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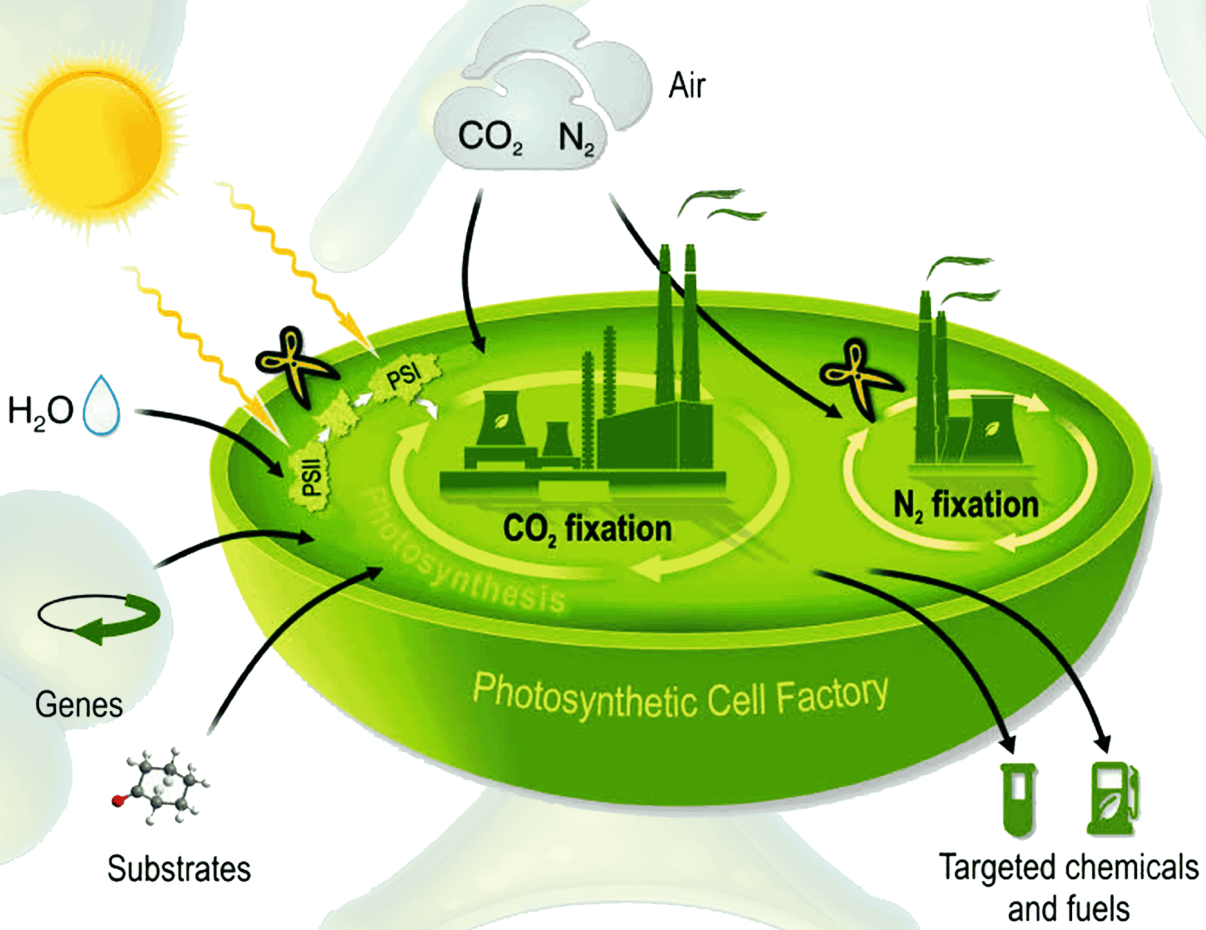
BOOK OF ABSTRACTS



PHOTOSYNTHETIC MICROORGANISMS FOR SUSTAINABLE DEVELOPMENT

2 - 3 December 2025

Rome, Italy

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Consiglio Nazionale delle Ricerche

CONFERENCE PROGRAM AND ABSTRACTS

GREEN CHRISTMAS SESSION

PHOTOSYNTHETIC MICROORGANISMS FOR SUSTAINABLE DEVELOPMENT

INTERNATIONAL ONLINE CONFERENCE

TOPICS:

Structure, Function & Dynamics of Photosynthetic Components

Photosynthetic Factories: From the Lab to Industrial Applications

for details visit the conference webpage

free registration is available here

contact us at gcs.org@cnr.it

2-3 Decembre 2025, Rome, Italy

Green Christmas Session

PHOTOSYNTHETIC MICROORGANISMS FOR SUSTAINABLE DEVELOPMENT

2025

Consiglio Nazionale delle Ricerche
Istituto per i Sistemi Biologici, Dipartimento di Scienze Bio-Agroalimentari
Green Christmas Session 2025 Book of Abstracts

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Cover image: *Biocatalytic solar chemicals and fuel production by photosynthetic cell factories*. © Prof. Yagut Allahverdiyeva-Rinne, University of Turku, Finland (Credits: SkiGrafik, Dmitry Shevela)

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The **Green Christmas Session** has been conceived as a series of interactive online meetings. The discussions will centre around various fundamental and applied aspects of photosynthesis research and its potential to offer sustainable solutions for addressing emerging questions and problems in modern society.

