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# The importance of Synthetic Biology activities in a European Biotechnology Programme

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European Commission

DG-Research

Biotechnologies, Agriculture and Food

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# What is Synthetic Biology?

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.

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# SYNTHETIC BIOLOGY

a new conceptual frame that:

- **[i]** addresses biological systems with the tools and the descriptive language of Engineering
- **[ii]** tackles old questions and challenges with fresh approaches inspired in electric circuitry and mechanical manufacturing and
- **[iii]** pursues the creation of new materials with *à la carte* properties based on the rational combination of standardized biological parts decoupled from their natural context.

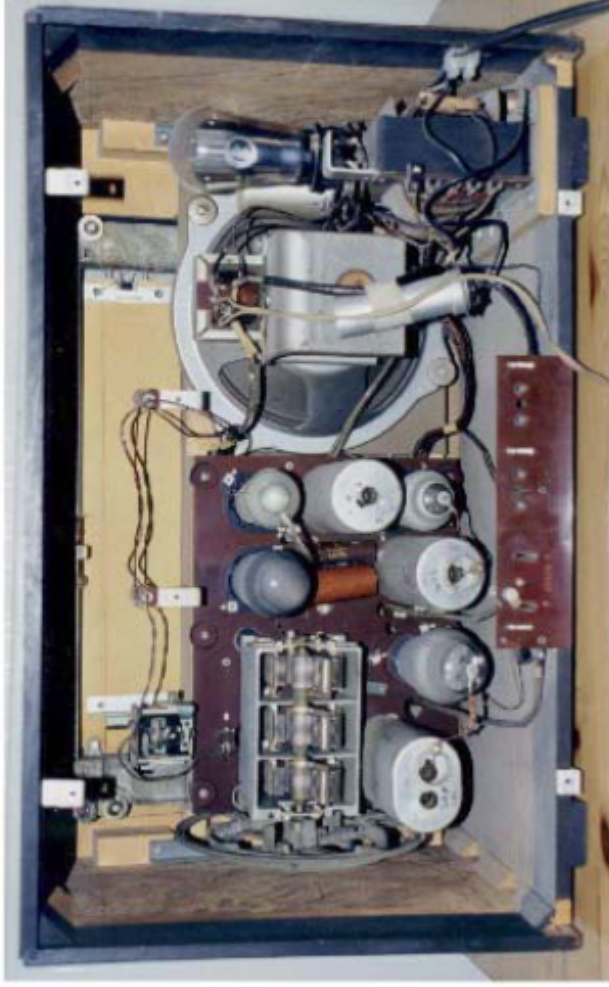


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# Metaphor #1: The radio

## Building a radio with parts



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J. Keasling

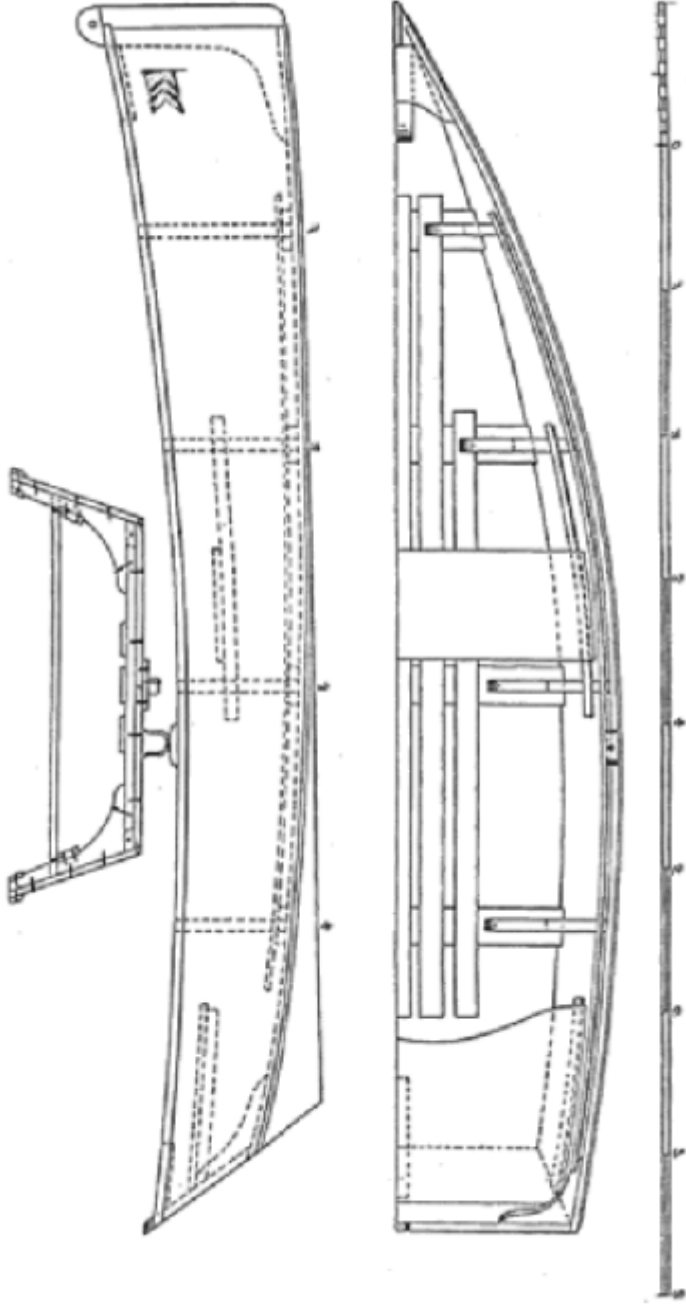




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# Metaphor #2: The Delphic boat



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A. Danchin





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# Metaphor #3: The chassis



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D. Endy





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# The NEST PATHFINDER initiative on "Synthetic Biology"

