

FP7-ICT-2013-10
Evolving Living Technologies

Evolution of Evolution

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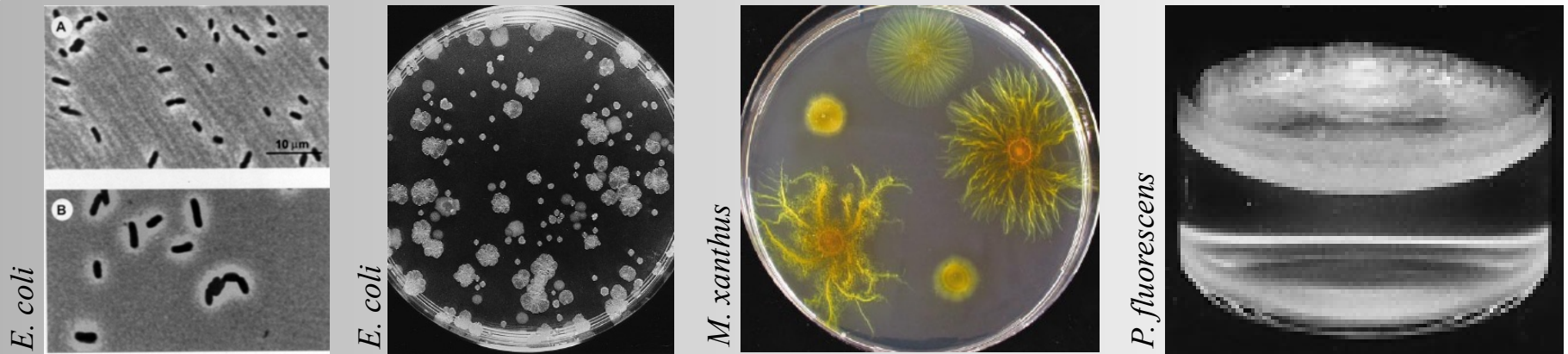
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EvoEvo: The key concepts

- Microorganisms are adapted to evolve
 - Evolution has optimized their ability to evolve as a primary mean to react to environmental changes



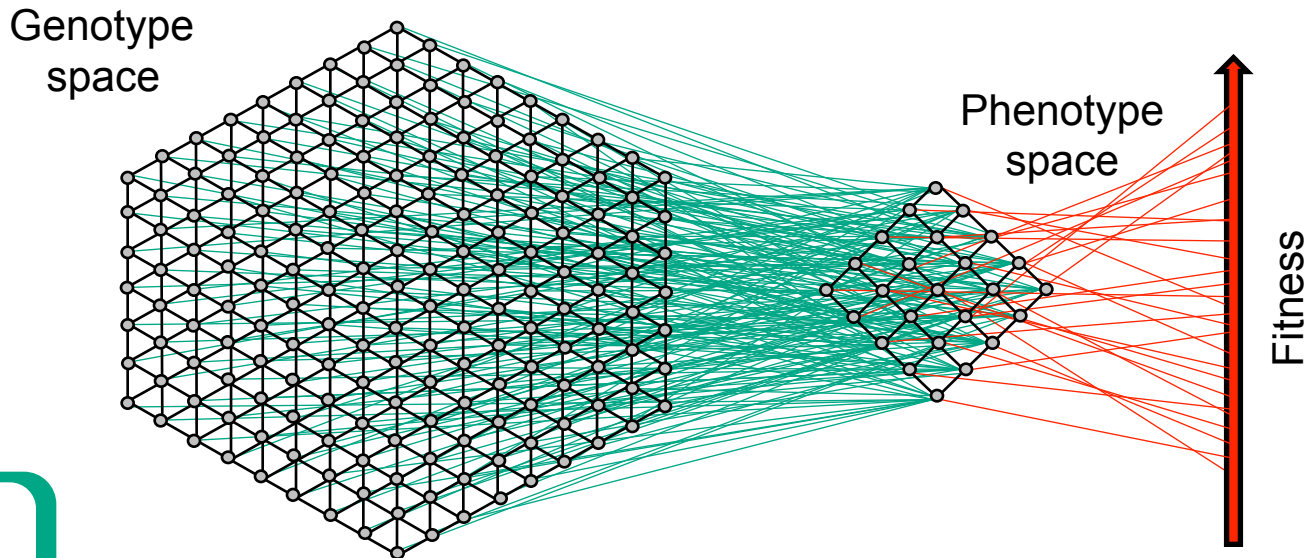
Examples from microbial experimental evolution (experiments from Rich E. Lenski, Greg J. Velicer and Paul B. Reyney; for a review see Hindré *et al.*, 2012)

→ Can we provide *evolutionary* technologies with the same property so as to create *living* technologies?