The **Green Christmas Session 2025** is under the patronage of the International Society of Photosynthesis Research (*ISPR*), Italian Society of Plant Biology (*SIBV*), European Algae Biomass Association (*EABA*), Italian Society for Photobiology (*SIFB*), Biology Department of Padova University (*DiBio*), GdR Integrative Biology of CO_2 (*IBCO2*), VLAG Graduate School of Wageningen University (*VLAG*), HE funded SPIN-FERT project (SPIN-FERT) and European Society for Photobiology (*ESP*).

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The Conference is hosted by the Institute for Biological Systems, National Research Council, Territorial Research Area of Rome 1.

WELCOME

Dear participants,

On behalf of the Scientific Committee, we are delighted to welcome you to the fourth edition of the online **Green Christmas Session *"Photosynthetic microorganisms for sustainable development"***. The GCS 2025 will showcase the potential of photosynthetic microorganisms to promote the development of technology enabling the sustainable growth of modern society.

The use of photosynthetic microorganisms as living cellular devices and factories with self-propagating and self-repairing capabilities continues to gain momentum in the development of solar-powered biotechnology for fuel, chemicals, and energy production. Both oxygenic and anoxygenic photosynthetic microorganisms are highly efficient in light-energy conversion and possess an astonishing capacity to adapt to different growth environments and unique metabolic diversity and flexibility. Knowing better the mechanisms of their photochemistry and environmental adaptation might promote the carbon-neutral production of a vast number of desirable compounds and the generation of green energy, and might strengthen the notion of the circular economy.

The GCS 2025 will highlight recent advances in the structure, function, and dynamics of photosynthetic systems, as well as progress in developing photosynthetic factories from laboratory research to industrial-scale applications. Attendees will also discover inspiring EU success stories that showcase how photosynthetic microorganisms are driving innovations in green energy, powering the production of high-value compounds, and enabling sustainable, next-generation waste management solutions.

The conference format includes preselected invited speakers, free audience attendance, and dedicated Q&A sessions after each presentation.

Once again, we extend a warm welcome and look forward to a fruitful exchange of knowledge!

Maya Dimova Lambreva
(*chair*)

Giorgio Perin
(*co-chair*)

CONFERENCE PROGRAM

The conference schedule is set to Central European Time

2nd December 2025

08:50 Online Platform Opening

09:00 Welcome address by **Zeineb Aturki** *(Acting Director of the Institute for Biological Systems, CNR)*

Opening by **Massimo Trotta** *(President of the European Society for Photobiology)*

SESSION TITLE:

Structure, Function and Dynamics of Photosynthetic Components

CHAIRS: Giorgio Perin, Lauri Nikkanen, Maya D. Lambreva

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Genetic optimization of photosynthesis to improve biomass productivity in algae

10:00 **Maria Agustina Dominguez-Martin** (University of Cordoba, Spain) Page 2

Cyanobacterial light harvesting: structure, diversity, and regulatory mechanism

10:25 **Gilles Peltier** (*Aix-Marseille Institute of Biosciences and Biotechnology, CEA, France*) Page 3

Interplay between the CO_2 concentrating mechanism and photorespiration in green algae

10:50 **Break 25 min**

11:15 **Stefania Viola** (*Aix-Marseille Institute of Biosciences and Biotechnology, CEA, France*) Page 4

Role of respiratory oxidases in photosynthetic electron transport in Synechococcus elongatus PCC 7942

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Structure/function studies of chlorophyll f-containing photosystems from Chroococcidiopsis thermalis PCC 7203

12:05 **Volha U. Chukhutsina** *(Vrije University Amsterdam, The Netherlands)* Page 6

Using advanced crystallographic approaches to resolve how orange carotenoid protein works

12:30 **Dimitris Petroutsos** (*Uppsala University, Sweden*) Page 7

Remote regulation of photosynthesis through plasma membrane light perception

12:55 **Closing remarks**

3rd December 2025

08:50 Online Platform Opening

SESSION TITLE:

Photosynthetic Factories: From the Lab to Industrial Applications

CHAIRS: Yagut Allahverdiyeva, Sarah d'Adamo, Yonghua Li-Beisson

09:00 **Rui Miao** (*Uppsala University, Sweden*) Page 8

Oldest organism for newest sustainable chemical production

09:25 **Yasuyo Yamaoka** (*The Catholic University of Korea, Republic of Korea*) Page 9

Designing industrial microalgae by controlling stress response

09:50 **Julie Zedler** (*Friedrich Schiller University Jena, Germany*) Page 10

Spatial organisation of product biosynthesis in cyanobacteria: from protein targeting to new-to-nature structures

10:15 **Lu-Ning Liu** (*University of Liverpool, UK*) Page 11

Design principles and environmental adaptation of natural photosynthetic complexes

10:40 **Break 25 min**

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Genetic optimization of photosynthesis to improve biomass productivity in algae

