



Biodesic

hardware :: wetware :: mindware

Building the Bio-economy

The Synthetic Biology Pathway to Innovation in Fuels and Chemicals

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A Hierarchy of Engineering and Economic Complexities



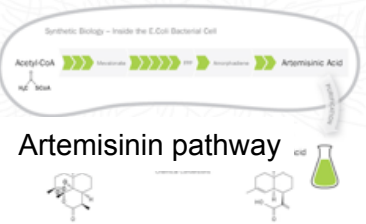
Claudia Cadillo
Transplant Recipient

Multiple Cells: Control of growth and differentiation; products are cells and structures that cells make (Tissues, Organs, Animals, Houses).



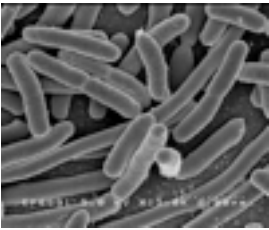
J.C. Venter

Synthetic Single Cells: Looks initially like Metabolic Engineering; products are chemicals and biologicals made by cells.



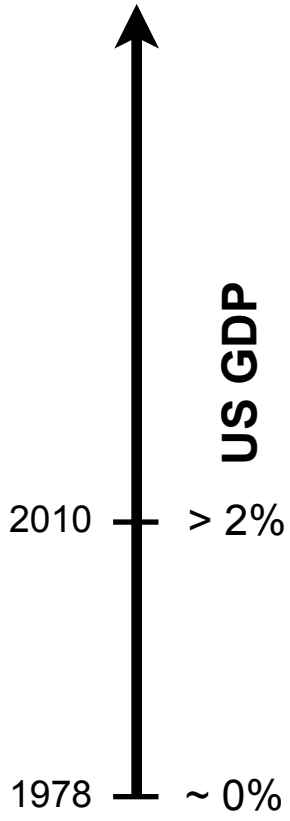
Artemisinin pathway

Multiple Genes in a Single Cell Type: Metabolic Engineering: Fuels, Plastics, Terpenoids for Drugs, Flavors, and Fragrances. **RFS.**



Expression in *E. coli*

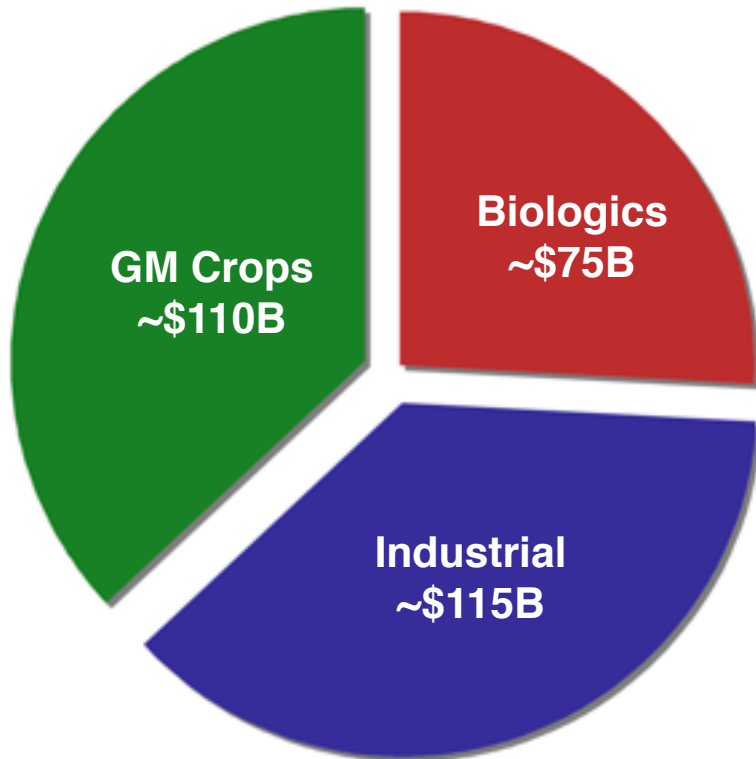
Single Gene in a Single Cell: Recombinant Proteins: Laundry Enzymes, HGH, EPO.