...was launched in 2003. Following two calls for proposals, 18 projects have been selected for funding. These projects apply design and engineering principles to biology with the aim to construct new functionalities and novel artificial systems based on sub-cellular biological building blocks.

A high-level expert group was established in 2005 with the aim, to examine, forecast and describe this new and emerging scientific field, its potential impact and support needs. (2005)

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- BIOMODULAR H2: Energy project promises a new biotechnology
- BIONANO –SWITCH: Matching up living organisms with computers
- CELLCOMPUT: Building computers in the body
- COBIOS: Solution for complex diseases
- EMERGENCE: Coordination puts synthetic biology on firm footing
- EUROBIOSYN: A sweeter way to make saccharides

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- FuSyMEM: Functional synthetic membranes to mimic nature's sense of smell
- HIBLIB: Monoclonal antibody production make quick and easy
- NANOMOT: Nature's motors tuned for delivery on demand
- NEONUCLEI: Synthetic analogues of cell nuclei
- NETSENSOR: Genes join up to detect and defend
- ORTHOSOME: When artificial nucleic acids control microbial genetics

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- **PROBACTYS**: Programming bacterial catalysts *à la carte*
- **SYNBIOCOMM**: Pushing the boundaries further
- **SYNBIOLOGY**: A European perspective on synthetic biology
- **SYNBIOSAFE**: Safety and ethics of synthetic life
- **TESSY**: Foundations for a European synthetic biology

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# What can the field deliver?

- Biomedicine
- Synthesis of biopharmaceuticals
- Sustainable chemical industry
- Environment and energy
- Production of smart materials and biomaterials
- Security: counter-bioterrorism