Keywords: photosynthesis, regulation, biomass productivity

Sunlight drives photosynthesis but also imposes fluctuating conditions that can lead to overreduction and photodamage. While photosynthetic regulation has evolved for natural environments, these mechanisms may not be optimal in artificial cultivation systems such as photobioreactors.
We investigated strategies to improve photosynthetic performance in the marine microalga *Nannochloropsis oceanica* by targeting the xanthophyll cycle, which regulates light harvesting through the reversible conversion between violaxanthin and zeaxanthin. This cycle balances energy use and protection, but its natural kinetics can limit productivity under rapidly changing illumination found in a photobioreactor.
Engineered strains overexpressing violaxanthin de-epoxidase (VDE) and zeaxanthin epoxidase (ZEP) were generated to accelerate activation and relaxation of photoprotection. Their physiological performance was evaluated in tubular and flat-panel photobioreactors under various light conditions.
Increased VDE accumulation enhanced photoprotection and tolerance to strong illumination but caused unnecessary energy dissipation in low light. Conversely, ZEP overexpression promoted faster recovery of photosynthetic efficiency yet caused increased photosensitivity. The combined overexpression of both enzymes balanced these effects, enabling dynamic adjustment of photoprotection and resulting in higher overall biomass productivity across cultivation geometries and light regimes, showing that fine-tuning the kinetics of the xanthophyll cycle represents an effective approach to improve microalgal photosynthetic efficiency and productivity in industrial photobioreactors.

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Cyanobacterial light-harvesting: structure, diversity and regulatory mechanism

Keywords: phycobilisomes, cyanobacteria, OCP, photoprotection

Phycobilisomes (PBS) are intricate light-harvesting antennae found in cyanobacteria and are essential for harvesting light energy. To balance efficient light capture with the risk of photodamage, many cyanobacteria have evolved a photoprotective mechanism based on the interaction between the Orange Carotenoid Protein (OCP) and the PBS[1]. OCP is a modular carotenoid-binding photoreceptor composed of two main domains: the N-terminal domain (NTD), which functions as the effector domain, and the C-terminal domain (CTD), which plays a regulatory role. A carotenoid molecule, embedded between these two domains, acts as the chromophore. Recently, the structures of both PBS and the OCP–PBS complex were resolved in the model cyanobacterium *Synechocystis* sp. PCC 6803, with resolutions ranging from 1.6 to 3.5 Å (1,2). These studies revealed three distinct conformational states of the antenna, including two previously unknown unquenched states[1]. The PBS–OCP complex contains four OCP molecules organized as two dimers that bind to the PBS core and induce quenching. Importantly, these structural findings indicate that differences in PBS architecture among cyanobacteria may influence OCP binding. The OCP-based photoprotection system is now understood to be more complex than initially proposed. New protein families homologous to individual OCP domains-HCPs (NTD-like) and CCPs (CTD-like)—have been identified (3,4), suggesting the presence of an expanded and diversified network of carotenoid-binding proteins across cyanobacterial lineages. We are currently conducting biochemical and spectroscopic characterizations of OCPs and PBS from several marine cyanobacterial species. These strains differ in PBS pigment composition, and some possess notably more complex OCP-related systems. Our work aims to expand current knowledge of light harvesting, photosynthetic regulation, and photoprotection in these ecologically important organisms. Ultimately, these insights will support the future engineering of photosynthetic antennae to generate more efficient cyanobacterial cell factories.

1. 10.1038/s41586-022-05156-4. **2.** 10.1126/sciadv.adk7535. **3.** 10.1016/j.molp.2016.06.009.
4. https://doi.org/10.1016/j.crstbi.2024.100141

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Interplay between the CO_2 concentrating mechanism and photorespiration in green algae

Keywords: CO_2 concentrating mechanism, glycolate, microalgae, photorespiration.

Because CO_2 availability is low in aquatic environments, microalgal photosynthesis microalgal photosynthesis relies on carbon-concentrating mechanisms (CCMs), sophisticated systems composed of transporters, carbonic anhydrases, and pH gradients across cellular compartments. CCMs elevate CO_2 concentrations within the pyrenoid, a specialized compartment where Rubisco resides and CO_2 fixation takes place. By increasing CO_2 levels around Rubisco, CCMs enhance carboxylation over oxygenation, thereby reducing photorespiration. In *Chlamydomonas,* two distinct modes of CCM operation have been described. Under low CO_2 conditions, CO_2 passively diffuses across cellular membranes into the chloroplast, where it is converted into bicarbonate by stromal carbonic anhydrase, then transported into the thylakoid lumen and reconverted to CO_2. Under very low CO_2, additional plasma membrane transporters are recruited to boost inorganic carbon uptake. During photorespiration, a portion of the glycolate produced is metabolized in the mitochondria into glyoxylate, glycine, and serine, while another fraction is excreted from the cell. To quantify photorespiration in different regimes of CCM functioning, we developed an experimental approach aiming at measuring glycolate excretion and CO_2 fixation rates in mutants deficient in glycolate dehydrogenase. Our findings are discussed in the context of the energetic costs of the two CCM modes and their relative efficiencies in minimizing photorespiration.

