Social and Ethical Issues in Synthetic Biology

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"Engineering Life: The emerging field of synthetic biology"

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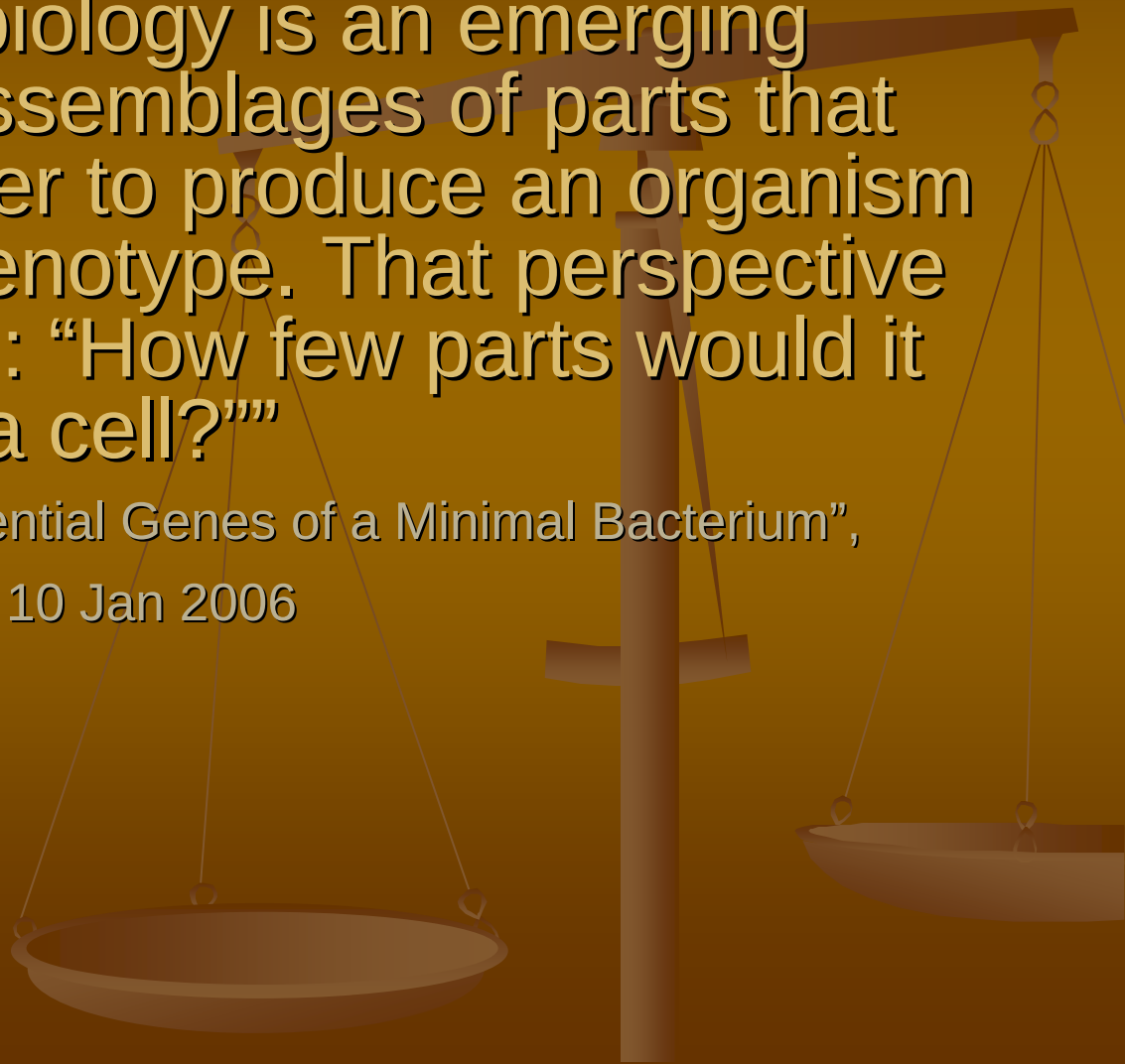
What *is* 'Synthetic Biology' ?

- Technical-scientific, but also a social-public question
- "Engineering *Life* " - new? or ancient ?
  - 'synthetic'...
- The hype problem... (not only here - but here...)
- In key respects, new – so, *which* respects ?
- "extreme genetic engineering" (ETC group) – rDNA continued/intensified? Or "a step-change"?
- *Writing new* DNA from scratch, not merely reading, mapping, manipulating '*existing*' DNA..
- The stem cells analogy (Lartigue et al., 2007)
- 'minimal functional' genome construction/transplant

“One consequence of progress in the new field of synthetic biology is an emerging view of cells as assemblages of parts that can be put together to produce an organism with a desired phenotype. That perspective begs the question: “How few parts would it take to construct a cell?””

