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Synthetic Biology activities in the Knowledge Based Bioeconomy

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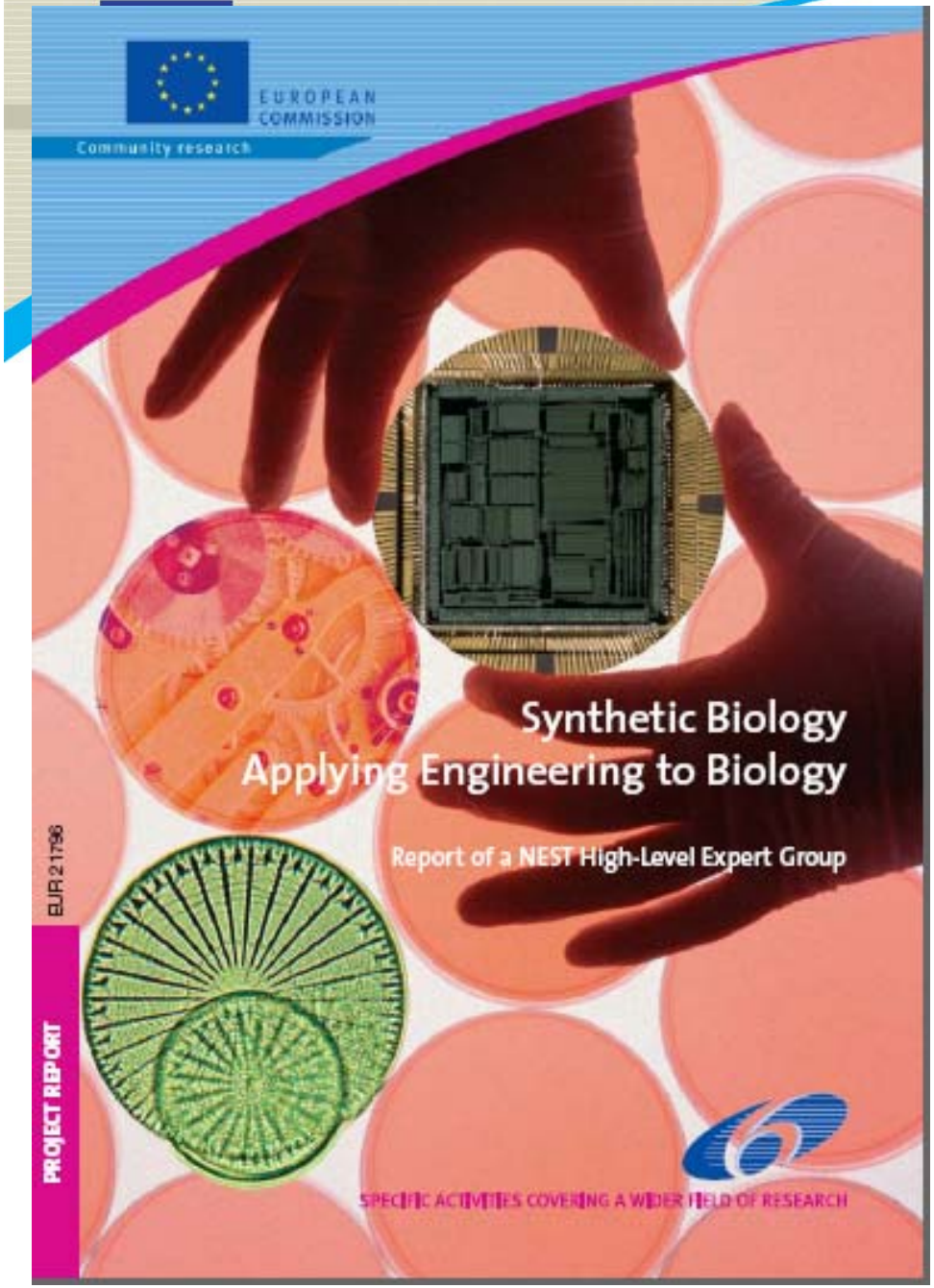

Synthetic biology is the engineering of biology: the synthesis of complex, biologically based (or inspired) systems which display functions that do not exist in nature. This engineering perspective may be applied at all levels of the hierarchy of biological structures – from individual molecules to whole 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 *á la carte* properties based on the *rational combination of standardized biological parts* decoupled from their natural context.

