europass Curriculum vitae

PERSONAL INFORMATION Maria Cristina Cannarsa

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contact mariacristina.cannarsa@uniroma1.it

WORK EXPERIENCE

Present

Research grant

Department of Physics of Sapienza University of Rome
Square Aldo Moro 5, 00141, Rome (RM), Italy

Research project "Light computing with synthetic genetic programs in living cells". Principal Investigator: Roberto Di Leonardo. Disciplinary sector: FIS/03.

Research grant

Department of Physics of Sapienza University of Rome
Square Aldo Moro 5, 00141, Rome (RM), Italy

Research project "Optical control of growth and form in colonies of engineered microorganisms". Principal Investigator: Roberto Di Leonardo. Disciplinary sector: FIS/03.

GRANTS AND AWARDS

Progetti per Avvio alla Ricerca - Tipo 1

From Sapienza University of Rome.

Best poster prize

From Swiss-UK Synthetic Biology Conference.

EDUCATION AND TRAINING

PhD in Genetics and Molecular Biology
Thesis Title: “Optogenetics in bacteria: engineering optical control in synthetic genetic oscillators”

Sapienza University of Rome, Italy
Final grade: summa cum laude.

Thesis abstract:
Light is emerging as a powerful tool to investigate and control natural and synthetic cellular processes. In this thesis, we modeled, developed, and characterized a synthetic genetic oscillator controllable through light inputs. We started from the repressilator, a synthetic oscillatory circuit that was a milestone in the field of synthetic biology, and a light-driven gene expression system, CcaS-CcaR.
We designed a mathematical model to represent our ideal outcome circuit and then refined the model according to the emerging experimental data. To build the circuit, we faced the problem of correctly interfacing two genetic systems and solved it through genetic engineering. While doing this, we paid attention to the use of modular and non-case-specific engineering steps in order to develop a possible guideline for adding an optogenetic module to a pre-existing circuit. The result is the optorepressilator.
To analyze the circuit's behavior, we combined population and single-cell experiments with computational simulations. We demonstrated that a population of optorepressilators can be synchronized and entrained using light. We analyzed the single-cell output to light inputs, examining the phase response of the system. We characterized the response to detuning inputs, highlighting how entrainment influences the system's frequency and creates different synchronization states. This analysis highlighted our model's performance in interpreting and predicting experimental data, recapitulating several physics phenomenologies.
These results deepened our knowledge of the behavior of genetic oscillators, with similarities to the human circadian clock. We showed optogenetics' versatility in controlling a genetic network and how theory and experiments can interplay in this effort. Furthermore, we enriched synthetic biology's toolbox with a light-driven oscillatory circuit and its theoretical framework.
Finally, we show how light can be applied to other cellular processes, such as the investigation of flagellar bundling dynamics.

Master's Degree in Genetics and Molecular Biology (LM-6)
Thesis Title: "Single-cell optical control of gene expression in *Escherichia coli*"

Sapienza University of Rome, Italy
Final grade: 110/110 cum laude.

Thesis abstract:
This thesis studies the regulation of prokaryotic gene expression using light-sensitive two component signalling systems. These systems are the mechanism commonly used by bacteria to couple the presence of a certain stimuli to the appropriate intracellular response, and they have been engineered to respond to a great variety of stimuli, including luminous inputs. The output of such engineered systems has been characterized and optimized extensively using reporter genes, but using them to regulate effector proteins requires a further tuning of their behavior. In particular, the Cph8-OmpR system couples presence of 650 nm red light with repression of transcription from a specific promoter. The aim of this thesis was to study with single-cell resolution the regulation of gene expression operated by Cph8-OmpR, and to use it to regulate cellular growth rate through expression of the enzyme MetE. The experimental work carried out includes preparation of the genetic, physical and optical components of the set up, and the development of strategies to speed up analysis of image data. In particular, we deleted *metE* open reading frame from the genome of *Escherichia coli*. We cloned the same open reading frame under control of Cph8-OmpR system, and we inserted the modified system in the *E. coli* strain deleted of *metE*. We started to characterize and model the growth behavior of the resulting strain, and to analyse the problems in regulation of MetE production. In parallel, we prepared a mother machine microfluidic set up to study single bacterial cells for prolonged time periods, and we modified the set up to allow better imaging conditions. We tried to use this set up to study the dynamics of activation of expression of a reporter gene by the Cph8-OmpR system with single cell resolution, but we had an unexpected toxicity problem. To overcome this problem, we switched temporarily the set up to agarose pads, which allowed us to monitor the reporter gene expression in a bacterial colony. We started to develop strategies to automate the analysis of image data both for agarose pads and for mother machine experiments, which generate huge amounts of images. Our results provide the necessary basis for future applications of the Cph8-OmpR system and for the characterization of its dynamic with single-cell resolution. The set up we developed for this purpose provides a highly versatile device, which can be applied to the study of multiple cellular behaviors, while our image analysis protocols help to extract rapidly quantitative data from this kind of experiments. Our findings on the control of cell growth through light contribute to future advances in using engineered signal transduction systems to manipulate cellular processes.

Bachelor's Degree in Genetics and Molecular Biology (L-13)
Thesis Title: "Adult neurogenesis in the human brain"

Sapienza University of Rome, Italy
Final grade: 110/110 cum laude.

PUBLICATIONS

[1] Maria Cristina Cannarsa, Filippo Liguori, Nicola Pellicciotta, Giacomo Frangipane, and Roberto Di Leonardo. "Light-driven synchronization of optogenetic clocks". en. In: *eLife* 13 (Oct. 2024), RP97754.

[2] S. Bianchi, F. Saglimbeni, G. Frangipane, M. C. Cannarsa, and R. Di Leonardo. "Light-Driven Flagella Elucidate the Role of Hook and Cell Body Kinematics in Bundle Formation". en. In: *PRX Life* 1.1 (Sept. 2023), p. 013016.

PERSONAL SKILLS

Mother tongue: Italian

Other languages

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C2	C2	C2	C2	C2
	Cambridge C2 Proficiency				
French	A2	A2	A2	A2	A2
	Diplôme d'études en langue française (DELF) A2				

Levels: A1 and A2: Basic user – B1 and B2: Independent user – C1 and C2: Proficient user
Common European Framework of Reference for Languages

Technical skills
- Genetic engineering in *E. coli*: genome manipulation such as insertions, deletions, mutations (lambda red recombination, MAGE); plasmid cloning (In-Fusion Cloning, Q5 mutagenesis).
- Microscopy: bright field, phase contrast, fluorescence.
- Microfluidics.
- Standard molecular biology techniques, such as PCR, bacterial transformation (electroporation, heat shock), gel electrophoresis.

Computer skills
- coding with Python
- coding with C++ for Arduino
- LateX
- competent with most Microsoft Office programmes

Driving licence: B