J. Glass et al., “Essential Genes of a Minimal Bacterium”, *PNAS*, **103**, 10 Jan 2006



Is ethics and the social – ELSA - *society's* problem, thus not science's ?

- "Basic-Applied"? The Independent Republic of Science (Polanyi, 1962) has been decisively removed
- Science lives on imagination – and promise ("Can complexity be commercialised?" – Yes! … BUT!!)
- A *political economy of promise* now drives science
- How can we render exaggerated (& false) promises accountable? – Merton: "Organised Scepticism"...
  - Evidence ? (*evidence-based* science policy ?)
  - Resilience through critique and questioning the promises
  - Competition (eg race to patent) =X= critique and questioning
  - Scepticism/questioning =X= ignorant or dogmatic opposition
  - Is real *plurality* alive and well in synbio, or convergence science?

“We have long been interested in defining a minimal genome that is just sufficient for cellular life, and have advocated the approach of chemically synthesising a genome as a means for testing hypotheses concerning the minimal set of genes. The societal and ethical implications of this work have been explored” (Lartigue et al., *Science*, **317**, 2007)

This ethical-social analysis addressed only possible bio-weapons production, not questions, for example:

- about possible lack of control due to technological exploitation of immature scientific practice & knowledge;
- about failure of containment of diverse industrial-scale production systems (not controlled labs) for synthetic organisms whose environmental implications could be severe;
- about creating societal expectations of ‘big-tech’ fixes for eg climate change, which divert society from other initiatives.
- Inconsistencies in scenarios, between patent claims and peer-reviewed publications, have also been neglected.

Intellectual Property Rights Questions:

"Current patenting practices may already be restricting development of and access to clinical applications of genomics, as well as academic and industry researchers' access to genetic information and reagents. Large-scale gene identification efforts such as that involved in minimal genome research, as well as other technologies that require use of large numbers of genes simultaneously (eg gene arrays) have great potential to exacerbate these problems. A new regulatory framework for intellectual property pertaining to genes and organisms is needed to ensure that public and commercial interests are protected"

M.K.Cho et al., *Science,* vol. 286 (10 Dec 1999), pp.2087-2090

Synthetic genomes

Publication number: US2007264688
Publication date: 2007-11-15
Inventor: VENTER J C (US); SMITH HAMILTON O (US); HUTCHISON CLYDE A III (US)
Applicant:
Classification:
- international: ***C07H21/04; C12N5/06; C12P1/04;*** **C07H21/00; C12N5/06; C12P1/04;**
- European:
Application number: US20060635355 20061206
Priority number(s): US20060635355 20061206; US20050742542P 20051206

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Abstract of **US2007264688**

Methods are provided for constructing a synthetic genome, comprising generating and assembling nucleic acid cassettes comprising portions of the genome, wherein at least one of the nucleic acid cassettes is constructed from nucleic acid components that have been chemically synthesized, or from copies of the chemically synthesized nucleic acid components. In one embodiment, the entire synthetic genome is constructed from nucleic acid components that have been chemically synthesized, or from copies of the chemically synthesized nucleic acid components. Rational methods may be used to design the synthetic genome (e.g., to establish a minimal genome and/or to optimize the function of genes within a genome, such as by mutating or rearranging the order of the genes). Synthetic genomes of the invention may be introduced into vesicles (e.g., bacterial cells from which part or all of the resident genome has been removed, or synthetic vesicles) to generate synthetic cells. Synthetic genomes or synthetic cells may be used for a variety of purposes, including the generation of synthetic fuels, such as hydrogen or ethanol.

