9.3 Annex III: Synthetic biology - definitions

Source	Definition	Key words/ focus
European Commission Report of a NEST High-Level Expert Group: "Synthetic Biology Applying Engineering to Biology" 2005	Synthetic biology is the engineering of biology: the synthesis of complex, biologically based (or inspired) systems which display functions that do not exist in nature. This engineering perspective may be applied at all levels of the hierarchy of biological structures from individual molecules to whole cells, tissues and organisms. In essence, synthetic biology will enable the design of biological systems in a rational and systematic way.	Engineering Principles applied to biology; Rational design and synthesis of complex (novel) biological systems.
Synthetic Biology project EU FP6[31] 2006	Synthetic biology is the engineering of biological components and systems that do not exist in nature and the re-engineering of existing biological elements; it is determined on the intentional design of artificial biological systems, rather than on the understanding of natural biology.	(Re) engineering of novel biological components and systems through intentional design.
Synthetic Biology 3.0[32] 2007	Synthetic biology is a new and rapidly emerging discipline that aims at the (re-)design and construction of (new) biological systems.	(Re-) designing and synthesis of (new) biological systems.
Synthetic Biology 4.0[33] *2008*	Synthetic Biology is a new approach to engineering biology, with an emphasis on technologies to write DNA. Recent advances make the de novo chemical synthesis of long DNA polymers routine and precise. Foundational work, including the standardization of DNA-encoded parts and devices, enables them to be combined to create programs to control cells. With the development of this technology, there is a concurrent effort to address legal, social and ethical issues.	Engineering biology; DNA coded parts and devices; Control of cell function.
UK parliamentary office for Science and Technology Post Note[34] 2008	Synthetic biology aims to design and build new biological parts and systems or to modify existing ones to carry out novel tasks.	New or modified biological parts and systems for novel tasks.
Towards a European Strategy for Synthetic Biology - EU FP6[35]	Synthetic Biology aims at designing biological systems that do not exist in nature using engineering principles or re-designing existing ones to better understand life processes, to generate and assemble functional modular components, and to develop novel applications or processes.	(Re)design of (novel) biological systems; Functional modular components for novel applications and processes.
Ethic report [36]	A definition of synthetic biology should therefore include: 1.The design of minimal cells/organisms (including minimal genomes); 2. The identification and use of biological 'parts' (toolkit); 3. The construction of totally or	Identification, design and use of (artificial) biological parts.

[31]http://www2.spi.pt/synbiology/documents/news/D11%20-%20Final%20Report.pdf (accessed 24 06 2013)
[32]http://www.syntheticbiology3.ethz.ch/index.htm (accessed 24 06 2013)
[33]http://sb4.biobricks.org/field/ *(accessed 24 06 2013)*
[34]http://www.parliament.uk/documents/post/postpn298.pdf (accessed 24 06 2013)
[35]http://www.tessy-europe.eu/public_docs/TESSY-Final-Report_D5-3.pdf
[36]http://ec.europa.eu/bepa/european-group-ethics/docs/opinion25_en.pdf (accessed 03 07 2013)

Source	Definition	Key words/ focus
	partially artificial biological systems.	
Synthetic Biology Org[37]	Synthetic Biology is (a) the design and construction of new biological parts, devices, and systems, and (b) the redesign of existing, natural biological systems for useful purposes.	Design of new biological parts, devices and systems; Redesign of existing, natural biological systems.
Richard Kitney for "Synthetic Biology From Science to Governance: A workshop organised by the European Commission's Directorate-General for Health & Consumers"[38]. 2010	Two complementary definitions for SynBio: (a) designing and making biological parts and systems that do not exist in the natural world using engineering principles, and (b) redesigning existing biological systems, again using engineering principles.	Designing new or redesigning the existing biological systems through engineering processes
Presidential Commission for the Study of Bioethical Issues, Report on Synthetic Biology[39] 2011	Synthetic biology is the name given to an emerging field of research that combines elements of biology, engineering, genetics, chemistry, and computer science. The diverse but related endeavors that fall under its umbrella rely on chemically synthesised DNA, along with standardised and automatable processes, to create new biochemical systems or organisms with novel or enhanced characteristics.	Combines different scientific disciplines; uses synthetic DNA to develop new biochemical systems or organisms with novel or enhanced characteristics.
A synthetic biology roadmap for the UK[40] 2012	Synthetic biology is the design and engineering of biologically based parts, novel devices and systems as well as the redesign of existing, natural biological systems.	(Re)design/engineer-ing of biologically based parts, novel devices and systems; Engineering of biologically based parts, novel devices and systems Redesign of existing, natural biological systems
UNICRI[41] 2012	Synthetic Biology is the deliberate design of biological systems and living organisms using engineering principles	Design / engineering of biological systems and organisms.
Blake and Isaacs (2004)[42]	Synthetic biology is advancing rapidly as biologists, physicists and engineers are combining their efforts to understand and program cell function. By characterizing isolated genetic components or modules, experimentalists have paved the way for more quantitative analyses of genetic networks	Genetic components and module
De Vriend (2006)[43]	Synthetic biology is a newly emerging scientific	Convergence of various