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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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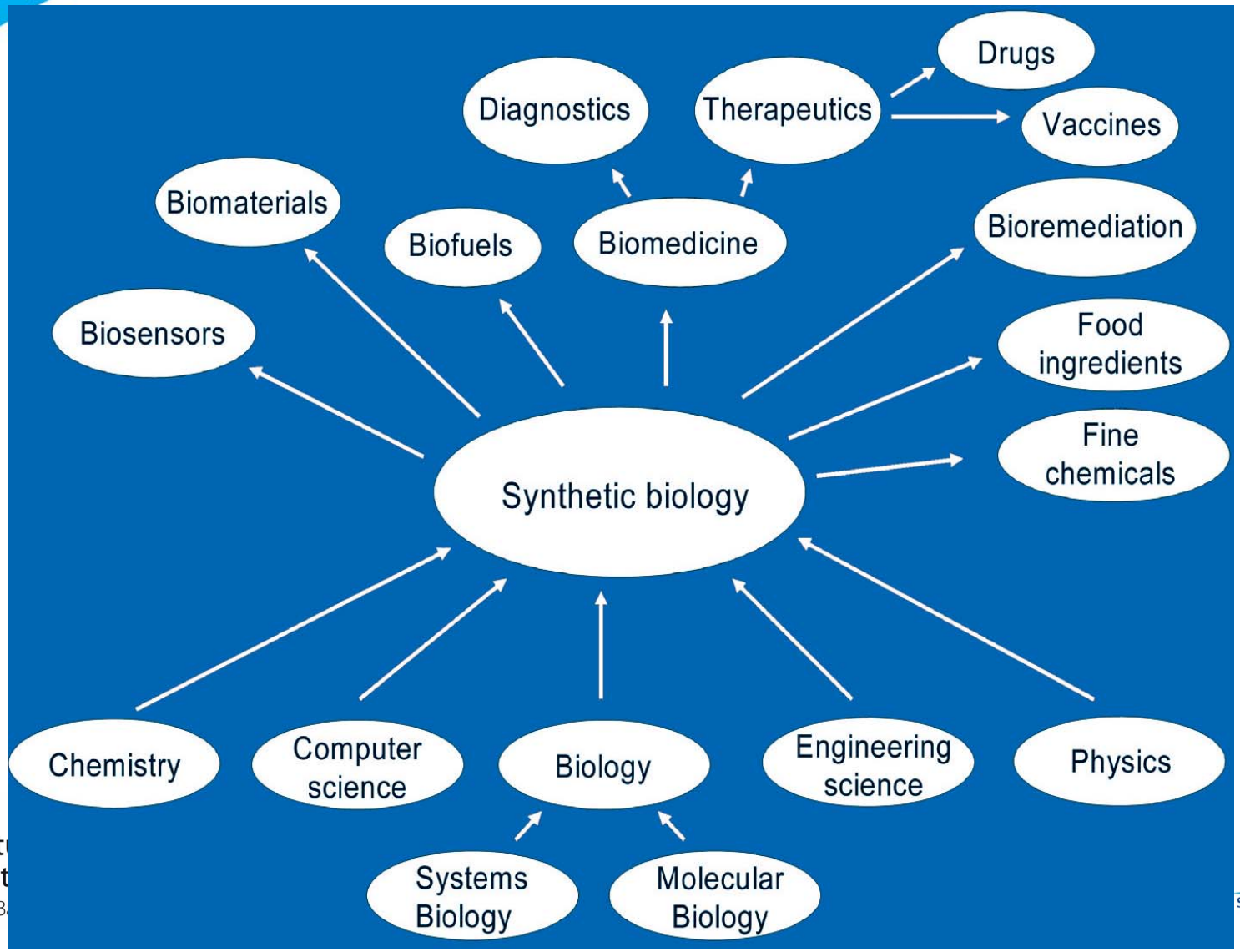
Knowledge transformation via SB



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transforming life sciences knowledge into new, sustainable, eco-efficient and competitive products

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Bioeconomy

The term "bio-economy" includes all industries and economic sectors that produce, manage and otherwise exploit biological resources (e.g. agriculture, food, forestry, fisheries io-