INSTALLATION OF GENOMES OR PARTIAL GENOMES INTO CELLS OR CELL-LIKE SYSTEMS

Publication number: WO2008016380
Publication date: 2008-02-07
Inventor: GLASS JOHN I (US); YOUNG LEI (US); LARTIGUE CAROLE (US); ASSAD-GARCIA NACYRA (US); SMITH HAMILTON O (US); HUTCHISON CLYDE (US); VENTER J CRAIG (US)
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Classification:
- international: ***C12N15/87; C12N5/06; C12P21/04;*** **C12N15/87; C12N5/06; C12P21/04;**
- European:
Application number: WO2006US49231 20061222
Priority number(s): US20050752965P 20051223

Also published as:
US2007269862 (A1)

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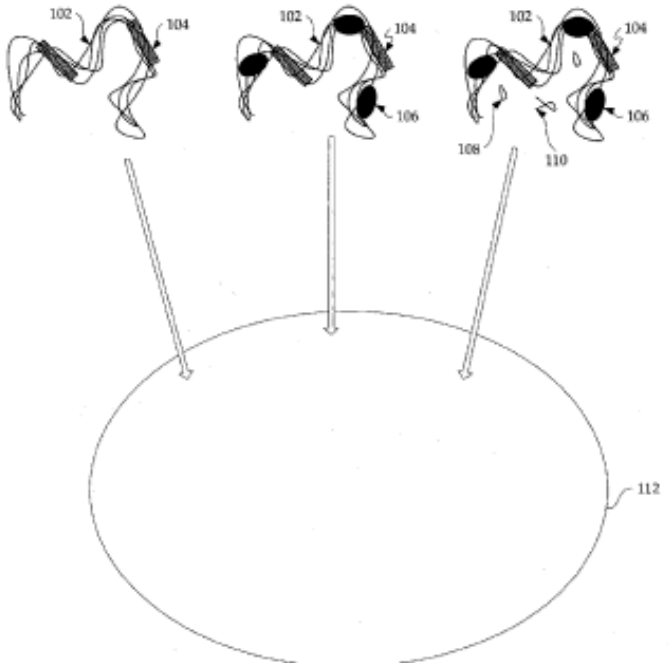
Abstract of **WO2008016380**

A method is provided for introducing a genome into a cell or cell-like system. The introduced genome may occur in nature, be manmade with or without automation, or may be a hybrid of naturally occurring and manmade materials. The genome is obtained outside of a cell with minimal damage. Materials such as a proteins, RNAs, polycations, nucleoid condensation proteins, or gene translation systems may accompany the genome. The genome is installed into a naturally occurring cell or into a manmade cell-like system. A cell-like system or synthetic cell resulting from the practice of the provided method may be designed and used to yield gene- expression products, such as desired proteins. By enabling the synthesis of cells or cell-like systems comprising a wide variety of genomes, accompanying materials and membrane types, the provided method makes possible a broader field of experimentation and bioengineering than has been available using prior art methods.



Imagined Technologies – containment or release?

"The [artificial] genome may be introduced into a cell or a cell-like system. Exemplary embodiments include introducing such a genome into a living plant, animal, fungal, yeast, mitochondrion, chloroplast, or other cell or organelle, whether in vivo, in culture, or in other circumstances, introducing a genome into a cell from which the natural genome has been removed, and/or introducing a genome into a membrane-bound volume derived by any method…Alternatively the genome containing an antibiotic resistance gene or other selectable marker can be introduced into a living plant, animal, fungal, yeast, mitochondrion, chloroplast, or other cell or organelle so that transiently the cell or organelle contains both the introduced genome and its own genome. Subsequent cell or organelle division then segregates the introduced genome into a new daughter cell or organelle. That cell or organelle then takes on the phenotype programmed by its introduced genome"

US Patent Application (22 Nov) 2007/0269862, J.Glass et al, "Installation of Genomes into Cells or Cell-like Systems" (filed 22 Dec 2006)

Synbio Security – government or self-regulation ?

"Existing laws in the US as well as most other countries do not require companies to screen DNA orders, let alone turn down suspicious requests or report them to any government or body such as the UN… If the government were to get tough in this area, "it could drive business overseas", says David Relman (Head of US National Science Advisory Board for Biosecurity's synthetic biology group" (*Science*, **316**, 22.6.07)

"I think it would take a significant change in the culture of science and business to support broad-scale surveillance of DNA sequences that people work on. I think it would be a difficult change to make" (John Mulligan, Blue Heron Corp., June 2007)

Function Questions: unpredicted consequences?

"There could be two explanations for why new feedback loops have almost no effect on protein levels. For one, the dynamics of large-scale transcriptionally regulated genetic networks is probably more complicated than thought. In other words, analysing large networks by decomposing them into simpler sub-networks, as Isalan *et al* have done, may lead to faulty conclusions about how the subsystems work within the whole. Alternatively, it may be that transcriptional regulation is less important than expected. Perhaps post-transcriptional regulatory mechanisms that affect mRNA translation regulate the network to a larger extent"

M. Bennett and J. Hasty, *Nature,* **452,** 17 April 2008, 824-5