EvoEvo: The key concepts

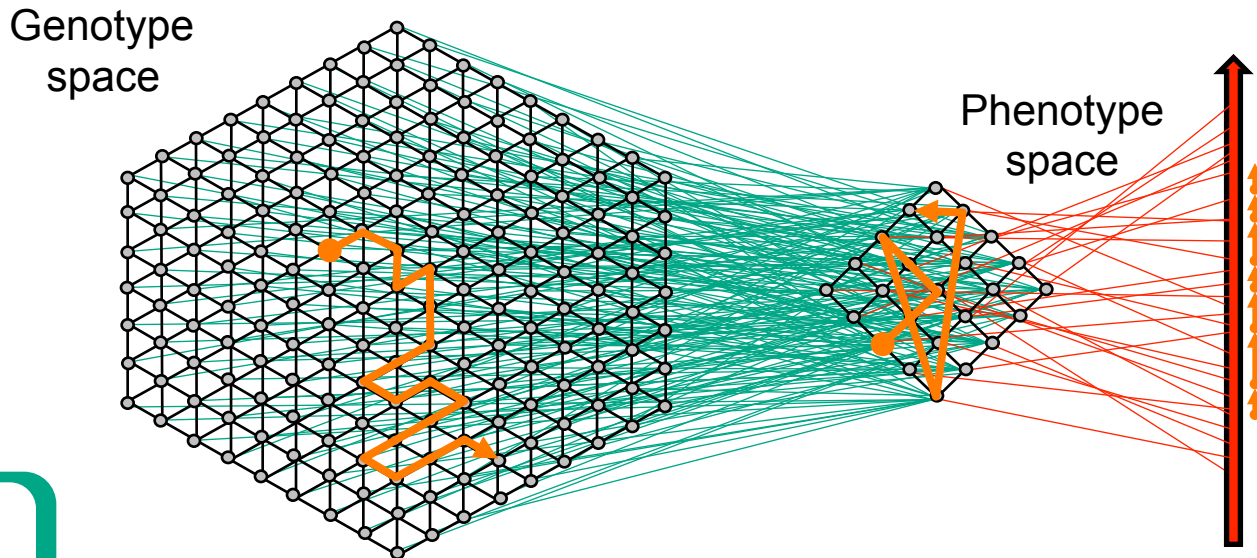
- Microorganisms are adapted to evolve
 - Evolution has optimized their ability to evolve as a primary mean to react to environmental changes
 - This optimisation process is the Evolution of Evolution
 - It is based on the evolution of the genotype-to-phenotype mapping and of the fitness landscape



(Figure from Stadler & Stephens, 2003)

