leadingIDEAS@UCIBIO

Botlenecks and Challenges in Biological Processes

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I- Is that possible to valorize CO_2 using Biological Processes?

II- How to improve the performance of biological processes using microbial consortiums

USABLE PACKAGING

I- Is that possible to valorize CO2 using Biological Processes?

PROBLEMATIC

- **Plastic pollution**

2020 DATA

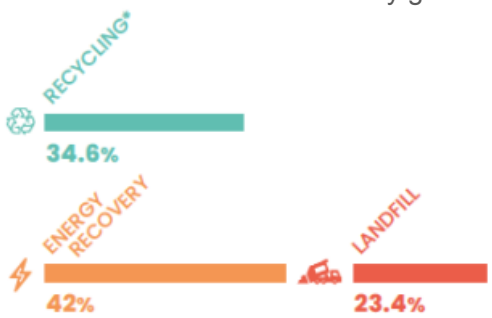
PLASTICS DEMAND IN EU27+3

49.1 Mt

~ 20 Mt plastics

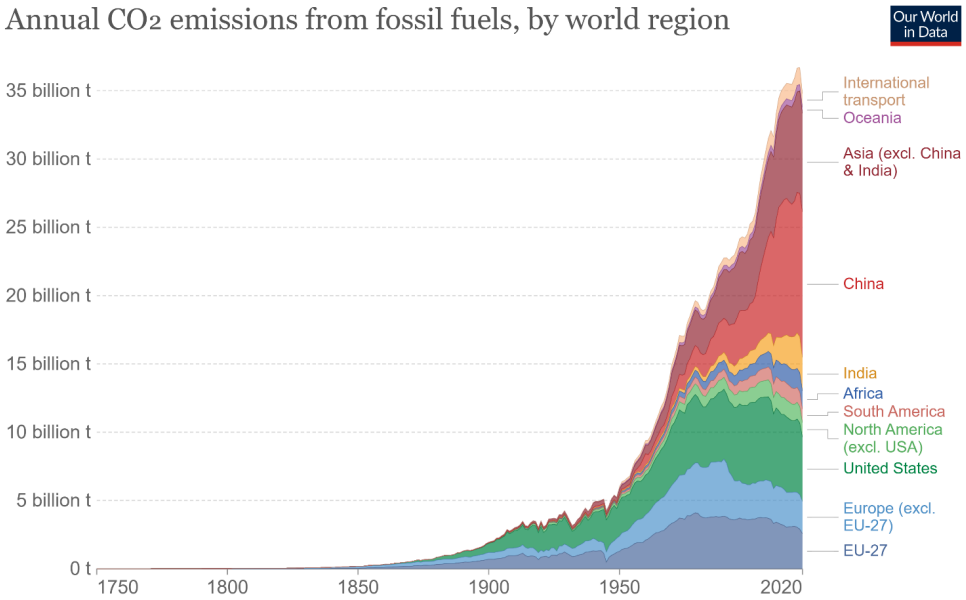
Where did they go?...

29.5 Mt
Collected plastic post-consumer waste



Source:
Plastics – the Facts 2021
Plastics Europe

- **CO_2 pollution**



Source:
Global Carbon Project
through Our World in Data

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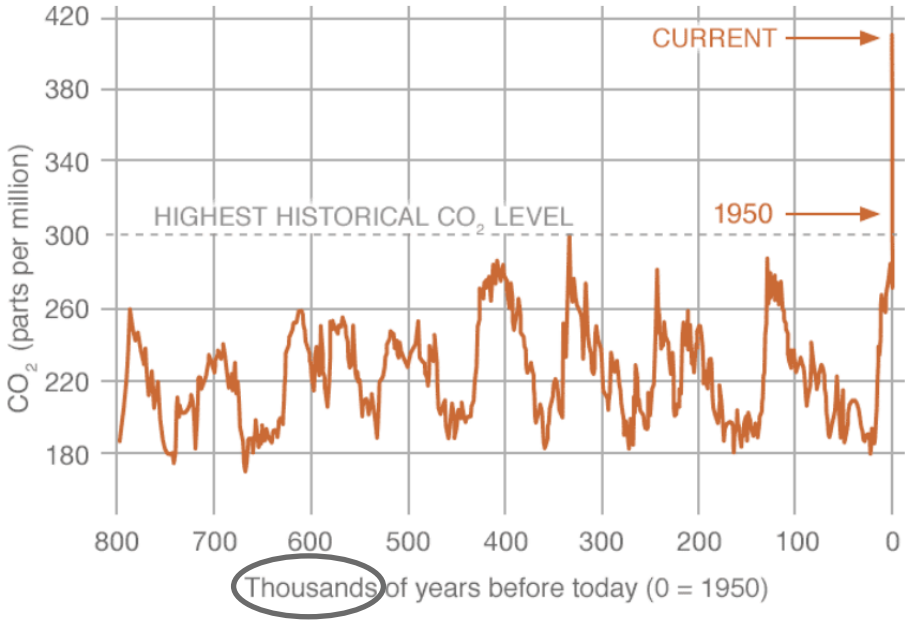
I- Is that possible to valorize CO2 using Biological Processes?