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Role of respiratory oxidases in photosynthetic electron transport in *Synechococcus elongatus* PCC 7942

Keywords: cyanobacteria, electron transport, proton motive force, respiration

In cyanobacteria, the photosynthetic and respiratory electron transport chains are co-localised in the thylakoid membranes, and share some components. Respiratory complexes can thus participate in electron transport during illumination, contributing to the regulation of ATP and NADPH production for CO_2 fixation. *Synechococcus elongatus* PCC 7942 possess two cytochrome *c* oxidases (COX and Cbb) and a cytochrome *bd* quinol oxidase (Cyd) that share electron-carrier pools with PSI and PSII. We investigated the participation of the three respiratory oxidases in regulating the photosynthetic efficiency of *S. elongatus*, using a combination of genetics, biochemistry and spectroscopy. Our *in vivo* biophysical measurements show that COX and Cyd play the main bioenergetic role, maintaining a trans-thylakoid *pmf* in the dark and acting as electron sinks during dark-to-light transition. While COX and Cyd contribute to *pmf* generation and fine-tune the redox poise of the intersystem chain at the light onset, their absence doesn't affect photosynthetic electron transport and CO_2 assimilation under continuous illumination, where O_2 reduction by the Flavodiiron proteins predominates. However, mutants lacking both COX and Cyd have severely impaired growth in fluctuating light. We could not detect an activity for Cbb, that we show accumulates to much lower levels than COX and, especially, Cyd. All three oxidases form protein supercomplexes, whose composition and subcellular localization are currently under investigation. Altogether, our results provide new insights on the consequences of the connection with respiration on the photosynthetic activity of *S. elongatus*, revealing the role of COX and Cyd both in dark respiration and in priming electron transport upon illumination.

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Structure/function studies of chlorophyll f-containing photosystems from *Chroococcidiopsis thermalis* PCC 7203

Keywords: far-red photo-acclimation, chlorophyll f, Photosystem 1, Photosystem 2

The discovery of chlorophyll *f*-containing oxygenic photosynthesis, with its long-wavelength photochemistry, represented a new low-energy paradigm. Here, I will present our recently solved structures of the chlorophyll *f*-containing Photosystem 2 dimer (PS2), and Photosystem 1 trimer (PS1), from *Chroococcidiopsis thermalis* PCC 7203. These structures were solved at resolutions of 2.17 Å and 1.89 Å, respectively, through cryo-electron microscopy single particle analysis. The high resolution and intactness of these structures allowed for in depth structural/functional studies. By analysing the electrostatic potential, all of the chlorophyll *f* molecules have been located with high confidence. This includes the elusive chlorophyll *f* in the reaction centre of PS1, confirming its photochemical role. The fully intact, oxygen-evolving far-red adapted PS2 dimer revealed the presence of the far-red specific subunit PsbH2', a novel and specific subunit. By locating all of the chlorophyll f pigments, we provide new insights on the excitation energy transfer and in particular on the potential advantages of intermonomer energy transfer in both PS1 and PS2. In addition, combining our recently published structure of the intact far-red allophycocyanin from *Chroococcidiopsis thermalis* PCC 7203 with the structure of the PS2 dimer, potential energy transfer pathways can be hypothesised.

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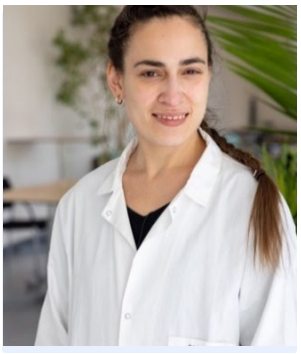

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Using advanced crystallographic approaches to resolve how orange carotenoid protein photocycle works

Keywords: orange carotenoid protein, photosynthesis, X-ray crystallography, spectroscopy

In cyanobacteria, photoregulation is controlled by the orange carotenoid protein (OCP) photocycle. OCP is the only known photoreceptor that utilizes a carotenoid for light activation. Understanding and potentially controlling this unique photocycle could offer new opportunities in optogenetics and enhancing photosynthetic biomass. However, the precise mechanisms by which the carotenoid drives and regulates the OCP photocycle remain unclear. OCP presents significant experimental challenges, particularly for conventional spectroscopic and crystallographic methods, owing to its extremely low photo-conversion yield. In this presentation, I will discuss the combined spectroscopic and crystallographic strategies we employ to unravel the photocycle of this unusual and technically demanding photoreceptor. Recent structural insights that illuminate key steps of the OCP photocycle will also be presented.

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Remote regulation of photosynthesis through plasma membrane light perception

Keywords: blue-light signalling, phototropin, kinases, photoprotection, carbon partitioning

Light serves as more than just an energy source for photosynthesis—it also functions as a crucial biological signal that regulates diverse cellular processes. However, excessive light exposure can induce oxidative stress and ultimately lead to cell death. To mitigate these harmful effects, photosynthetic organisms employ energy-dependent quenching (qE), a photoprotective mechanism that dissipates surplus excitation energy as heat.
In *Chlamydomonas reinhardtii*, the induction of the key qE effector protein LHCSR3 depends on the plasma membrane localized blue-light photoreceptor Phototropin (PHOT). In the *phot* knockout mutant, LHCSR3 expression is markedly reduced. Despite this, the mechanisms by which PHOT initiates photoprotective signaling remain largely uncharacterized.
Here, we show that PHOT activates photoprotective signaling via a direct, blue-light-dependent interaction with a previously uncharacterized GAF-domain protein, which we term PMSK2 (*Phototropin-Mediated Signalling Kinase 2)*. Disruption of *PMSK2* leads to overaccumulation of LHCSR3 under high-light conditions. Notably, deletion of *PMSK2* in the *phot* background restores LHCSR3 expression to wild-type levels. Treatment with the proteasome inhibitor MG132 prevents PMSK2 degradation and leads to a reduction in LHCSR3 levels, indicating that PMSK2 functions as a suppressor of LHCSR3 through a ubiquitin-mediated mechanism. We finally demonstrate that PHOT and PMSK2 physically interact in a blue-light-dependent manner, and that this interaction is regulated by post-translational modification of serine 644.