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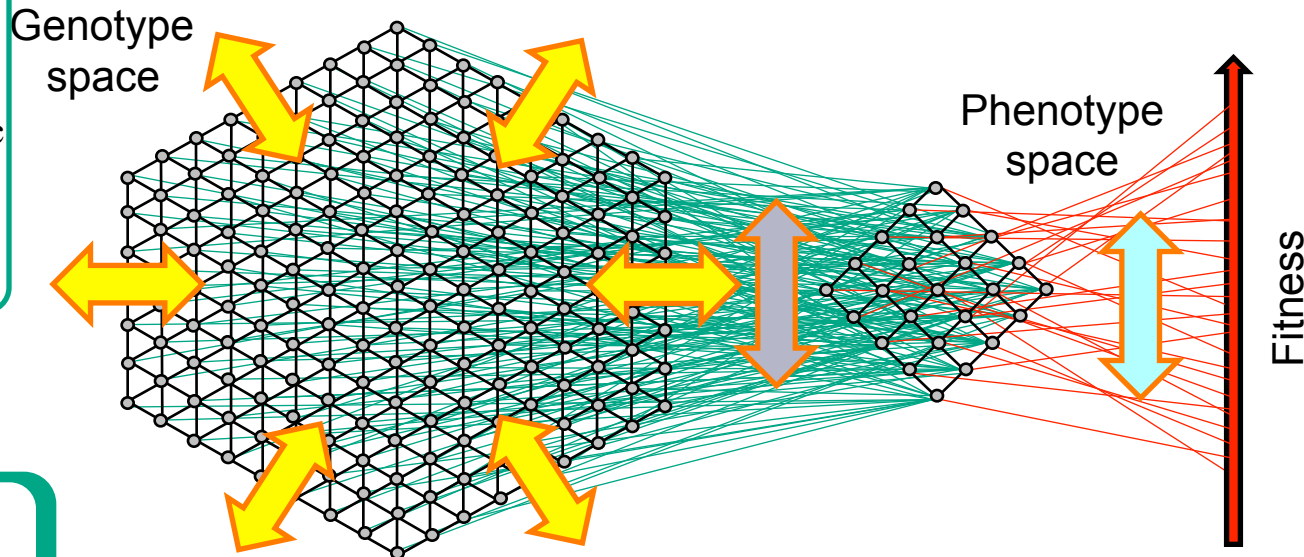
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EvoEvo Levels

- ☐ Genome & Mutations
- ☐ Gene/metabolic Networks
- ☐ Ecosystem & Resources



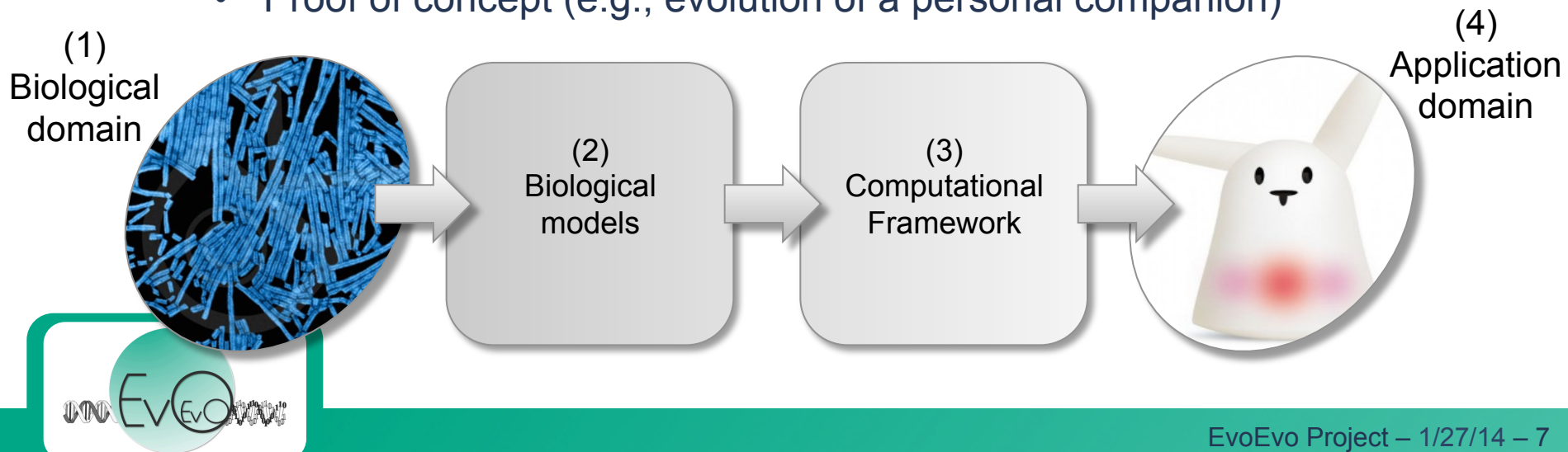
EvoEvo: The key concepts

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 - This optimisation process is the Evolution of Evolution
 - It is based on the evolution of the genotype-to-phenotype mapping and of the fitness landscape
- *EvoEvo will study how organism's genetic, regulatory, metabolic and social structure can be indirectly selected and the resulting effect of the evolutionary pace.*
- *EvoEvo will then exploit the results to create new living technologies that will be based on this knowledge*