Relentless rise of CO_2 concentrations in the atmosphere



23rd January 2022: **416 ppm!**

and rising….

Source:
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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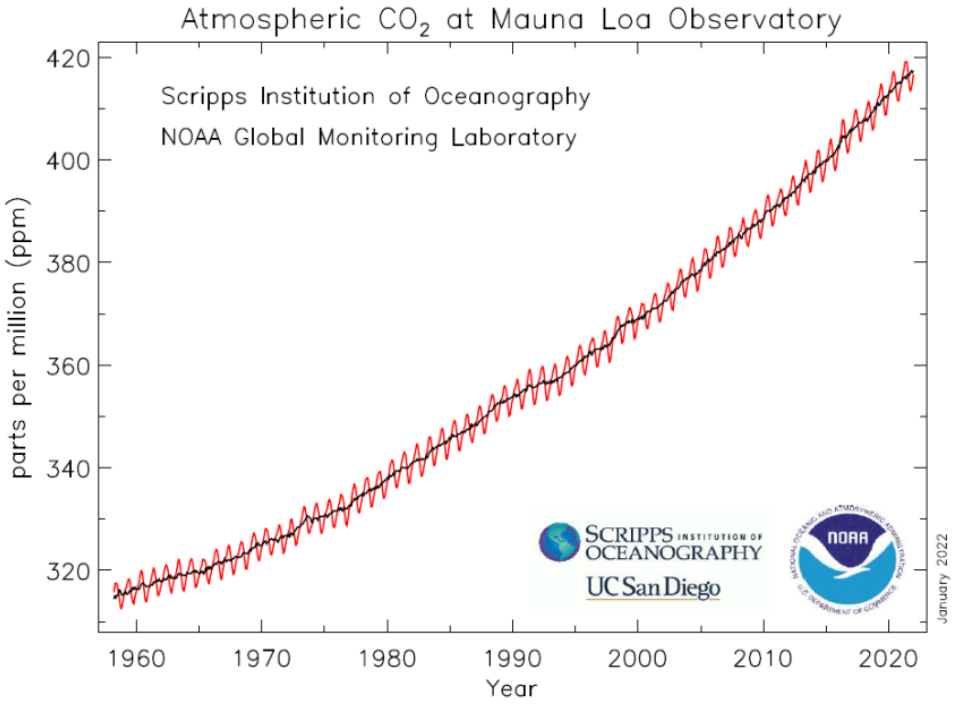


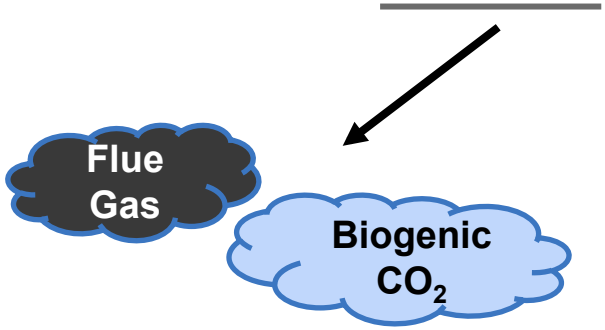
USABLE PACKAGING

PHA production with Anoxygenic Photosynthetic Bacterial Cultures

AIM: Develop an innovative photosynthetic system for PHA production using a mixed culture of Anoxygenic Photosynthetic Bacteria (APB) that use light as the sole energy source and CO_2 as carbon source

IMPACT

- Production of a biodegradable polymer that can replace conventional plastics
- Utilization of CO_2 as carbon source to mitigate CO_2 effect on global warming



	Process	CO_2 (10^6 t yr^{-1})	Off-gas CO_2 concentration (%)
Fermentative processes	Bioethanol	71.7	only minor impurities
	Breweries	6.9	only minor impurities
	Biogas (off-gas from upgrading plants)	2.6	only minor impurities
Technical processes	Natural gas processing	160.0	95–100 %
	Ammonia production	239.4	30–100 %
	Ethylene oxide production	6.3	95–100 %
	Coal-to-liquids	20.0	30–100 %
	Total	**506.9**	

Source:
B. Drosg, et al. (2015). Photo-autotrophic Production of Poly(hydroxyalkanoates) in Cyanobacteria. Chemical and Biochemical Engineering Quarterly, 29(2), 145–

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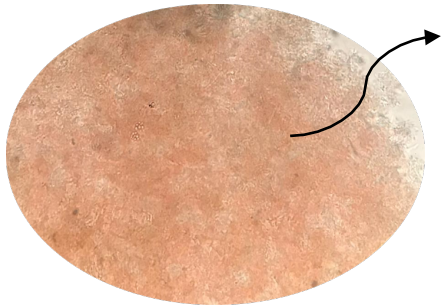
PHA production with Anoxygenic Photosynthetic Bacterial Cultures

How?