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Oldest organism for newest sustainable chemical production

Keywords: photoautotroph, gene function, data-driven, cell factory

The biological production of fuels and other valuable chemicals through photosynthetic microorganisms offers a sustainable alternative to fossil-based processes. Cyanobacteria are prokaryotic photoautotrophs capable of converting solar energy and CO_2 directly into chemical compounds, making them attractive hosts for bio-based production. Engineered strains have demonstrated the synthesis of a range of target molecules, including n-butanol, although productivities often remain below those achieved in heterotrophic systems. Advances in metabolic engineering, synthetic biology, and systems-level modelling have accelerated efforts to improve cyanobacterial performance as cell factories. However, a major limitation is the incomplete understanding of cyanobacterial gene functions, with nearly half of the genes in model strains still lacking functional annotation. To address this gap, a genome-wide gene repression library was employed to systematically map essential and fitness-contributing genes under varying light and carbon conditions. These data provide new insights into photosynthetic physiology and identify key targets for metabolic optimization. Together, these approaches highlight the potential of cyanobacteria as sustainable platforms for solar-driven production of fuels and chemicals, and emphasize the need for integrative, data-driven strategies to realize their industrial application.

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Designing industrial microalgae by controlling stress response

Keywords: triacylglycerol; transcriptional regulation; stress-induced lipid biosynthesis; *Chlamydomonas*; *Chlorella*

Microalgae are promising platforms for bio-based lipid production because of their metabolic flexibility and ability to accumulate energy-rich triacylglycerol (TAG) under various environmental conditions. Our recent studies have adopted two complementary strategies to enhance lipid accumulation: the use of lipid master regulators and the design of stress conditions that naturally promote lipid biosynthesis. The first strategy focuses on identifying and manipulating key transcriptional regulators that coordinate the expression of lipid biosynthetic enzymes and metabolic pathways in Chlamydomonas. By fine-tuning these regulatory networks, it becomes possible to boost lipid accumulation even under non-stress conditions. The second strategy employs environmental and nutritional cues to induce lipid synthesis as part of the stress response in Chlorella. Interestingly, certain stress-induced systems achieve lipid accumulation comparable to classical nitrogen-starvation conditions, showing similar TAG content but higher total fatty acid content. These findings reveal how different regulatory layers contribute to lipid biosynthesis and highlight the potential of integrating metabolic and environmental strategies for efficient lipid production in microalgae.

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Spatial organisation of product biosynthesis in cyanobacteria: from protein targeting to new-to-nature structures

Keywords: *Synechocystis*, *Synechococcus elongatus*, nanofilaments, protein targeting

Cyanobacteria are an attractive group of organisms for the development of sustainable industrial processes. Over the years, engineering cyanobacteria has significantly advanced, and their potential has been demonstrated by the production of a large array of economically relevant compounds. Biosynthesis of a specific compound usually requires multi-enzyme metabolic pathways. However, the efficient spatial organisation of heterologous enzymes within the complex cellular architecture of cyanobacteria remains challenging. In this talk, I will give two examples of approaches for spatial organisation from our work. One example focuses on targeting native subcellular compartments. We have shown that targeting of a model plant cytochrome P450, CYP79A1, to the thylakoid membrane as a native subcellular compartment, improves enzyme stability and, thus, product yields (1). It is also possible to engineer de novo spatial organisation into cyanobacteria. We have shown that protein-based nanofilaments can be assembled *in vivo* and targeted with enzymes using targeting peptides (2). Spatial organisation of enzymes in the cellular context can substantially improve the metabolic flux towards a product of interest and, thus, contribute to advancing cyanobacterial biotechnology.

1. doi.org/10.1021/acssynbio.4c00800. **2.** doi.org/10.1021/acsnano.3c08600

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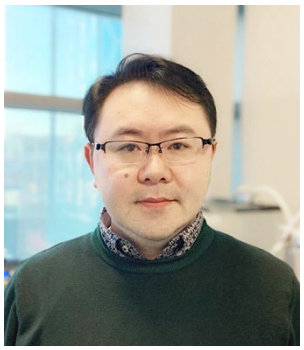

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Design principles and environmental adaptation of natural photosynthetic complexes

Keywords: photosynthetic complexes, photosynthetic membrane, assembly, adaptation

Phototrophic microorganisms have developed efficient strategies to regulate the structures and functions of photosynthetic apparatus to conduct and regulate light absorption and energy conversion during evolution and environmental adaptation. However, the extent of the variability of natural photosynthetic complexes across diverse organisms is still not well understood. In this seminar, I will present our studies on the organisations and functions of photosynthetic complexes and the biogenesis of photosynthetic membranes in various phototrophic microorganisms, by employing a multidisciplinary approach involving biochemistry, spectroscopy, structural biology, and computational modelling. These findings shed light on the intricate balance between precise design and environmental regulation that drive the formation and structural diversity of natural photosynthetic machinery. The advanced knowledge will inspire rational design and engineering of artificial photosynthetic systems for biotechnological application.