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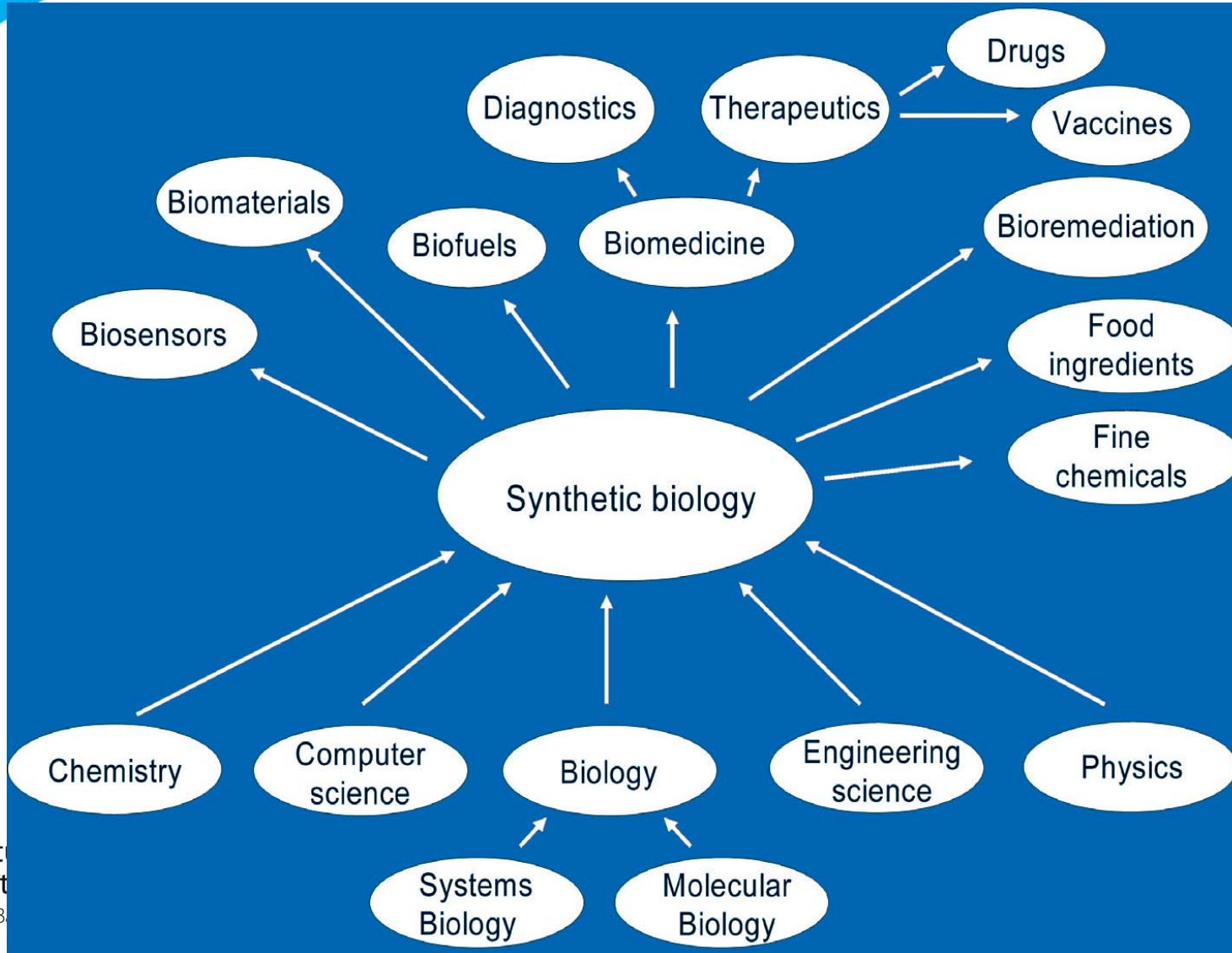




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# Knowledge transformation via SB



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TESSY



SEVENTH FRAMEWORK  
PROGRAMME



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# Synthetic biology in Knowledge-based Bioeconomy

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# THE EUROPEAN KNOWLEDGE-BASED BIOECONOMY

NUTRITION (nutrigenomics) - PATHOGENS  
CONTAMINANTS - ALLERGENS

CONSUMER CHOICE

STABILITY - BIODEGRADABILITY  
FUNCTIONALITY (Chirality)

SAFE HEALTHY  
& DIVERSE  
FOOD SUPPLY  
"Fork to Farm"

BIOBASED  
MATERIALS  
FOR HEALTH  
INDUSTRY  
& ENERGY



TRACEABILITY SYSTEMS  
ADVANCED FOOD TECHNOLOGIES

PROCESSING

WHITE BIOTECH  
CLEAN BIOPROCESSES  
RAW MATERIALS/WASTE

LOW INPUT FARMING - BIODIVERSITY  
ANIMAL HEALTH - RURAL DEVT.