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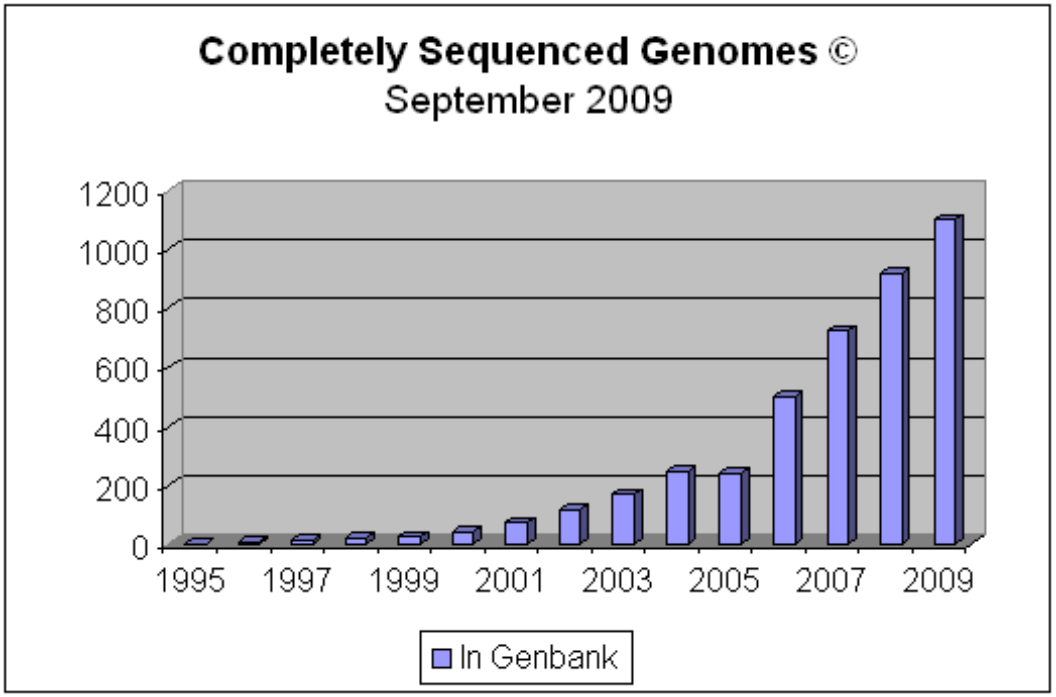

