Technology Roadmaps from the ERASynBio 1st Strategic Conference

Important underpinning technologies for synthetic biology

Current (2013)	Short term (2014-2018)	Medium (2019-2025)	Long term (2025+)
Systems engineering	Metrology metrics	Synthetic biosis	Safe by design technology
Bioinformatics for systems engineering	3D, parallelization and miniaturization of experiments	Synthesis of non-DNA based life	Synthesis of non-DNA based life
Well controlled bioreactors	Automation	Re-scale up	Digital organisms
Well defined chassis organisms	Web based Information Systems		
Sequencing	In-vivo assembly		
DNA synthesis	Professional registries		
Quantitative characterization	Good model repositories		
Heterogeneity & noise / single cell analysis	Design tools predictive		
Better Systems Biology definition of parts	Common standards with Systems biology		
Well defined Systems Biology chassis	Capacity to handle? Circuits: Systems Biology		

Basic science opportunities for synthetic biology

	Current (2013)	Short term (2014-2018)	Medium (2019-2025)	Long term (2025+)
Metabolic engineering: Performing complex modifications, using predictive models, of biosynthetic pathways to allow/enhance production of useful products	Elimination of complexity Chassis & Circuits Automation (spans Current and Short term) Model driven design Enter design cycle	Lignocellulose treatment Bioplastics Reduction in prices Robust chassis and improved processes Enter design cycle	Biosensors Therapeutic agents Marine platforms More pathways More predicable Metagenomics platforms	Plants Smart catalysts Alternative biochemistries Expansion of diversity
Minimal genomes: Understanding the minimal number of parts (genes) needed for life, to serve as a chassis for engineering minimal cell factories for new functions		Improve cell factories Organelle genomes Should be compatible with orthogonal systems Helps feasibility of Bio bricks	Quick synthesis - Mycoplasma & other Intracellular lifestyle Simple reduced risk systems Minimal genomes as using vaccines	Organelles Complete computer replicas of minimal organisms
Regulatory circuits: Designing and inserting well-characterised, modular, artificial networks to provide new functions in cells and organisms	Underpins many other areas of synthetic biology	Simplify endogenous networks Re-engineer desirable behaviour	Self steering fermentation Hijacking quorum sensing systems	Self steering fermentation Swarm intelligent cellular systems/agents
Orthogonal biosystems: Engineering cells to include systems or parts not found in nature to impart new capacities or chemistry	Novel amino acid incorporation, genetic code (spans Current and Short term) Coding activity of DNA XNA's	Genetic circuits independent from cellular processes XNA, enlarged genetic alphabet (bases), polymers	A registry of orthogonal parts Quality control for biopart Contained use / release into the environment	Semi orthogonal life forms, new functions, not interacting with nature

Basic science opportunities for synthetic biology

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Protocells: Bottom-up chemical design approaches to produce (semi-) synthetic cells and compartments	Investigations into the origins of life	Minimal cells and compartments Bottom-up protocells Hybrid integrated ICT-BIO systems for production of materials (sophisticated)	Living functionalized BIO-ICT machines e.g. microfluidics or nanopore	Hybrid life forms ICT-BIO based
Bionanoscience: Utilising and exploiting synthetic molecular (nano) machines based on cellular systems	Nano patterning (DNA Origami) Drug display	Modular scalable protein genetic regulators Biosensing - APP, Protocells Molecular motors that communicate with biotic and abiotic systems Ways to communicate between systems over larger distances	Ways to communicate between systems over larger distances Self replicating nano machines Biomimetic mineralization Robots - sensor and effector, in vivo therapy	Designed catalytic functions Responsive biomaterials (for drug delivery and therapy) Personal fabricators where top-down manufacturing is integrated with (self-assembling) bottom-up synthesis
Peptide / protein / DNA / RNA / XNA engineering	Ways to communicate between systems over larger distances Self replicating nano machines	Non-canonical amino acids XNA R&D get off the ground. From proof of principle to engineering XNA computing XNA R&D get off the ground. From proof of principle to engineering	Fine tuned synthetic metabolic pathways Integrated information processing and material production systems Intrinsic safety systems based on XNA - genetic firewall building protein complexes from standard parts	Electronics - genetic guided Complex synthetic pathways such as novel orthogonal secretion mechanisms Second life based on orthogonal biochemistry and genetic code xenobiology

Applied / industrial science opportunities for synthetic biology

	Current (2013)	Short term (2014-2018)	Medium (2019-2025)	Long term (2025+)
Synthetic biology for medicine	Prototype therapeutic gene circuits (in vitro, mouse) Bio-therapeutic bioprocessing proteins Public health interventions - mosquito control, clean water e.g. arsenic sensor Production of bioactive molecules - artemesinin	Systems engineering Drug discovery Cell based therapies Immunotherapies Antibiotic development Intermediates for pharma Personalized medicine Biosensors for diagnostics	Plants as production systems for complex medicines Bioengineering of stem cells Architectures for drug delivery Integrated diagnostics and therapeutics	Architectures for drug delivery Applications for gene therapy Development of tissue and organ biogenesis
Synthetic biology for Industrial biotechnology & bioenergy	Bioenergy - oil price, carbon benefit, carbon neutral	High value products Route to bioenergy	New bioactives and new chemistry for new applications Polymers and biomaterials Waste to useful products Sustainable bulk chemical production (reduced inputs) New food / feeds e.g. protein	Personalized chemical production Smart materials Personalized food hybrid energy transfer - physics to biology
Synthetic biology in environmental & agricultural research	Sensors, drug delivery e.g. Frussenegger's LH-sperm Biofuels and non-food products Pest control	Smart food storage Diagnostics and biosensors Pest control Bio-agro chemical production	Addressing toxins and contaminants Food and Biomass yield Bioremiation Synthetic food Bio-agro chemical production Abiotic and biotic stress resistance in crop plants	Engineering animals Aquaculture Designer crops, nitrogen fixation, climate change Artificial food Engineering of seed structure, size and quality
Synthetic Biology for novel research tools	Tools to analyse / manipulate molecules, assembles, cells, tissues, organs Genome engineering e.g. Zinc fingers, TALENs Protein engineering Engineering cells	Model organisms (tools to study disease - cancer etc) Ex vivo tissues for - drug screening, cell biology, systems biology Cell free systems and reporter systems	Protein coupled engineering - molecular machines, communicating, molecular machines network molecular machines	Artificial / synthetic cells Cellular synthetic reactors