PRODUCTION

GREEN / BLUE BIOTECH  
OPTIMISED RAW MATERIALS



SUSTAINABLE MANAGEMENT OF BIOLOGICAL RESOURCES



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# International interest on the field

- EU-USA Synthetic Biology Workshop (April 2006) – DoE
- International meetings (Cambridge, MA, USA-2004; Berkeley, CA, USA-2006; Zurich, CH-2007; Hong Kong-2008)
- ESF Workshop (Nov. 2007, April 2009)
- Royal Society
- OECD
- KBBE-net
- European Group of Ethics

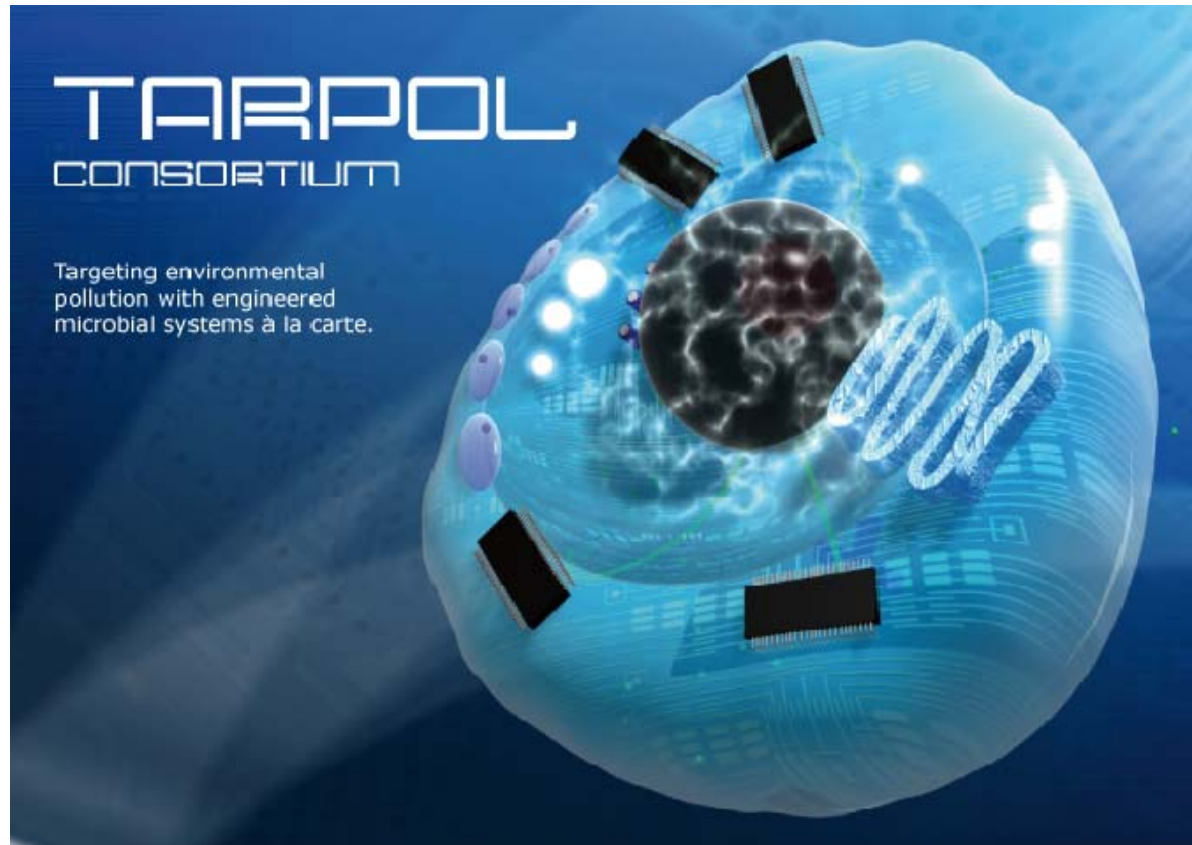


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# **KBBE-2007-3-3-01: SYNTHETIC BIOLOGY FOR THE ENVIRONMENT - The use of Synthetic Biology for the solution of environmental problems**

**Call: FP7-  
KBBE-2007-1**



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# TARPOL

## The 7 Work Packages are:

- Conceptual Frame and Consensual Language Definition
- Genetic Tools and Molecular Assets
- Design and Modelling Tools
- Biodegradation and Environmental Metabolism Database
- Social, Economic and Environmental Assessment
- Training Program and Dissemination
- Project Management