Scientific and Technological Objectives

1. Observe, quantify and characterize EvoEvo (microbiology)
 - Biological domain: Bacteria (*Escherichia coli*) and viruses (*Tobacco ETCH virus*)
2. Simulate EvoEvo (computational biology)
 - Unravel the structural roots of EvoEvo
3. Design a platform to exploit EvoEvo (computational evolution)
 - Transfer the knowledge to the ICT world
4. Apply EvoEvo to real ICT problems (application)
 - Proof of concept (e.g., evolution of a personal companion)



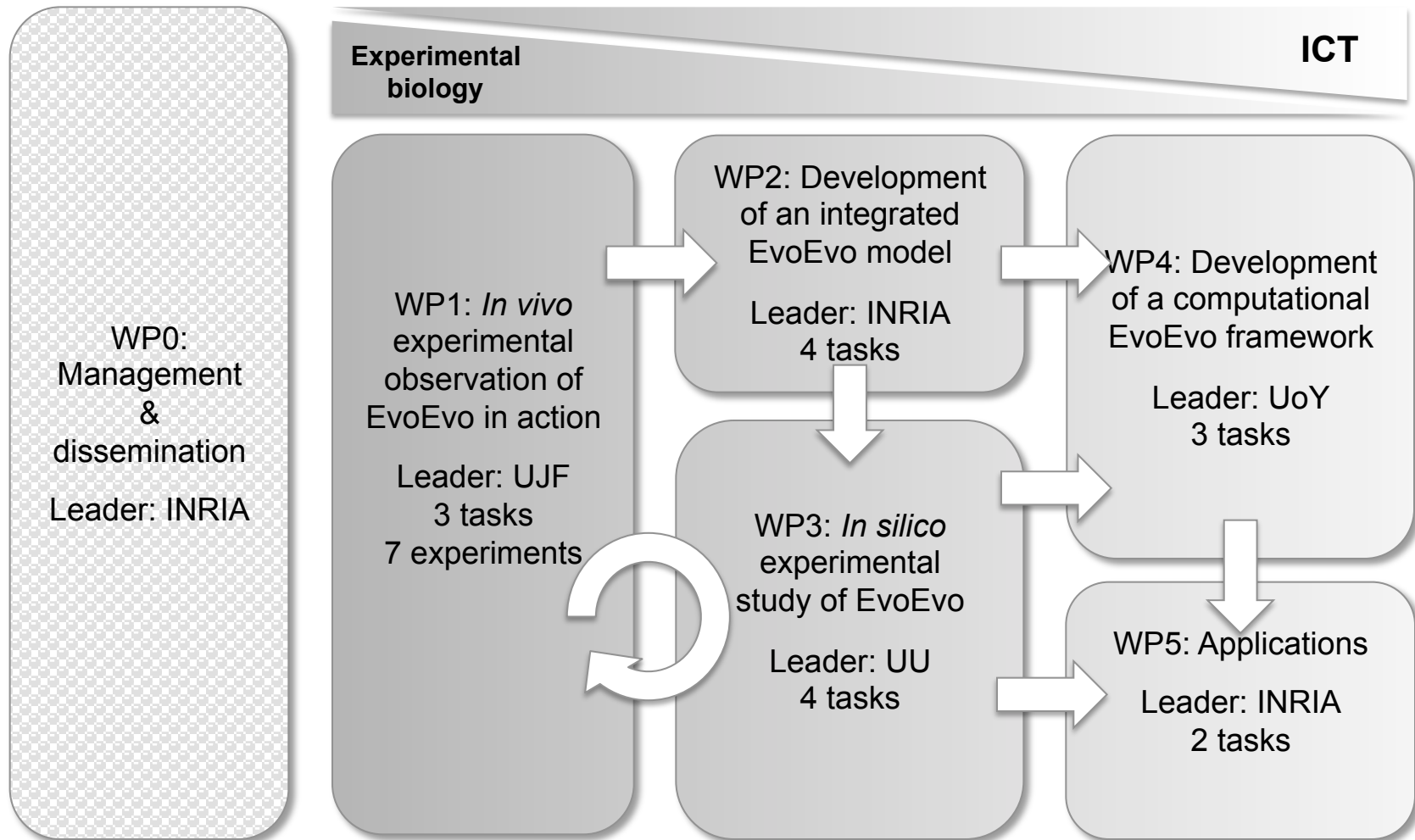
Approach: 4 properties, 3 systems of interest