“Genetically Modified Stuff” in the US Bioeconomy (2010 est.): >\$300B or Equivalent of >2% of GDP

U.S. Biotech Revenues (billions)



R. Carlson, “Biodesic 2011 Bioeconomy Update”
www.biodesic.com

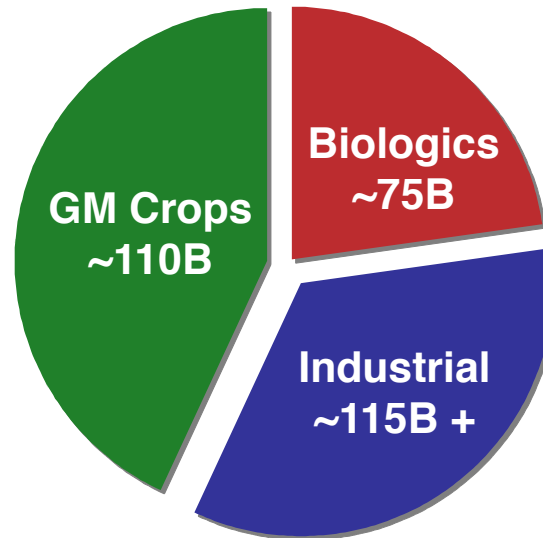
BEA (2007) value added to GDP: mining 2%, construction 4.1%, information and broadcasting 4.7%, all of manufacturing 11.7%, transportation and warehousing 2.9%, finance 20.7%, and all of government 12.6%.



Scale and Regulation

U.S. Biotech Revenues in \$ Billions

Medium regulation
Long lead times to market
~\$100s millions



Highly regulated
Long lead times to market
~\$1 billion

Market includes engineering tools
Operate closer to consumer
Could be much smaller, lower capital reqs.
As low as ~\$10K-100K?

non-drug + non-food = not-so-regulated

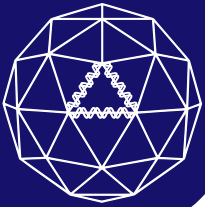


Economically Driven Global Adoption: Biotech Revenues as % of GDP

Country	2010 Biotech Revenues	2020 Target Biotech Revenues
United States	> 2%	NA
China	2.5% (?)	8%
Malaysia	2.5%	10%
India	0.24%	NA
Pakistan	1.4%	NA
Europe	~1%	NA

Source: Biodesic

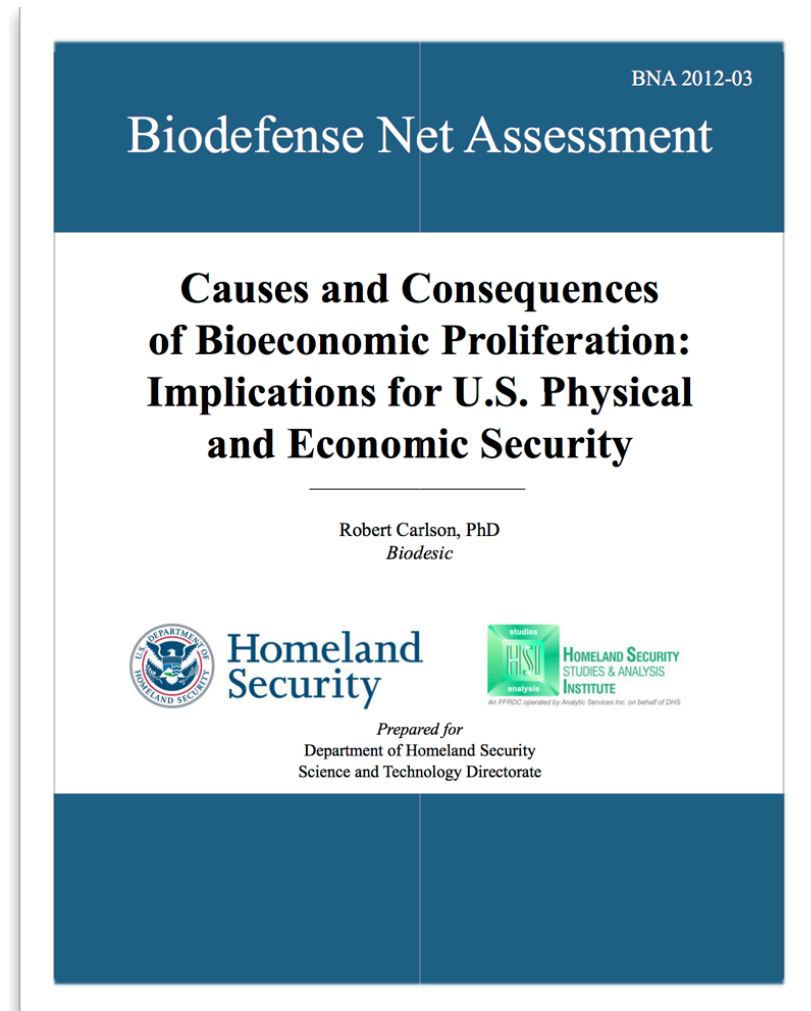
Main source of uncertainty is definition of “biotechnology”; i.e., all biology or only products of genetic modification.