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# KBBE-2009-3-6-05: Synthetic biology for biotechnological applications

Synthetic biology enables a rational (engineering) recreation from basic elements of predetermined metabolic and catalytic properties. Synthetic biology may lead to minimal or even totally artificial microorganisms that can be used for microbial production processes with significant advantages in industrial or environmental biotechnology particularly where complex metabolic networks are required. Such as yet hypothetical microorganisms could be derived from natural microorganisms with a minimal set of genes (minimal microorganisms), or could be synthetically generated *de novo*, using a given set of essential genes (synthetic microorganism). The main objective is the design of artificial cells *à la carte* with predetermined metabolic or catalytic properties aiming at catalysing microbial production processes or at degrading recalcitrant compounds in the environment. Safety and ethical issues should be addressed within the project by involving experts in these areas. It is expected that technological achievements as well as issues of safety and ethics to be discussed at international research fora.

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# BaSynthec: *Bacterial Synthetic Minimal Genomes for Biotechnology*

- combines computational and experimental biology approaches with novel high-throughput methodologies to reduce and modify à la carte the chromosome of *Bacillus subtilis*, a genetically tractable bacterium and one of the key microbes used as a Cell Factory in biotechnology.
- Simpler *B. subtilis* strains with reduced energy consumption for self maintenance will be designed and constructed by removing some potentially expensive cellular processes. The cells with the lowest experimentally determined waste of energy and with industrially relevant phenotypes will be engineered to reroute the flux devoted to biomass formation through rational modifications of the complex metabolic regulations, and will be used as biotechnological platforms to plug in synthetic modules.

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# SYNTH-ETHICS

- addresses the ethical, legal and social implications of the emerging field of synthetic biology, with a special focus on biosafety and biosecurity and on notions of life. The project starts with discerning relevant ethical issues in close collaboration with the synthetic biology community. Next, the public debates around these issues are analysed. The current ethical and regulative frameworks existing in synthetic biology and closely related fields like nanobiotechnology and genetic engineering will then be reconstructed and assessed for their ability to deal adequately with existing and newly emerging ethical issues in synthetic biology. On that basis, challenges for current regulatory and ethical frameworks will be identified and recommendations for dealing with these challenges will be formulated targeted at three relevant groups: 1) the synthetic biology community, 2) EU policy makers and 3) NGOs/the public

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# SYBHEL

- Carry out high quality ethical research and evaluation of SynBio as it will impact on human health and well-being;
- Underpin research with a consistent awareness of the SYBHEL cross-cutting themes, namely: the definition of SynBio; scientific research (including documenting and regularly updating the state-of-the-art); safety and justice;
- Create a hub for all researchers and policy-makers interested in ethical, legal and social issues arising in SynBio as it applies to human health to meet and exchange ideas;
- Debate and agree key recommendations for regulation and commercialisation of SynBio as it applies to human health and well-being; and
- Determine a strategy for policy deliberation for SynBio in