Properties of the genotype-phenotype mapping

	<i>In vivo</i> experimental evolution	Computational evolutionary models	Computational applications
<u>Variability</u> Ability to generate new phenotypes	Indirect selection of mutation operators, including chromosomal rearrangements	Evolution of mutation operators, rates and phenotypic variability	Discover new solutions through efficient exploration of the functional space
<u>Robustness</u> Ability to mutate without losing fitness	Evolution of regulatory networks and DNA repair pathways	Indirect selection of robust genotype-phenotype mapping	The service is not perturbed by mutational events
<u>Evolvability</u> Ability to increase the proportion of favorable events	Dynamics of regulation networks (mutation and compensatory mutation)	Evolvability of genomic structures and regulation networks	Increase the system ability to adapt to new users or conditions
<u>Open-endedness</u> Ability to generate new challenges while evolving	Exploration of new niches, diversification and polymorphism	Evolution of new species in an artificial ecosystem; resources cycling	Emergence of new functions/species in the digital ecosystem
	Two model organisms: <i>E. coli</i> , Tobacco ETCH virus	Two formalisms: “aevol”, “pearls on a string”	On-line classification, Evolvable companion

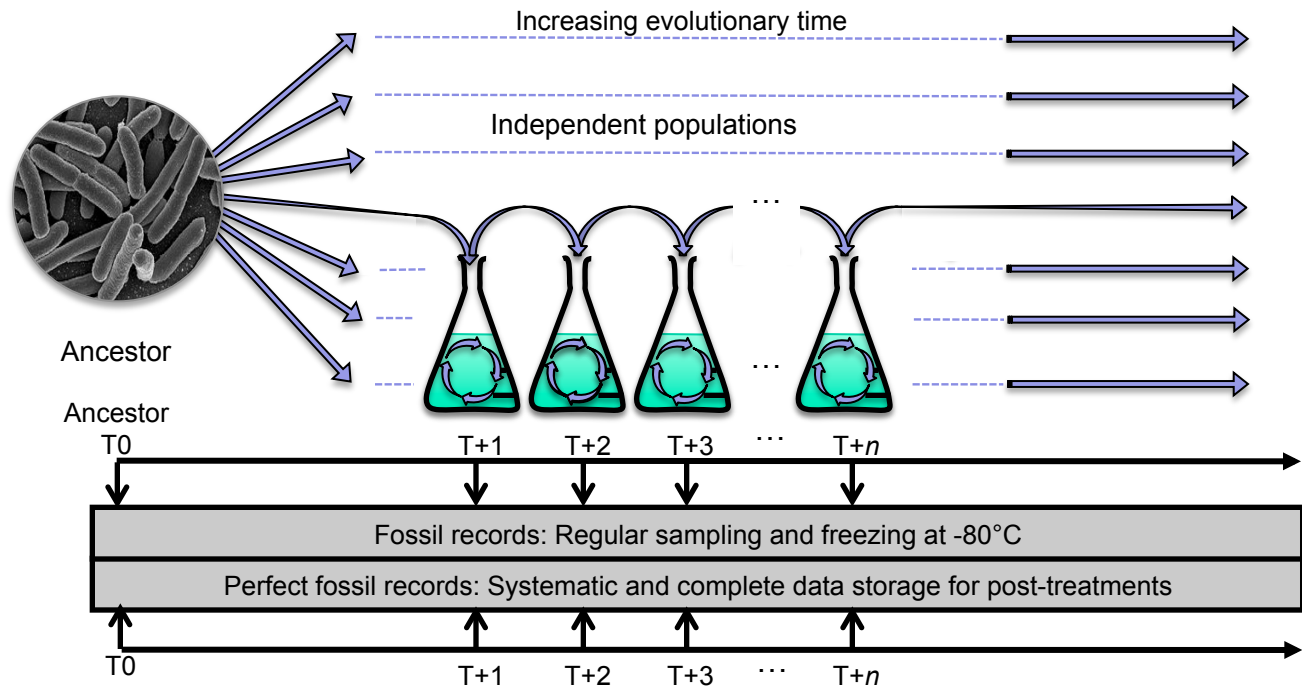


Organization of the workplan

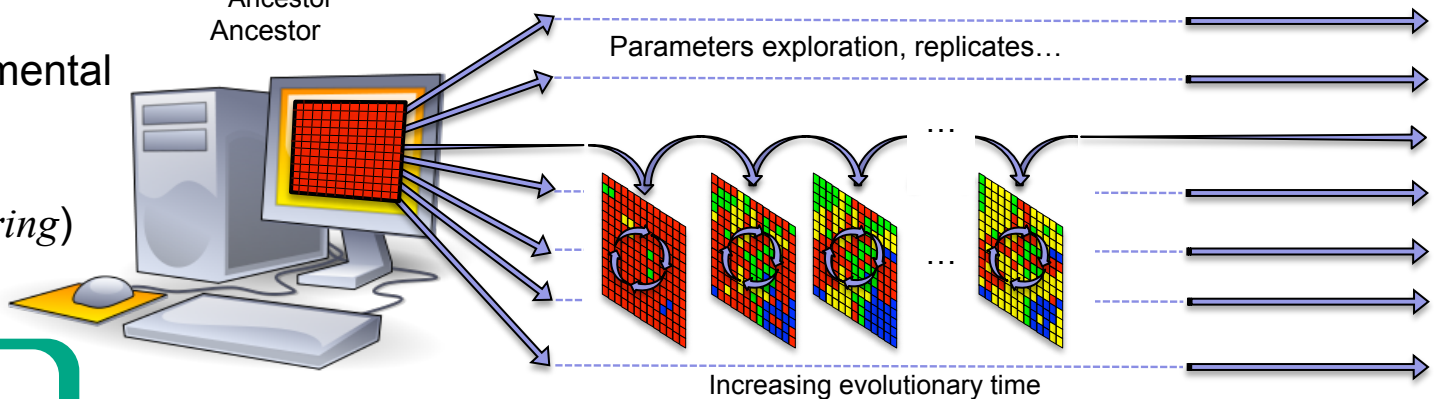


Experimental approach (WP1-3)

WP1
In vivo experimental
evolution
(*Escherichia coli*,
Tobacco ETCH virus)