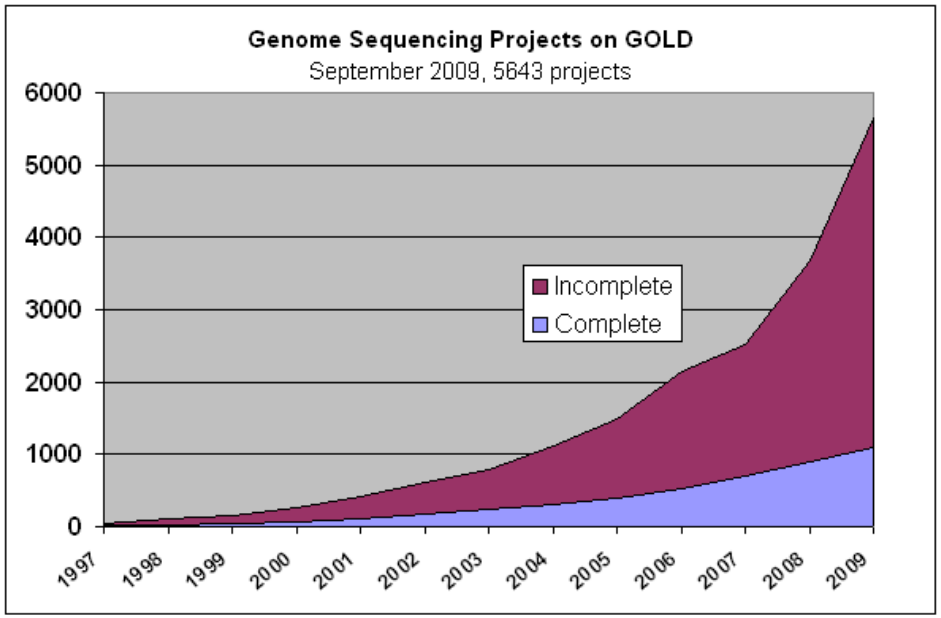

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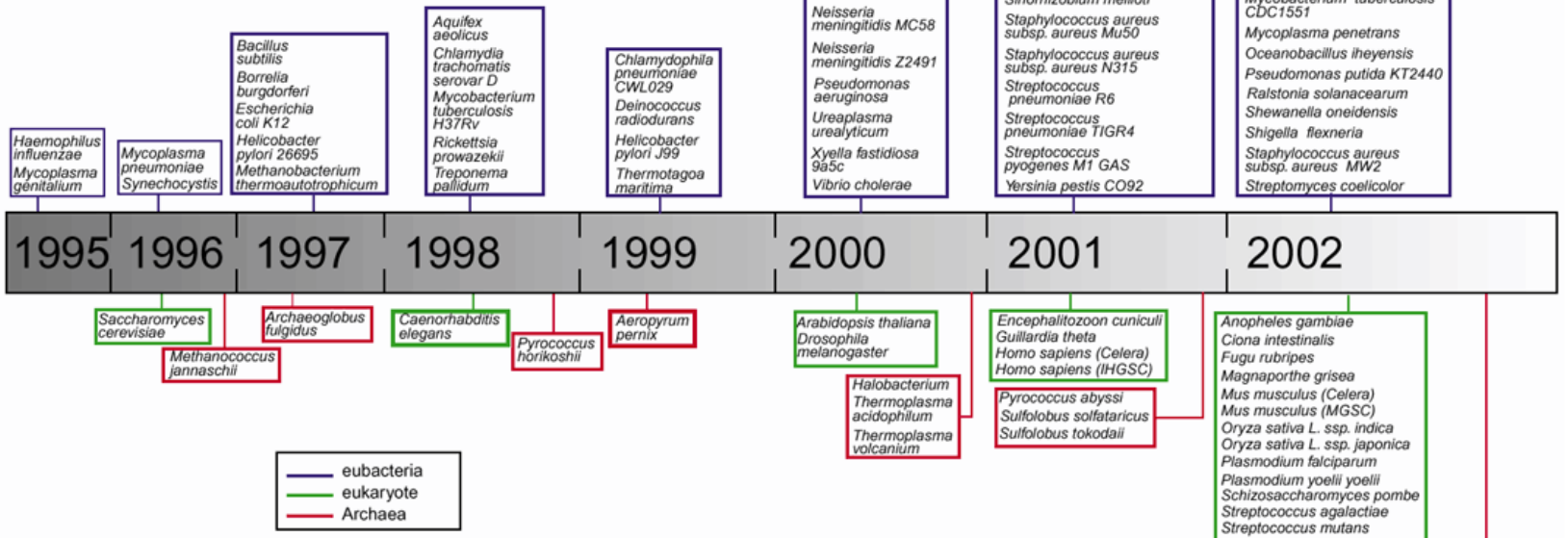
Exponential increase in the amount of experimental data

completed genomes