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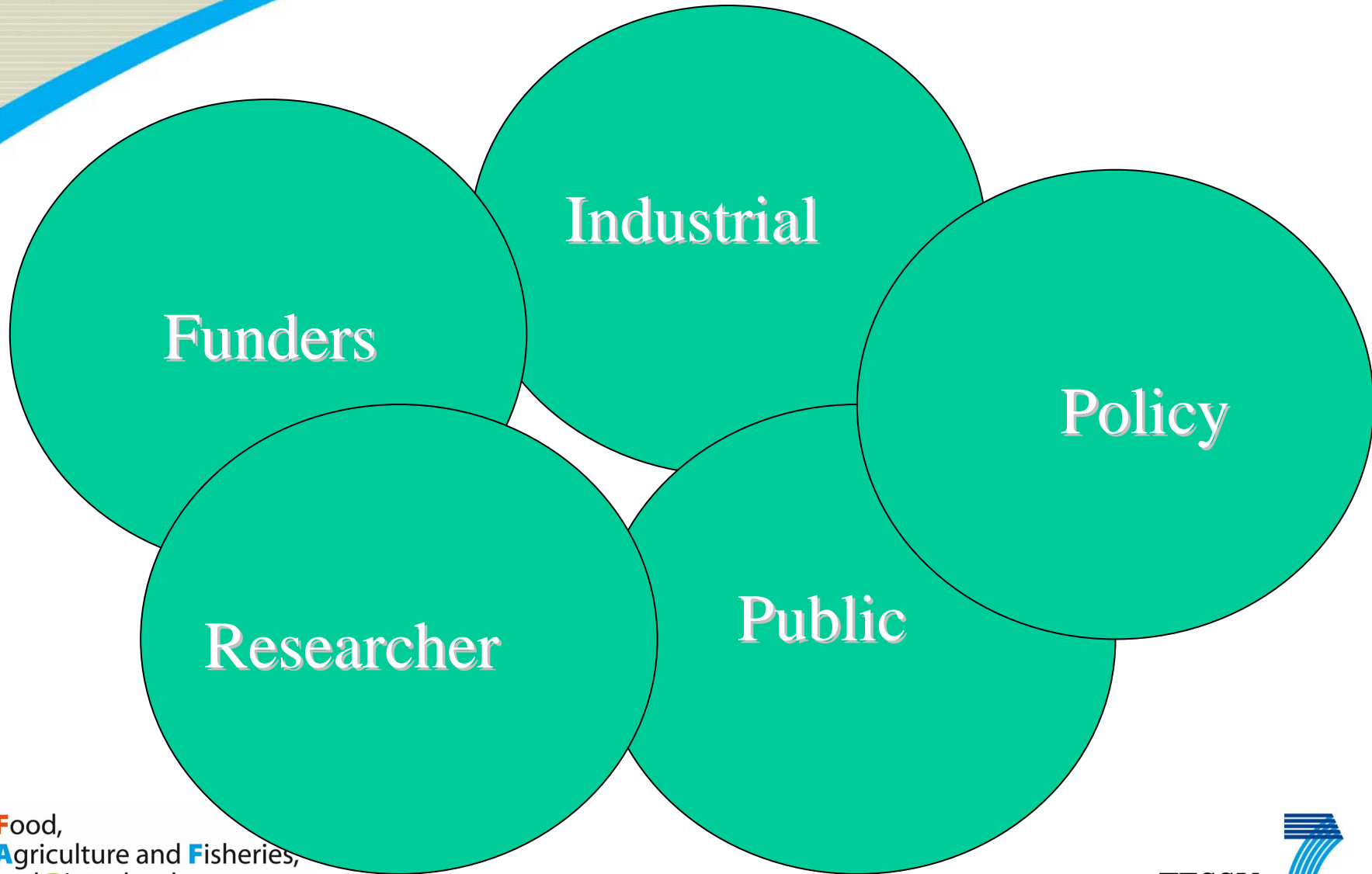
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# Biomedicine

- Complex molecular devices for tissue repair/regeneration
- Smart drugs
- Biological delivery systems
- Vectors for therapy
- Personalized medicine
- Cells with new properties that improve human health

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# In vivo synthesis of small-molecule pharmaceuticals

- Complex natural products

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# Expanding the chemistry of life

- Expanding the genetic alphabet
- Nucleic acids
- Proteins
- Novel imaging & targeting methods

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# A sustainable chemical industry

- Environmentally friendly production of chemicals

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# Environment and energy

- Bioremediation
- Production of energy
- GMO safety

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# Smart materials & biomaterials

- Synthesis
- Organization
- Integration

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# Industrial SB

Objective to provide:  
modular molecular tool-boxes  
applicable for speeding up any R&D  
in the design of biological systems.  
The expectation is to reduce costs

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# Public

- Potential and perceived risks due to deliberate or accidental damage
- Ethical issues

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# Policy

- Intellectual property
- Guidelines and regulations
- Dual use

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# OECD - US National Academies - UK Royal Society - International Symposium on Opportunities and Challenges in the Emerging field of Synthetic Biology

- Review the development and growth of the field and its potential.
- Identify scientific and commercial infrastructure needs.
- Explore how Synthetic Biology could challenge present legal and regulatory arrangements (e.g. biosafety, biosecurity, Intellectual Property rights).
- Discuss the underlying ethical dimensions of this new field.

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