Online Ethics Center
FOR ENGINEERING AND SCIENCE

Emerging Technologies Subject Aid

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Description

A short guide to some key resources and readings on the topic of the ethics of emerging technologies.

Body

Technology shapes every aspect of human experience, including our social and ecological world and in turn our social and ecological world helps shape technology. Technologies are often developed as a tool to accomplish a specific goal, like engineering crops to increase food productivity. In turn, these technologies may be adopted, rejected, or changed to fit a specific need or desire of different communities. An example of this is the ready adoption of genetically engineered crops by some communities, such as in the U.S., and the resistance to the use of these modified crops in parts of Europe, Asia and Africa. In other cases, emerging technologies can lead to unintended consequences – both positive and negative – such as the growing use of autonomous vehicles for military and civilian use or the editing of the human genome. The study of emerging technologies focuses on how technologies influence human life and society, and how humans in turn influence how these technologies are developed, utilized and changed.

Sandler, R.L.2014. "Introduction: Technology & Ethics," in R.L. Sandler (ed.). *Ethics and Emerging Technologies*. Palgrave Macmillan, 1-3.

Subject Overviews

Al-Rodhan, Nayef. 2015. "The Many Ethical Implications of Emerging Technologies." *Scientific American.* March 13. Accessed July 7, 2015.

> This article, produced as part of the 2015 World Economic Forum, discusses ethical and regulatory challenges posed by emerging technologies and the ways in which engaging in meaningful discussions about potential implications and good governance can help shape the ethical development of new and emerging technologies.

Gutmann, Amy. 2011. "The Ethics of Synthetic Biology: Guiding Principles for Emerging Technologies." *Hastings Center Report.* 17-22.

> Focusing specifically on synthetic biology, this short article describes the U.S. Presidential Commission for the Study of Bioethical Issues project that examined the social challenges presented by this emerging technology and discusses the five ethical principles that guided their evaluation process of the current state of synthetic biology, its potential benefits and risks, and their policy recommendations.

Moor, James H. 2004. "Why we need better ethics for emerging technologies". *Ethics and Information Technology*. 7(3): 111-119.

> Technological revolutions are dissected into three stages: the introduction stage, the permeation stage, and the power stage. The information revolution is a primary example of this tripartite model. A hypothesis about ethics is proposed, namely, ethical problems increase as technological revolutions progress toward and into the power stage. Genetic technology, nanotechnology, and neurotechnology are good candidates for impending technological revolutions. Two reasons favoring their candidacy as revolutionary are their high degree of malleability and their convergence. Assuming the emerging technologies develop into mutually enabling revolutionary technologies, we will need better ethical responses to cope with

them. Some suggestions are offered about how our approach to ethics might be improved.

Sandler, R.L.2014. "Introduction: Technology & Ethics," in R.L. Sandler (ed.). *Ethics and Emerging Technologies*. Palgrave Macmillan, 1-23.

A good introduction to an undergraduate textbook that focuses on some of the main ethical concerns of emerging technologies, genetic modification, human enhancement, geoengineering, robotics, virtual reality, artificial meat, neurotechnologies, information technologies, nanotechnology, sex selection, and more.

Policy and Guidance

National Academy of Engineering (U.S). 2004. *Emerging Technologies and Ethical Issues in Engineering: Papers from a Workshop.* Washington D.C.: National Academies Press. https://www.nap.edu/catalog/11083/emerging-technologies-and-ethical-issues-in-engineering-papers-from-a

Engineers and ethicists participated in a workshop to discuss the responsible development of new technologies. Presenters examined four areas of engineering – sustainability, nanotechnology, neurotechnology, and energy – in terms of the ethical issues they present to engineers in particular and society as a whole. Approaches to ethical issues include: analyzing the factual, conceptual, application, and moral aspects of an issue; evaluating the risks and responsibilities of a particular course of action; and using theories of ethics or codes of ethics developed by engineering societies as a basis for decision making. Ethics can be built into the education of engineering students and professionals, either as an aspect of courses already being taught or as a component of engineering projects to be examined along with research findings. Engineering practice workshops can also be effective, particularly when they include discussions with experienced engineers. This volume includes papers on all of these topics by experts in many fields. The consensus among workshop participants is that material on ethics should be an ongoing part of engineering education and engineering practice.