2012 Biodefense Net Assessment: Causes and Consequences of Bioeconomic Proliferation

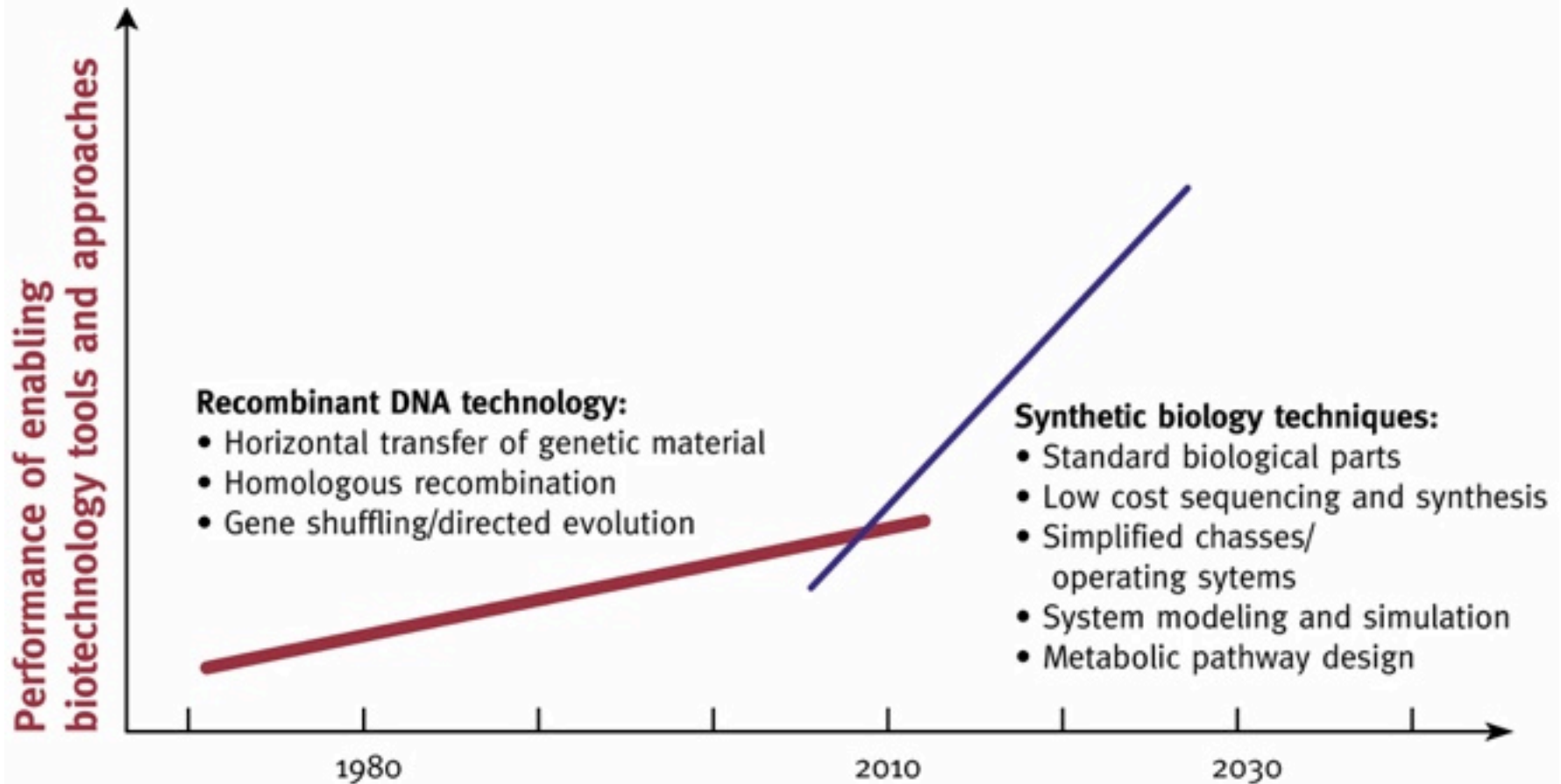
Executive Summary:

1. Global investment is growing rapidly, but:
2. It's complicated.
3. DATA DATA DATA!



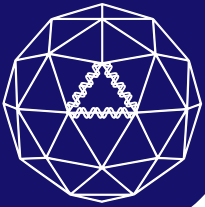


An Inflection Point in Biotech Capabilities?

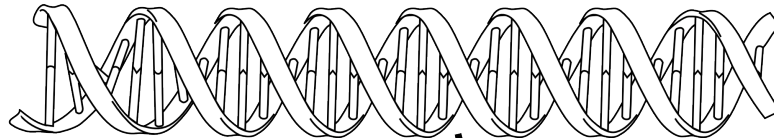


“Genome Synthesis and Design Futures: Implications for the U.S. Economy”

Bio Economic Research Associates, 2007. www.bio-era.net



Oligo Synthesis and Gene Assembly



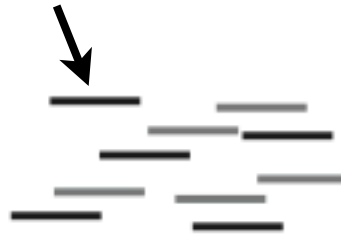
double stranded DNA

A T G C T C T A A A G

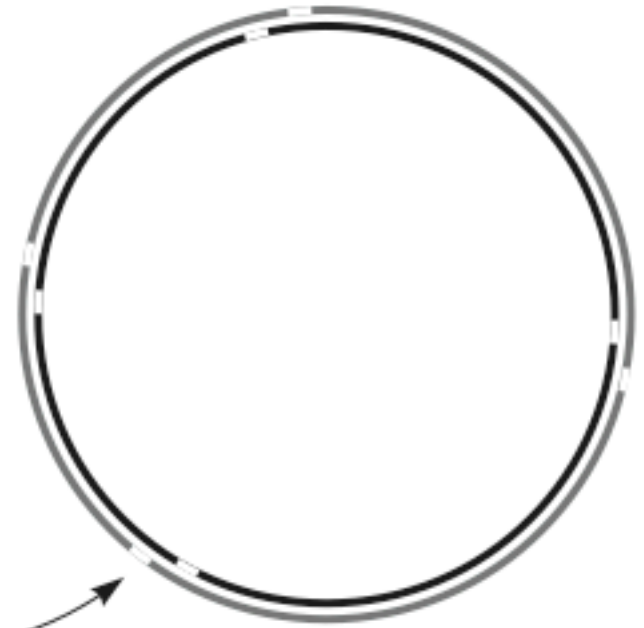


single stranded DNA

Oligos



Double-Stranded DNA

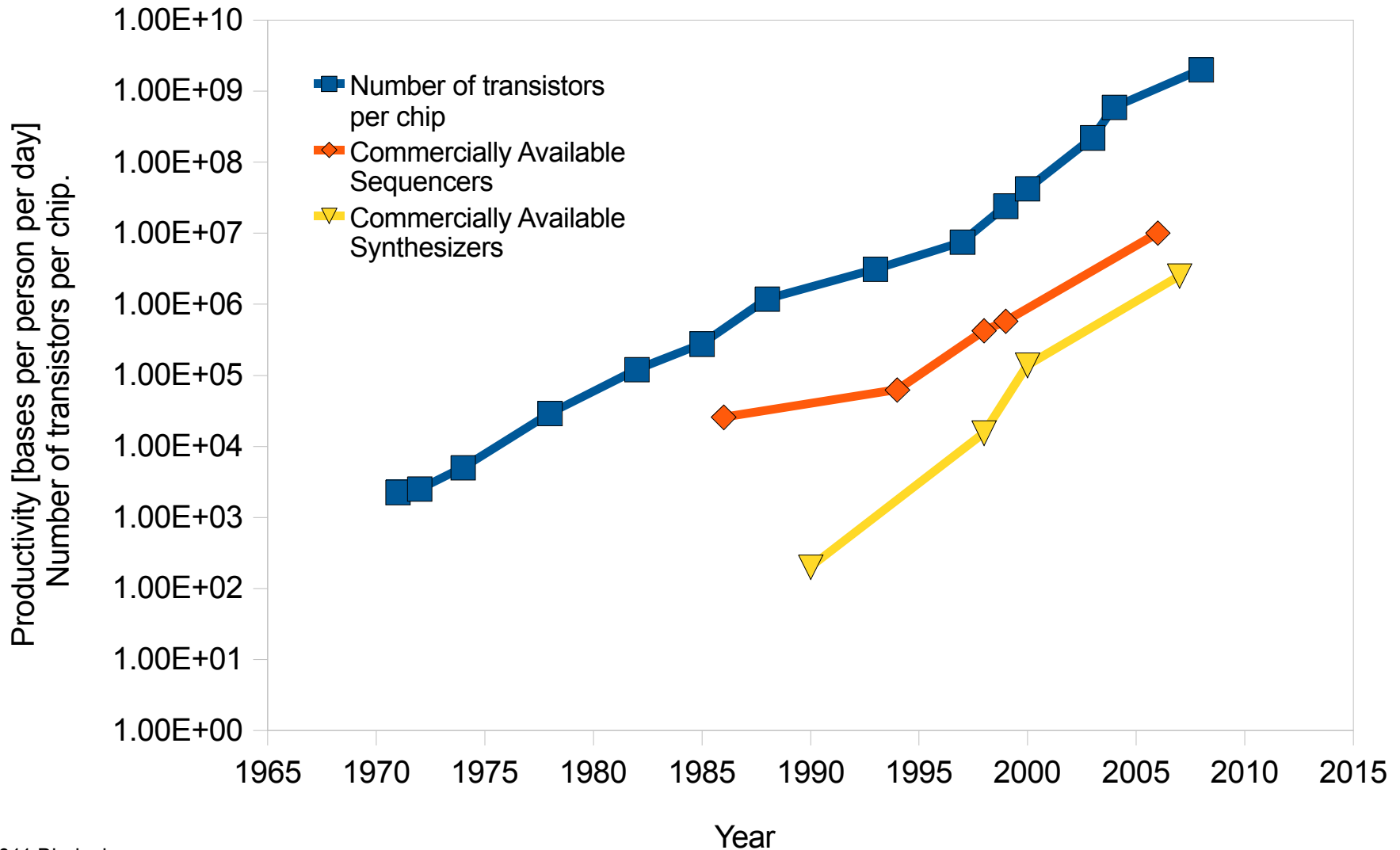


Plasmids and Chromosomes

Enabling Technologies Are Improving Rapidly

Productivity in DNA Synthesis and Sequencing

Updated Spring 2008





Cost Per Base of DNA Sequencing and Synthesis

Rob Carlson, June 2011, www.synthesis.cc