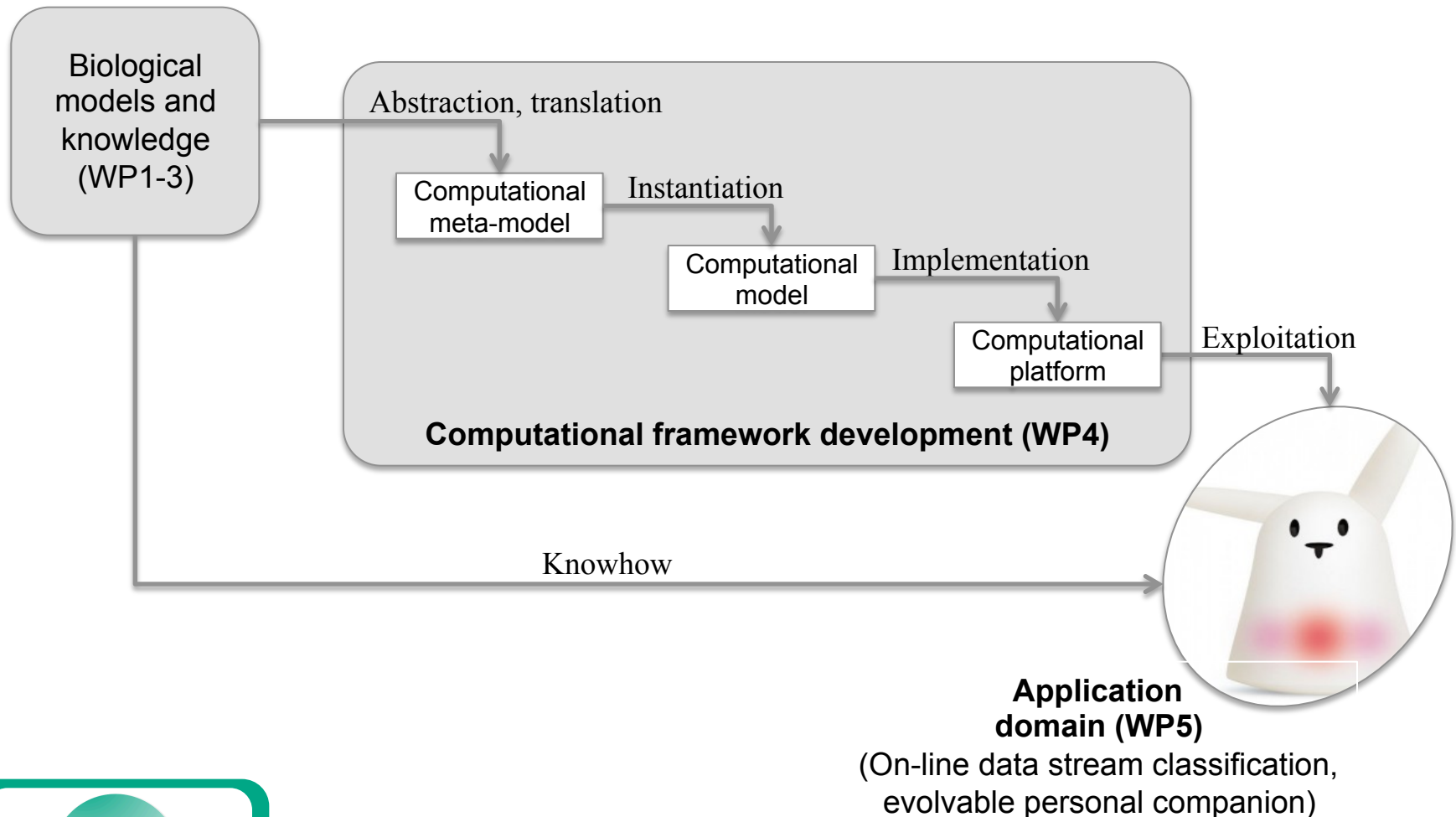
WP2-3
In silico experimental
evolution
(*aeol*,
pearls on a string)



(Figure from Hindré et al., 2012)



Development approach (WP4-5)



(From Andrews et al., 2011)

Expected impact

Impact in life science

An integrated framework for the understanding of the evolution of organism structure and function

- Clarify/disseminate the EvoEvo concept(s),
- Propose new tools to study evolution (computational evolution)
- Understand the origin of the amazing rapid evolution of microorganisms
- *Toward an integrated approach of evolution*

Impact on ICT

A realistic route towards evolving software and living technologies

- Create evolving technologies able to adapt dynamically to their environment,
- Create evolving systems able to grow in complexity and evolving capacities (let living technologies emerge and evolve),
- *Create co-evolving technologies that find their own niche in human interactions.*

Social impact

- **Impact on public health:** a better understanding of the evolution of pathogens, of nosocomial and emergent diseases, of antibiotic resistance...
- **Impact on social usage of ICT:** Co-evolving technologies will create new ways of programming and using information systems. Reduced constraints when using information systems



Partnership

- EvoEvo is an Information and Communication Technologies initiative funded by the European Commission under FP7.
 - FET-proactive FP7-ICT-2013-10 call: Evolving Living Technologies
- Partners:
 - G. Beslon, INRIA, Beagle, FR
 - S. Elena, CSIC, Valencia, SP
 - P. Hogeweg, Univ. Utrecht, NL
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 - S. Stepney, Univ. of York, UK
- Contact:
 - <http://www.evoevo.eu>