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Domestication of algal bio-factories: metabolic mapping and engineering of diatoms

Keywords: diatom, *Phaeodactylum tricornutum*, isoprenoids, terpenoids, synthetic biology, compartmentalized biosynthesis

Diatoms have colonized every aquatic habitat on Earth, mostly thanks to by their unique metabolic traits. This versatility makes them attractive candidates for biotechnological applications, yet they remain underexploited due to limited optimization for industrial cultivation and low product yields. Our research aims to accelerate the domestication of diatoms through metabolic engineering and synthetic biology, focusing on their potential as sustainable producers of terpenoid-based high-value compounds. A key aspect of this work is the exploitation of diatom compartmentalization, particularly the periplastidial compartment (PPC), as a minimal endosymbiotic cytoplasm surrounding the plastid. The PPC is largely devoid of competing metabolic pathways, offering a unique and finite space for targeted biosynthesis. We demonstrate that prenyl phosphate precursors such as GPP, FPP, and GGPP accumulate in the PPC, enabling heterologous terpenoid synthases to function effectively when targeted to this compartment. Specifically, we systematically explored the production of mono-, sesqui-, tri-, and tetraterpenoids (including geraniol, squalene, zizaene, and carotenoids), across different cellular compartments. By integrating modular DNA assembly and compartment-specific targeting strategies, we establish proof-of-concept for engineering complex biosynthetic routes. This approach positions diatoms as promising synthetic biology platforms for solar-driven, compartmentalized production of industrially relevant compounds, opening new opportunities for sustainable biomanufacturing.

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DigitAlgaesation: a knowledge-based training network for the digitalisation of photosynthetic bioprocesses

Keywords: microalgae, digitalisation, modelling, automatic control, monitoring

Microalgae represent a highly promising source for food, feed, chemicals, and fuels. However, despite the enormous potential and the impressive R&D effort, industrial use of microalgae is still at its first developmental stage. A major step forward can derive by the development and implementation of digital technologies, capable of automatizing and optimising culture conditions at industrial scale. In this talk, I will present some results achieved during the ITN Project DigitAlgaesation, which concluded in 2025 and aimed at:

1. Developing a sound modelling approach at the process scale to describe the dynamics of the photosynthetic phenomena that are relevant to an effective automatic control strategy in an industrial environment and be representative of different microalgae of industrial interest;
2. Developing a reliable smart monitoring approach for measuring and/or estimating the biological key performance indicators required for model identification and to support an effective control system
3. Developing and implement automatic control strategies in real industrial systems characterised by non-ideal behaviour in the presence of uncertainty, to achieve high level of productivity, and reduce manpower and energy costs while maintaining a constant product quality.

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From biomass to biocatalysis: harnessing photosynthetic biotechnologies for sustainable bio-production

Keywords: algae, cyanobacteria, biorefinery, biocatalytic production, ELMs

Photosynthetic microorganisms provide a sustainable foundation for next-generation biotechnologies. We present two complementary strategies for solar-driven production of fuels and chemicals: a short-term biomass-based approach and a long-term biocatalytic strategy utilizing live photosynthetic cells.

The short-term strategy follows a circular bioeconomy model that integrates large-scale algal cultivation in agricultural and industrial effluents with downstream biomass valorization. The harvested biomass is upgraded into biostimulants and bio-based pesticides, promoting nutrient recycling and sustainable agricultural practices. This approach forms the core of the EU REALM IA project, coordinated by Necton Oy.

The long-term strategy harnesses photosynthetic cells for direct solar-driven chemical and fuel production. This is achieved through (i) whole-cell biotransformation and (ii) the development of a solid-state biocatalytic platform that replaces traditional suspension cultures. In this system, engineered cells are immobilized within thin polymeric nano-matrices to form engineered living materials (ELMs). The EU RIA Solar-to-Butanol consortium, coordinated by the University of Turku, focuses on developing such solid-state photosynthetic production systems using additive manufacturing, engineered cyanobacteria and nanomaterials to enhance CO_2 fixation, light management, and continuous production efficiency. Together, these strategies bridge fundamental photosynthesis research with applied biotechnology, paving the way toward circular, light-powered biomanufacturing systems.

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[1]*Wageningen University and Research, The Netherlands*

Towards industrial photosynthetic factories: a SUN-PERFORM perspective

Keywords: genetic engineering, synthetic biology, nanotechnology, industrial biotechnology

Decarbonizing hard-to-abate sectors such as aviation and maritime transport necessitates the development of scalable, cost-effective, and CO_2-neutral fuel production systems. Current biofuel technologies remain constrained by high production costs, limited resource availability, and low solar-to-biomass conversion efficiencies, while emerging alternatives remain technologically immature. To address these limitations, the Horizon Europe project **SUN-PERFORM** aims to develop a biohybrid platform that integrates nanotechnology-based artificial light harvesting with advanced microalgal cell engineering. The central research question is: *Can the synergistic integration of artificial light-harvesting nanomaterials with synthetic biological reprogramming overcome the intrinsic photosynthetic limitations of microalgae to significantly enhance lipid productivity for sustainable fuel production?* The proposed platform employs low-cost nanomaterial modulated to convert underutilized regions of the solar spectrum into photosynthetically active radiation, thereby aiming to enhancing photon availability and utilization efficiency in photobioreactors. In parallel, synthetic biology strategies are applied to rewire cellular metabolism at multiple regulatory levels. These include: implementing an alternative cycle to the native the Calvin-Benson-Bassham, to enhance carbon fixation; rebalancing energy metabolism by establishing a phosphagen sink, to stabilize cellular ATP levels under fluctuating light conditions; engineering lipid metabolism to channel fixed carbon preferentially toward triacylglycerol (TAG) accumulation, the primary precursors for sustainable aviation and marine fuels. During the talk, we will outline the SUN-PERFORM concept and consortium framework and share our preliminary experimental insights into the development of the biohybrid platform.