The National Academies of Science, Engineering and Medicine (U.S.) 2015. *Climate Intervention: Reflecting Sunlight to Cool Earth*. Washington D.C.: National Academies Press. https://www.nap.edu/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth

This report examines albedo modification (changing the fraction of incoming solar radiation that reaches the surface) and includes consideration of the social, political, ethical, and legal issues within this area of research. In chapter 4, it identifies and discusses ethical issues surrounding doing research in this area and considers issues with the deployment of these methods.

The National Academies of Science, Engineering and Medicine. 2012. *A Research Strategy for Environmental, Health, and Safety Aspects of Engineered Nanomaterials.* Washington, D.C.: National Academies Press. https://www.nap.edu/catalog/13347/a-research-strategy-for-environmental-health-and-safety-aspects-of-engineered-nanomaterials

This report presents a strategy for developing the science and research infrastructure needed to address uncertainties regarding the potential environmental, health, and safety (EHS) risks of engineered nanomaterials (ENMs). The report summarizes the current state of the science and high-priority data gaps on the potential EHS risks posed by ENMs and describes the fundamental tools and approaches needed to pursue an EHS risk research strategy. The report also presents a proposed research agenda, short-term and long-term research priorities, and estimates of needed resources and concludes by focusing on implementation of the research strategy and evaluation of its progress, elements that the committee considered integral to its charge.

The National Academies of Science, Engineering and Medicine. 2009. *Nanotechnology in Food Products: Workshop Summary.* Washington D.C.: National Academies Press. https://www.nap.edu/catalog/12633/nanotechnology-in-food-products-workshop-summary

The Institute of Medicine held a one-day workshop, summarized in this volume, to further explore the use of nanotechnology in food. Specifically, the workshop was organized around three primary topic areas: (1) the application of nanotechnology to food products; (2) the safety and efficacy of nanomaterials

in food products; and (3) educating and informing consumers about the applications of nanotechnology to food products.

The National Academies of Science, Engineering and Medicine. 2007. *Applications of Toxicogenomic Technologies to Predictive Toxicology and Risk Assessment*. Washington D.C.: National Academies Press. https://www.nap.edu/catalog/12037/applications-of-toxicogenomic-technologies-to-predictive-toxicology-and-risk-assessment

The Human Genome Project, which set the goal of determining the complete nucleotide sequence of the human genome, was among the most important biologic research projects of all time. To capitalize on the enormous potential of having access to genome-wide sequence information, scientists, clinicians, engineers, and information scientists combined forces to develop a battery of new molecular and bioinformatics tools that now make it possible to obtain and analyze biologic datasets of unprecedented magnitude and detail. Generally referred to as genomic technologies, these approaches permit sequence analysis — as well as gene transcript, protein, and metabolite profiling — on a genome-wide scale. As a result, the Human Genome Project and the technologic innovations and computational tools that it spawned are having profound effects on biologic research and understanding. The application of these technologies to toxicology has ushered in an era when genotypes and toxicant-induced genome expression, protein, and metabolite patterns can be used to screen compounds for hazard identification, to monitor individuals' exposure to toxicants, to track cellular responses to different doses, to assess mechanisms of action, and to predict individual variability in sensitivity to toxicants. Given the inherent complexity in generating, analyzing, and interpreting toxicogenomic data and the fact that toxicogenomics cannot address all aspects of toxicology testing, interested parties need to prepare in advance. This preparation will help them understand how best to use these new types of information for risk assessment and for implementing commensurate changes in regulations and public health, while preparing for the potential economic, ethical, legal, and social consequences.