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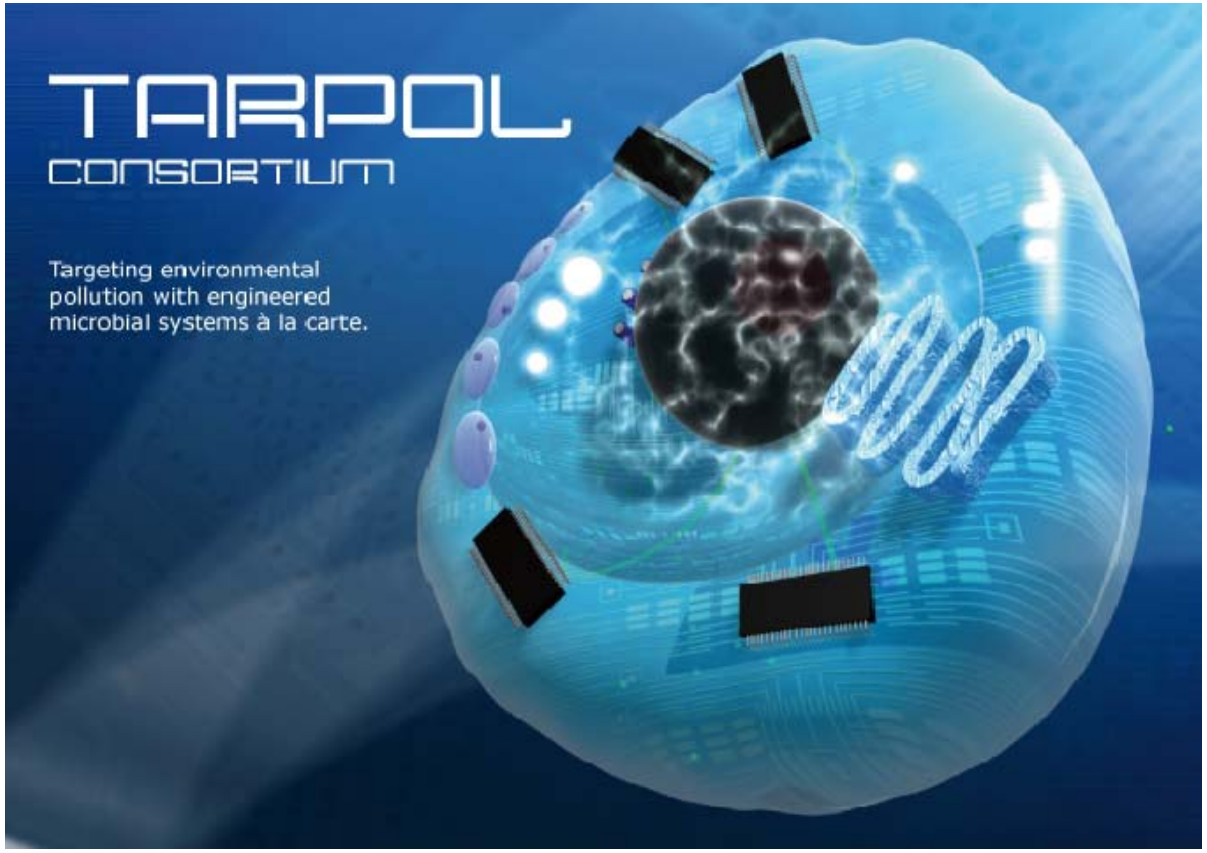
KBBE-2007-3-3-01: SYNTHETIC BIOLOGY FOR THE ENVIRONMENT - The use of Synthetic Biology for the solution of environmental problems Call: FP7-KBBE-2007-1