Back to the Program

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SIFB
Associazione Italiana di Fotobiologia

http://www.sifb.it/

Congress call ISFB 2026

The ISFB 2026 annual meeting is scheduled for 22-24 June and will be held in Brescia, Italy

Continuing the tradition of encouraging interdisciplinary exchange, the congress seeks to engage a wider community of researchers from diverse disciplines actively involved in the field of photobiology.

http://www.sifb.it/congress-call/

Follow us to get involved:

SIFB - Associazione Italiana di Fotobiologia

EUROPEAN ALGAE BIOMASS ASSOCIATION

https://www.eaba-association.org/en

Next EABA conference, *AlgaEurope 2025*, will be held in Riga, Latvia, 9-12 December

For years, AlgaEurope has been one of the most comprehensive global conferences on science, technology, and business in the Algae Biomass sector, organised by industry professionals.

The upcoming Young Algaeneers Symposium 2026 will take place in Wageningen, The Netherlands, from 26-29 May (agenda under construction).

EABA is the backbone of the European algae sector. Promotes mutual interchange and cooperation in the field of algae biomass production and use. Its general objective is to promote mutual interchange and cooperation in the field of algae biomass production and uses in all thinkable applications.

Green Christmas Session

PHOTOSYNTHETIC MICROORGANISMS FOR SUSTAINABLE DEVELOPMENT

2025

S. I. B. V.
SOCIETA' ITALIANA di BIOLOGIA VEGETALE

https://www.sibv.eu/

Workshop on Plant Biology 2026

intended for young researchers in plant biology

Centro Residenziale Universitario di Bertinoro

25-27 February 2026

CENTRO RESIDENZIALE UNIVERSITARIO Bertinoro

S. I. B. V.
SOCIETA' ITALIANA di BIOLOGIA VEGETALE

Topics:

- **Adaptation mechanisms to environmental stress**
- **Plant Nutrition and Metabolism**
- **Development and signal transduction**
- **Emerging technologies**

https://www.photobiology.eu/

The 8th ESP Photobiology School is scheduled for 15-20 June 2026 and will be held in Bressanone, Italy

The purpose of the ESP Photobiology School is to provide an introductory overview of all main aspects of photobiology, presented by experts in each area. The intention is to cover the basic principles of photobiology and photochemistry of biomolecules, as well as applications of such knowledge in understanding effects of climatic changes, influence of light on biological systems, applications of light in medicine and related purposes.

8th Photobiology School - June 15-20, 2026

Casa della Gioventù Universitaria **of the University of Padova**
Via Rio Bianco 12, I-39042 Brixen/Bressanone, Italy

With the the patronage of the University of Padova and of IQS-University Ramon Lull.

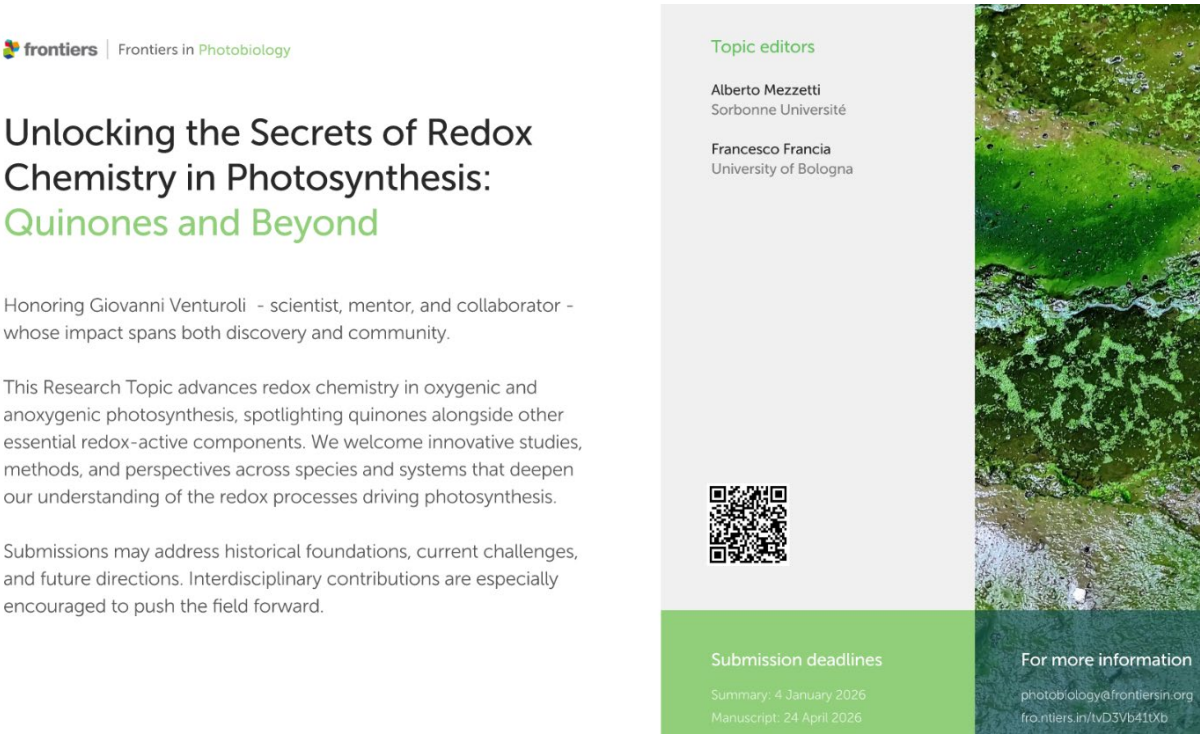
Please keep visiting https://photobiology.eu/photobiology-school for registration instructions (Registration will open in March 2026).