[37]http://syntheticbiology.org/ (accessed 24 06 2013)
[38]http://ec.europa.eu/health/dialogue_collaboration/docs/synbio_workshop_report_en.pdf (accessed 24 06 2013)
[39]http://bioethics.gov/sites/default/files/PCSBI-Synthetic-Biology-Report-12.16.10_0.pdf (accessed 24 06 2013)
[40]http://www.rcuk.ac.uk/documents/publications/SyntheticBiologyRoadmap.pdf (accessed 24 06 2013)
[41]http://www.unicri.it/in_focus/files/UNICRI%202012%20Security%20Implications%20of%20Synthetic%20Biology%20and%20Nanobiotechnology%20Final%20Public-1.pdf (accessed 03 07 2013)
[42]W. J. Blake, F. J. Isaacs, Synthetic biology evolves. Trends Biotechnol 22, 321 (Jul, 2004)

Source	Definition	Key words/ focus
	field where ICT, biotechnology and nanotechnology meet and strengthen each other. Synthetic biology is a new trend in science and technology and a clear example of converging technologies	technologies.
Heinemann and Panke (2006)[44]	Synthetic biology is interpreted as the engineering-driven building of increasingly complex biological entities for novel applications.	Engineering driven complex biological entities for novel applications.
sc | nat, "Synthetic Biology" (2006)	Synthetic biology is a new research field, combining elements of gene technology and nanotechnologies with elements of the engineering sciences	Convergence of various technologies.
Drubin et. al. (2007)[45]	Synthetic biology refers to a variety of experimental approaches that either seek to modify or mimic biological systems	Approaches to modify or mimic biological systems.
ETC, "Extreme Genetic Engineering An Introduction to Synthetic Biology" (2007)	Synthetic Biology (also known as Synbio, Synthetic Genomics, Constructive Biology or Systems Biology) – the design and construction of new biological parts, devices and systems that do not exist in the natural world and also the redesign of existing biological systems to perform specific tasks.	(Re)design and construction of (novel) biological parts, devices, and systems to perform specific tasks.
ETC, "Extreme Genetic Engineering An Introduction to Synthetic Biology" (2007)	Synthetic biology is an emerging area of research that can broadly be described as the design and construction of novel artificial biological pathways, organisms or devices, or the redesign of existing natural biological systems	(Re)design and construction of (novel) biological pathways, organisms or devices,
Entus et al. (2007)[46]	Synthetic biology is a useful tool to investigate the dynamics of small biological networks and to assess our capacity to predict their behavior from computational models	A means to investigate and model biological networks.
IRGC[47], "Synthetic biology: risk and opportunities of an emerging field" (2008)	Most definitions of synthetic biology have two parts: synthetic biology is defined as the construction of completely novel biological entities, and the re-design of already existing ones	(Re)design of (novel) biological entities.
HSE, "Synthetic biology A review of the technology, and current and future needs from the regulatory framework in Great Britain" (2012).	Synthetic biology is a term used to cover areas of biochemistry research that is involved in the chemical synthesis of DNA, utilising biological agents or their components for potential application across a wide range of industrial sectors	Manipulation of synthetic DNA in biological systems.
The Royal Academy of Engineering "Synthetic	Synthetic biology aims to design and engineer biologically based parts, novel devices and	(Re)design/engineer novel systems and

[43]H. De Vriend, "Constructing Life. Early social reflections on the emerging field of synthetic biology" (2006)
[44]M. Heinemann, S. Panke, Synthetic biology-putting engineering into biology. Bioinformatics 22, 2790 (2006)
[45]D. A. Drubin, J. C. Way, P. A. Silver, Designing biological systems. Genes Dev 21, 242 (Feb 1, 2007).
[46]R. Entus, B. Aufderheide, H. M. Sauro, Design and implementation of three incoherent feed-forward motif based biological concentration sensors. Syst Synth Biol 1, 119 (Aug, 2007)
[47]IRGC, Risk governance of synthetic biology (revised concept note), 2009. IRGC, Guidelines for the Appropriate Risk Governance of Synthetic Biology (Policy Brief), 2010 http://www.irgc.org/issues/synthetic-biology/ ISBN 978-2-9700672-6-9