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TARPOL

The 7 Work Packages are:

- Conceptual Frame and Consensual Language Definition
- GeneticTools 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.

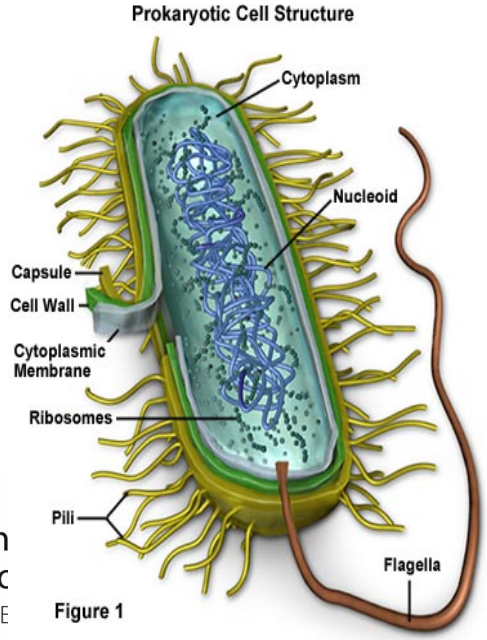

Figure 1

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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 human health.

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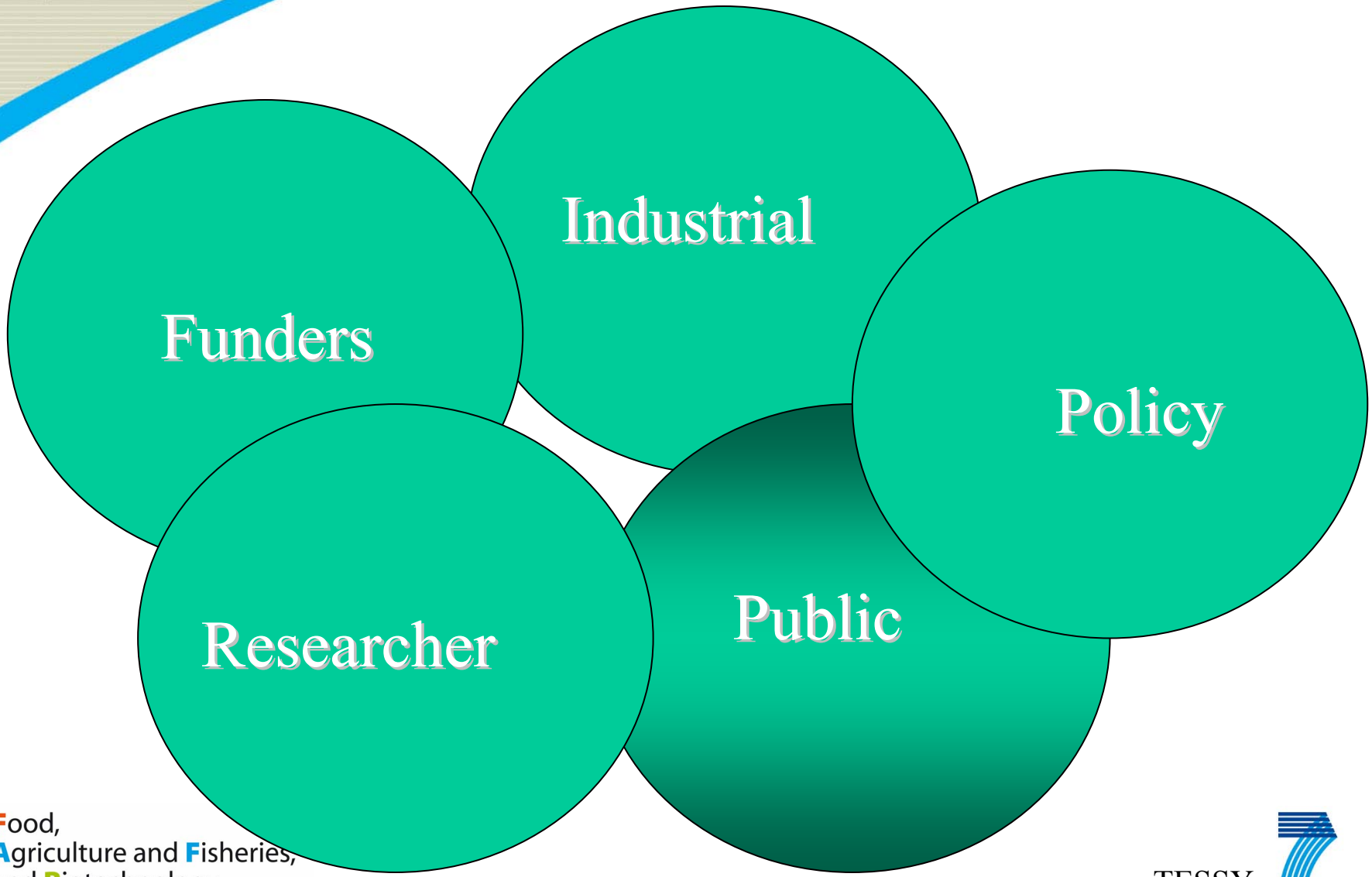

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International interest on the field

- EU-USA Synthetic Biology Workshop (April 2006) – DoE; June 2010 NSF.
- 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

The European Group on Ethics of science and new technologies (EGE)
Opinion on the ethics of synthetic biology

- On May 28, 2008 President José Manuel Barroso asked (EGE) to issue an Opinion on the ethical, legal and social implications raised by synthetic biology.
- The EGE adopted its Opinion on November 18, 2009.

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Ethics and beyond…

- ***Safety***
- ***Biosecurity, prevention of bioterrorism and dual use***
- ***Governance***
- ***Patenting and common heritage***
- ***Trade and global justice***
- ***Science and society dialogue***
- ***Research***

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- ***Science and society dialogue***

EGE asks the EU and EU Member States to take actions to promote ***public debates*** and engagement amongst the stakeholders in order to identify ***main societal concerns*** in the different areas covered by SB

- ***Research***

EGE invites the Commission to support ***basic research in the fields of biology, chemistry, energy, materials science, and engineering, as well as applied and interdisciplinary research***, as identified in this Opinion. This should be reflected in the R&D EU research Framework Programmes budget.

EGE notes that SB could lead, in the future, to a ***paradigm shift*** in understanding concepts of life. It therefore calls on the Commission to initiate an ***open intercultural forum to address the issues, to include philosophical and religious input***.

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Five hard truths for Synthetic biology

- Many of the parts are undefined
- The circuitry is unpredictable
- The complexity is unwieldy
- Many parts are incompatible
- Variability crashes the system

Nature 463, 288-290 (2010)

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Towards standardisation in Synthetic Biology

- definition,
- understanding and eventual cataloguing of *biological parts.*
- to bring natural existing biological modules to the point of *context-independence,* (engineering needs).
- pursuit of a *consensus language* for describing biological functions in a quantitative format,
- understanding of whether existing biological systems can be re-factored to be *orthogonal.*
- standards to ensure that a designed element of the system has a high chance of re-utilisation.

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Applying Synthetic Biology principles towards the cell factory notion in biotechnology

- approaches to engineer complex systems and redesign biological components towards cell factories. (paradigm shift)
  - towards efficient and safe, engineered biotechnological applications.
- using engineering principles like *orthogonality* and *hierarchy of abstraction* to assemble novel biological systems for the design of novel biomaterials or processes.
- The "cell factory" is a notion for the production of efficient and safe manufacturing of special fine, bulk, or fuel chemicals, biosensors for monitoring pollution or bioremediation tools to process contaminants.