Frontiers in Photobiology

https://www.frontiersin.org/journals/photobiology

Frontiers in Photobiology: a new Research Topic is now open for manuscript submissions

Manuscript Submission Deadline 24 April 2026



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2025

SPIN-FERT

Innovative practices, tools and products to boost soil fertility and peat substitution in horticultural crops

Funded by the European Union

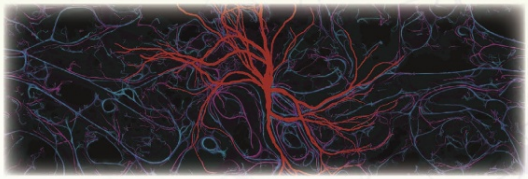
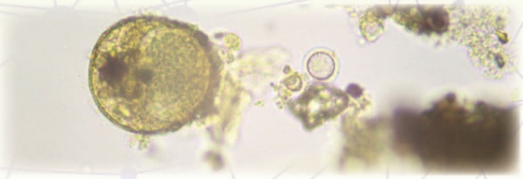
SPIN-FERT Consortium, the project funded by the European Commission under Horizon Europe, aims to revolutionise soil management in horticulture. It transforms agricultural by-products into high-quality fertilisers and peat-free substrates, promoting eco-friendly farming. SPIN-FERT integrates biostimulants and agro-industrial wastes to enhance soil fertility, employing AI-supported soil assessment tools, lab-on-chip devices, automated image analysis, and precision irrigation systems. The project develops policy recommendations for sustainable practices and fosters collaboration among 20 partners across Europe. Through community engagement and knowledge transfer, SPIN-FERT promotes healthy soil management for a greener, sustainable future.

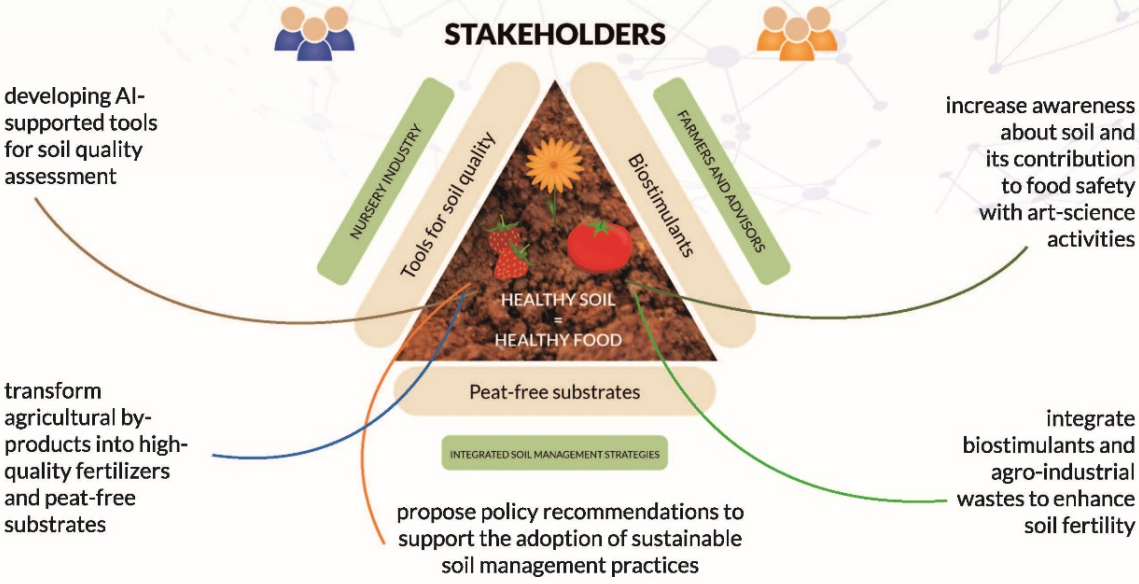



MISSION:
- ✓ To enhance soil health and sustainable horticultural practices
- ✓ To improve agricultural productivity, reduce environmental impact, and support climate change mitigation.

AMBITION:
- ✓ To lead the way in sustainable soil management by integrating cutting-edge technologies and fostering collaboration among stakeholders.
- ✓ To develop and implement effective practices that enhance soil health, reduce reliance on peat, and promote the use of innovative biostimulants and eco-friendly substrates

OBJECTIVES:
- ✓ To develop advanced soil health tools and sustainable horticultural practices.
- ✓ To transform agricultural by-products into valuable resources.
- ✓ To optimize fertilizer and peat-free substrate production.
- ✓ To engage stakeholders and to create supportive regulatory frameworks.



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