Source	Definition	Key words/ focus
Biology: scope applications and implications" (2009[48]).	systems as well as redesigning existing, natural biological systems. Synthetic biology strives to make the engineering of biology easier and more predictable.	devices
A. Danchin, 'Synthetic biology: discovering new worlds and new words', EMBO reports; doi:10.1038/embor.2008.159 (2008)	The fundamental idea behind synthetic biology is that any biological system can be regarded as a combination of individual functional elements — not unlike those found in man-made devices. These can therefore be described as a limited number of parts that can be combined in novel configurations to modify existing properties or to create new ones.	Novel combinations of biological functional parts
EU Project 'Towards a European Strategy for Synthetic Biology' (TESSY, 2007-2008): www.tessy-europe.eu/	Synthetic biology uses nucleic acid elements or complex systems that are predefined and chemically synthesised in the laboratory by a modular approach. This approach aims to: 1. engineer and study biological systems that do not exist as such in nature, and 2. use this approach for i) achieving better understanding of life processes, ii) generating and assembling functional modular components, iii) developing novel applications or processes.	Synthetic, artificial, assembly of functional modular components, novel processes/ applications
Benner SA and Sismour AM, Synthetic Biology Nat Rev Genet 6:533-43 (2005)	[Synthetic biology] attempts to recreate in unnatural chemical systems the emergent properties of living systems … [the] engineering community has given further meaning to the title…to extract from living systems interchangeable parts that might be tested, validated as construction units, and reassembled to create devices that might (or might not) have analogues in living systems.	Artificial assembly of biological parts
Hastings Center, USA	To advance knowledge and create products that can promote human welfare, synthetic biologists seek to create biological systems that do not occur naturally as well as reengineer biological systems that do occur naturally.	Artificial biological systems through (re)engineering
UK Parliamentary Office of Science and Technology, POSTNOTE Number 298, January 2008	[Synthetic biology] describes research that combines biology with the principles of engineering to design and build standardised, interchangeable biological DNA building-blocks. These have specific functions and can be joined to create engineered biological parts, systems and, potentially, organisms. It may also involve modifying naturally occurring genomes to make new systems or by using them in new contexts.	DNA building blocks to engineer biological parts
Erasynbio's definition https://www.erasynbio.eu	Synthetic Biology is the engineering of biology: the deliberate (re)design and construction of novel biological and biologically based parts, devices and systems to perform new functions for useful purposes, that draws on principles elucidated from biology and engineering.	
The Netherlands Commission on Genetic	Description: Synthetic biology is seen as a technology that offers new possibilities for	Re-designing and synthesis of (new)

[48]Royal Academy of Engineering (2009) Synthetic Biology: scope, applications and implications. https://www.raeng.org.uk/societygov/policy/current_issues/synthetic_biology/default.htm. ISBN: 1-903496-44-6

Source	Definition	Key words/ focus
Modification, 2013	biotechnological applications and research. It seeks to modify existing organisms and to design and synthesise new organisms.	biological systems.
The German Academy of Sciences Leopoldina, together with the German Academy of Science and Engineering and the German Research Foundation (DFG, 2009)	Description: Synthetic biology combines a wide spectrum of scientific disciplines and follows the principles of engineering science. Its chief characteristic is the modification of biological systems, which may also be combined with chemically synthesised components to produce new entities	Modification of biological systems / chemically synthesised components/ new entities
The Royal Netherlands Academy of Arts and Sciences, together with the Health Council of the Netherlands and the Advisory Council on Health Research[49]	Adopts definition of the European Commission Report of a NEST High-Level Expert Group: "Synthetic Biology Applying Engineering to Biology"): SynBio is the engineering of biology: the synthesis of complex, biologically based (or inspired) systems, which display functions that do not exist in nature. This engineering perspective may be added at all levels of the hierarchy of biological structures – from individual molecules to whole cells, tissues and organisms. In essence, synthetic biology will enable the design of 'biological systems' in a rational and systematic way	Rational design and synthesis of complex (novel) biological systems.
The Swiss Academy of Technical Sciences	Refers to definition of EASAC, (2011): Synthetic Biology: an introduction Synthetic biology is the application of engineering principles to biology. This may involve redesigning a living system so that it does something – manufacture a particular substance, perhaps – that it would not naturally do. Still more ambitious are attempts not merely to re-engineer living systems, but to fashion entirely new ones: to create life itself from non-living materials.	Engineering Principles applied to biology; (re) design and synthesis of complex (novel) biological systems.
Zentrale Kommission für die Biologische Sicherheit (2012) Monitoring der Synthetischen Biologie in Deutschland. http://www.bvl.bund.de/SharedDocs/Downloads/06_Gentechnik/ZKBS/01_Allgemeine_Stellungnahmen_deutsch/01_allgemeine_Themen/Synthetische_Biologie.pdf?_blob=publicationFile&v=3	Ziel der Synthetischen Biologie ist es, biologische Einheiten wie z.B. Enzyme, genetische Schaltkreise oder Zellen so zu gestalten, wie sie nicht in der Natur vorkommen.	
Arjun Bhutkar, Synthetic Biology: Navigating the Challenges Ahead. J. BIOLAW &BUS., Vol. 8, No.2, 2005**.**	Rather than splicing in a gene from one organism to another, or forcing a mutation in a genome for a specific purpose, synthetic biology mainly concerns designing and building artificial regulatory elements into genomes or constructing a complete genome	

[49]Royal Academy of Engineering (2009) Synthetic Biology: scope, applications and implications. https://www.raeng.org.uk/societygov/policy/current_issues/synthetic_biology/default.htm. ISBN: 1-903496-44-6