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Ensuring the safety of Synthetic Biology applications

- to identify and categorise hazards in function of their likelihood and potential seriousness in view of the main foreseeable developments and applications of Synthetic Biology;
- to formulate a conceptual framework for an early, systematic and comprehensive identification of potential hazards of Synthetic Biology;
- to develop appropriate tools and approaches for risk assessment; and,
- to develop an effective public dialogue.

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Synthetic Biology– ERA-NET/KKBE-net WG

- The aim of this ERA-NET is to provide the basis for a successful forum for the exchange of information between Member States, initiate the process of identifying research complementarities, and set up the basis for future joint transnational calls.
  - to identify and link together existing national bodies responsible for research policies and funding in the field.
  - to develop strategies to set up effective public funding schemes,
  - to mobilise new sources of funding, and
  - to coordinate existing and/or newly planned funding programmes at regional, national and European levels.
  - research, education and **training,**

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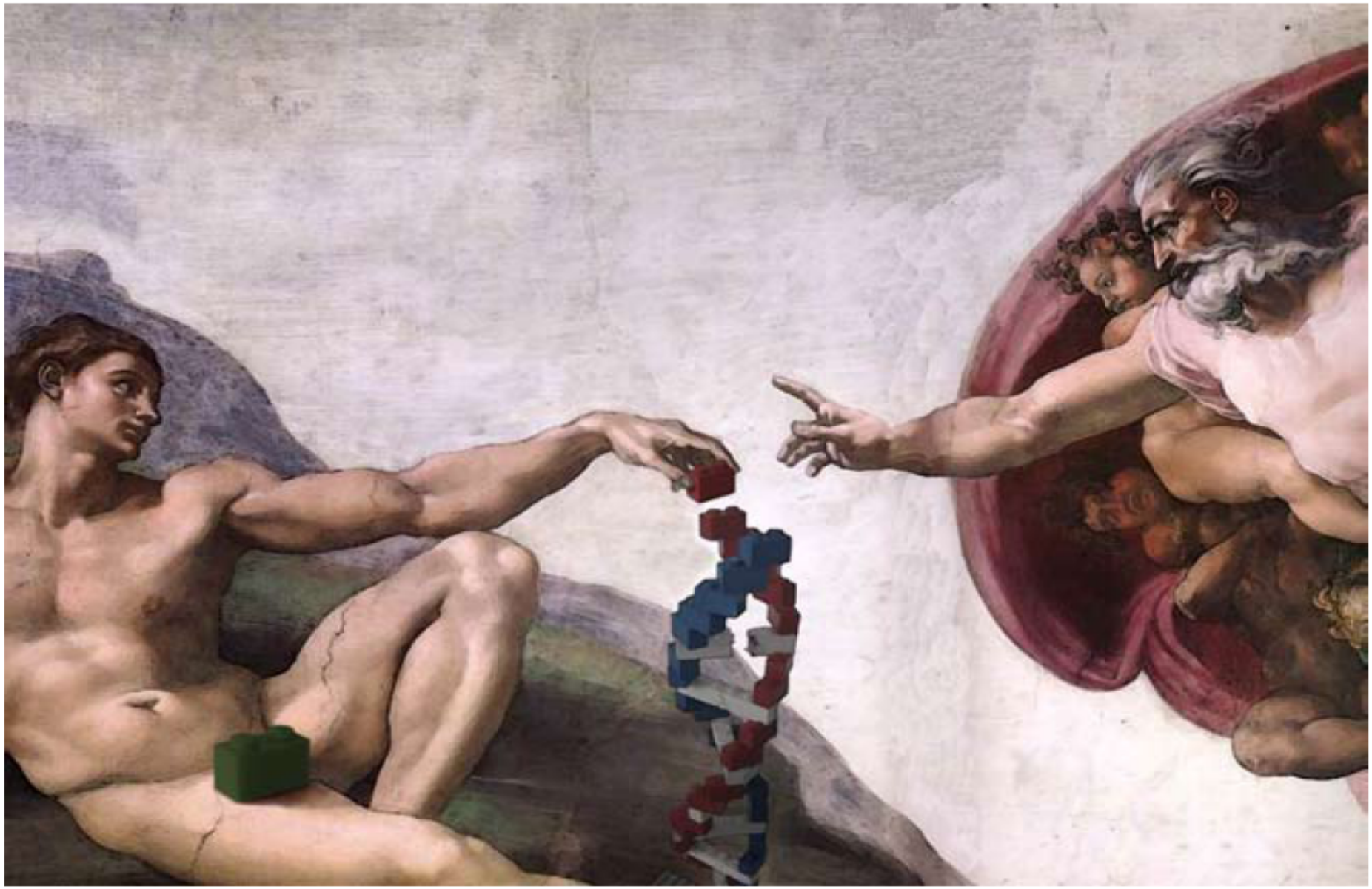