The National Academies of Science, Engineering and Medicine. 2004. *Biotechnology Research in an Age of Terrorism*. Washington D.C.: National Academies Press. https://www.nap.edu/catalog/10827/biotechnology-research-in-an-age-of-terrorism

In recent years much has happened to justify an examination of biological research in light of national security concerns. The destructive application of biotechnology research includes activities such as spreading common pathogens or transforming them into even more lethal forms. Policymakers and the scientific community at large must put forth a vigorous and immediate response to this challenge. This new book by the National Research Council recommends that the government expand existing regulations and rely on self-governance by scientists rather than adopt intrusive new policies. One key recommendation of the report is that the government should not attempt to regulate scientific publishing but should trust scientists and journals to screen their papers for security risks, a task some journals have already taken up. With biological information and tools widely distributed, regulating only U.S. researchers would have little effect. A new International Forum on Biosecurity should encourage the adoption of similar measures around the world. Seven types of risky studies would require approval by the Institutional Biosafety Committees that already oversee recombinant DNA research at some 400 U.S. institutions. These experiments of concern include making an infectious agent more lethal and rendering vaccines powerless.

The National Academies of Science Engineering and Medicine. 2014. *Emerging and Readily Available Technologies and National Security: A Framework for Addressing Ethical, Legal, and Societal Issues*. Washington D.C.: National Academies Press.
https://www.nap.edu/catalog/18512/emerging-and-readily-available-technologies-and-national-security-a-framework

Emerging and Readily Available Technologies and National Security is a study on the ethical, legal, and societal issues relating to the research on, development of, and use of rapidly changing technologies with low barriers of entry that have potential military application, such as information technologies, synthetic biology, and nanotechnology. The report also considers the ethical issues associated with robotics and autonomous systems, prosthetics and human enhancement, and cyber weapons. These technologies are characterized by readily available knowledge access, technological advancements that can take place in months instead of years, the blurring of lines between basic research and applied research, and a high uncertainty about how the future trajectories of these technologies will evolve and what

applications will be possible.

Presidential Council for the Study of Bioethical Issues. 2010. *New Directions: The Ethics of Synthetic Biology and Emerging Technologies*. Washington D.C.: Presidential Council for the Study of Bioethical Issues.

In May 2010, scientists at the J. Craig Venter Institute announced that they had created the world's first self-replicating synthetic (human-made from chemical parts) genome in a bacterial cell of a different species. Intense media coverage followed, and the announcement ricocheted across the globe within hours as proponents and critics made striking claims about potential risks and benefits of this discovery and whether it amounted to an early-stage example of "creating life." In response, President Barack Obama asked the Commission to review the developing field of synthetic biology and identify appropriate ethical boundaries to maximize public benefits and minimize risks. This report summarizes the findings of the Commission who went through an inclusive and deliberative engagement process with a wide variety of sources, including scientists, engineers, faith-based and secular ethicists, and others who voiced, as expected, sometimes conflicting views on the science, ethics, and social issues surrounding synthetic biology. Through public meetings in Washington, D.C., Philadelphia, and Atlanta, the Commission created a forum for open dialogue to hear and assess competing claims about the science, ethics, and public policy relating to synthetic biology.

United Nationals Educational, Scientific and Cultural Organization, 2007. *Ethical Implications of Emerging Technologies: A Survey*. Paris: UNESCO.

This report looks at emerging technologies in the area of communication and information and discusses how these technologies may affect the exercise of basic human rights.

Bibliographies

Laas, Kelly. 2016. OEC Emerging Technologies Bibliographies. https://onlineethics.org/cases/emerging-biotechnology-collection/emerging-biotechnologies-bibliography

- A set of partially-annotated bibliographies including biotechnology, brain implants, geoengineering, nanotechnology, robotics, and synthetic biology.

Racine, Valerie. 2017. OEC Emerging Biotechnologies Bibliography. Authoring Institution: Center for Biology and Society at Arizona State University. https://onlineethics.org/cases/emerging-biotechnology-collection/emerging-biotechnologies-bibliography

- A bibliography that includes books, journal articles and web sites looking at the ethics of emerging biotechnologies, and including sections on synthetic biology, CRISPR-Cas9 and other genomic editing technologies, and genetic screening and genetic modification in embryos. It includes a few more general references to emerging technologies.

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