; for example, there are concerns about the urgent need to adapt the legislative status of health technology to the digital landscape, where data is at the heart of investment strategies. Despite these hurdles and legal challenges, significant information is stored, providing insights into an individual organic farm. There is potentially a growing market for novel devices, including individual medical devices, from their early use to the world. [22][23]

Regulatory Considerations and Approval Process

The article is based on lectures in different universities in the field of medical product development, validation, and medical device regulation in the EU and USA. These lectures are usually given at the end of the education series because it is important for university students to know how medical devices are regulated in their chosen territory and what they should do to make their medical devices available for patients. This article focuses on the new EU regulation of Medical Devices and In Vitro Diagnostics as a main example, arising from the development of the presented lectures during the last year.

The main aim of medical device regulation is to protect public health. The approval process is directed toward the safety and efficacy of the medical device. The regulatory arm in the USA is the Food and Drug Administration, and the European one is the European Medicines Agency and the Obstetrics and Gynaecology Products of the Center for Therapeutic Products and Research. In Europe, from 25 May 2021, all EU member states will implement the new regulation for medical devices and regulation for in vitro diagnostics. Manufacturers should be compliant with the new regulations and must start working according to the new chapters. Regulatory authorities assess medical device applications from different aspects. The risk classification is a categorization of the medical device. Review of device applications is done according to the necessary approval pathway for every class or category of medical devices. The approval process starts with pre-clinical studies for the new chemical entities that were approved. Clinical trials and marketing authorization shall follow. Post-market surveillance includes monitoring and inspections. Regulatory authorities' concern is to inform manufacturers and sellers about the unique device identification. Manufacturers and regulatory authorities must sit down with academics and clinicians to create a communication line. Regulatory agencies will continue developing new tools to innovate and collaborate. New trends in medical device regulation are considered in the article. The joining of European and US manufacturers is the best start to consider the basic differences and the gap between the regulatory requirements of both countries. [24][25]

Challenges and Future Directions

The design of medical devices is shaped by a variety of factors, including advances in technology, scientific research, and pharmaceutical applications. As medical device technology diversifies and proliferates, regulatory bodies are exploring the process by which they clear new devices for the market and be vigilant about the expanding scope of their use after release. Makers of traditional,

externally implanted medical devices had long enjoyed a commercial, regulatory, and user environment dominated by economies of scale, the resulting consolidation in the supply chain, and the effectiveness of regulatory approvals in amplifying the already substantial financial barriers to the marketing of new products. While the list of future challenges relevant to the medical device industry is expansive, highlighting future research avenues is useful to both scholars and policymakers. A number of studies have come from efforts to make sense of the various disorders where the implantable artificial organ could be of medical use, with a variety of contingencies, challenges, and pathways for each. This future work touches on socioeconomic, ethical, and legal concerns that intersect directly with the future regulation of medical devices. In this closing section, we collate the vast landscape of challenges and future paths into eight focused lines of research that will help guide the field of science, technology, and society and regulatory practices in the years to come. The first intelligibility-based criterion concerns the fact that promising research avenues in medical devices are still, by and large, waiting for the fields of medicine, the life sciences, and biotechnologies to make second predictions. [1][26]

Conclusion

Medical devices are utilized in the delivery of healthcare services, and new devices support accurate diagnostics, efficient treatment, and continuous monitoring of the patient during and after care. This period witnesses the transition from mere mechanical tools to more sophisticated electronic devices, vastly influenced by the development in the semi-conductor device fabrication technology. These have opened new opportunities in medical management and are largely being made use of. Today, the employment of technologies like artificial intelligence, or digital health, along with system automation, mobile and portable medical devices, is revolutionizing medicine from invasive to non-invasive or even 'pinpricks.' A few medical devices, particularly, implantable devices, are examined in this essay. Comparatively non-invasive devices provide convenience to the patients, and it is increasingly being made use of. The trends suggest that new and innovative medical devices are being developed worldwide.

The device industry has to invest more money, bring in quality management professionals and talent into their fold. The average time between 'concept to bedside' is long, and only the regulatory bodies can slash it, as one of the complaints of the industry is the cumbersome regulations in approval. There are adversities and crises stemming from advanced technology use, notably biotechnology. These threats are seen in the areas of non-predictable consequences, long-term and large-scale irremediable impact, dangers in research and institutional pathologies. The technological missions of the future, however, will deal with risks of different types compared with the risks of the past: unknown by science, impossible to measure in time and space, delayed, irreparable, and spread out globally. There are side effects and after-effects accompanying modern technological innovations. In the knowledge society, paradoxically, old dreams of radical reform or reprogramming of human life can become quite realistic. An enlightened mind is being replaced by an "enlightening brain" in the ideology of the ‘bio-happiness of biotechnology’. It concludes on a hopeful note: "There is no necessity for an apocalyptic end of the world."

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