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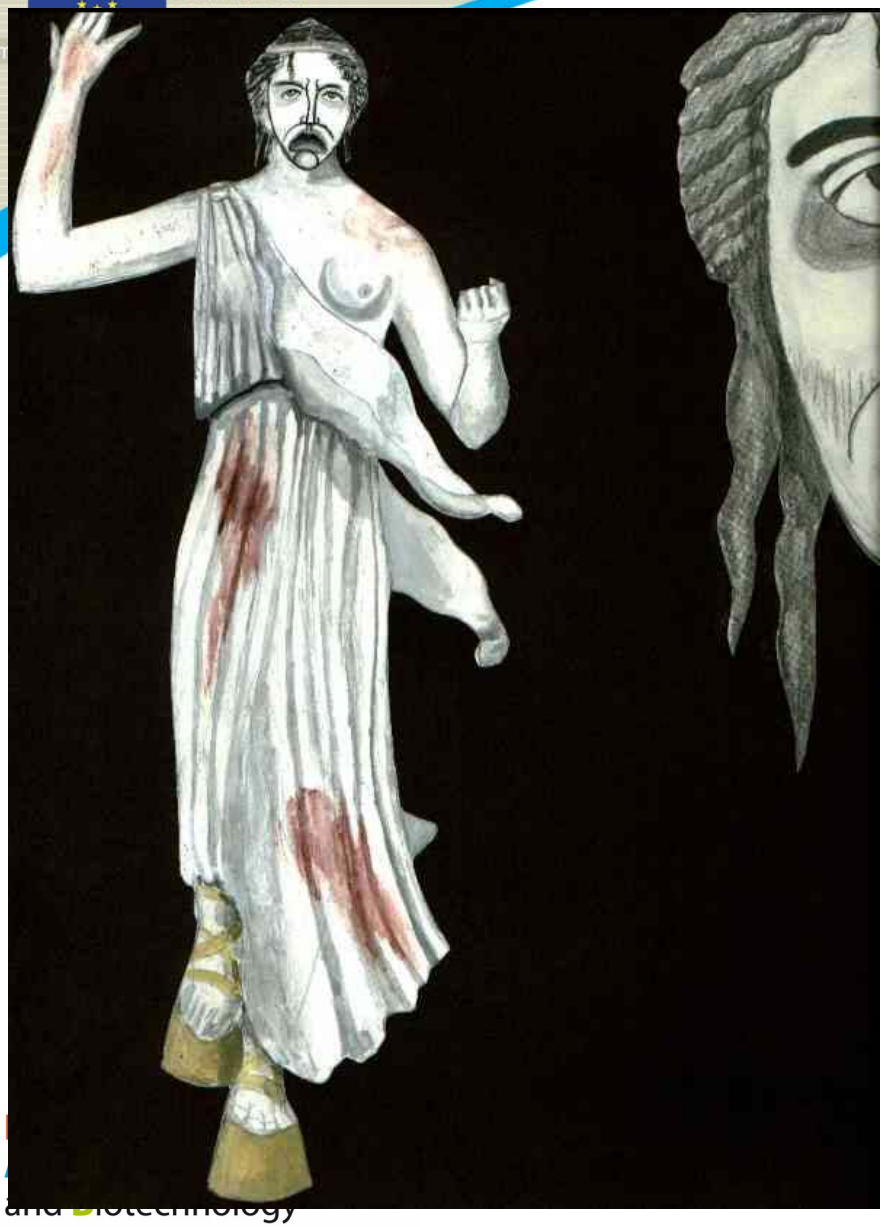

ΠΟΛΛΩ ΤΟ ΦΡΟΝΕΙΝ ΕΥΔΑΙΜΟΝΙΑΣ

(Wisdom is the foundation of happiness)

Σοφοκλέους, Αντιγόνη

(Sophocles' Antigone)

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