Purple Bacteria

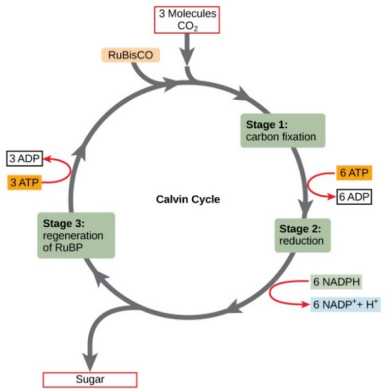


Bchl *a*

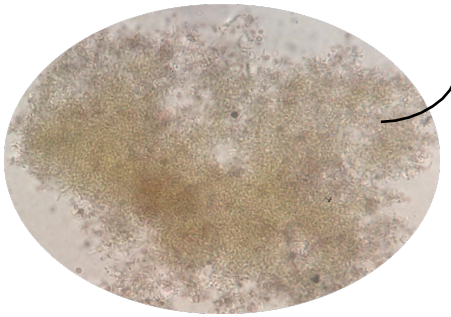
Purple colour

- Preferable **CO_2** fixation via Calvin cycle

Glycogen production



Green Bacteria

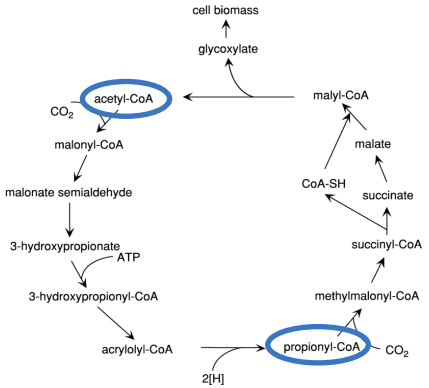


Bchl *c*

Green colour

- Preferable **CO_2** fixation via 3-Hydroxypropionate bicycle

PHB production



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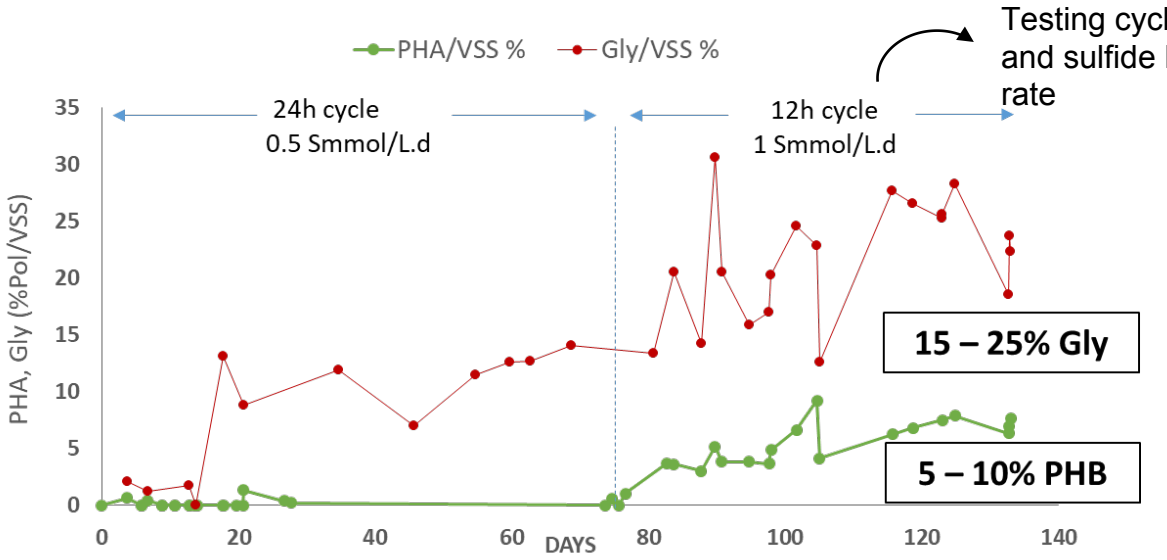
PHA production with Anoxygenic Photosynthetic Bacterial Cultures

CO_2 + H_2S

- External illumination
- 24h Light at 2.1 W/L
- T = 30ºC, pH = 6.5
- Filter to pass IR light only



✓ A phototrophic mixed culture (PMC) can be selected to accumulate PHB using inorganic carbon as feedstock (CO_2) and sulphide as electron donor.

✓ Future technology development will evaluate operation under dark/light cycles and ascertain the possibility of glycogen conversion into PHA during the dark phases.

II- How to improve the performance of biological processes using microbial consortiums- PROMICON

Harnessing the power of nature through productive microbial consortia in biotechnology – Measure, model, master

- A broad uptake of microbiomes as a production system is currently hindered by fundamental knowledge gaps regarding process control and composition of microbiomes
- Change of the community is frequently observed, despite the constant composition of feeds and reactor operating conditions

- The ability to predict evolutionary paths of environmental microbiomes under perturbations, will contribute for the optimization of environmental microbiomes *a la carte,* at industrial scale

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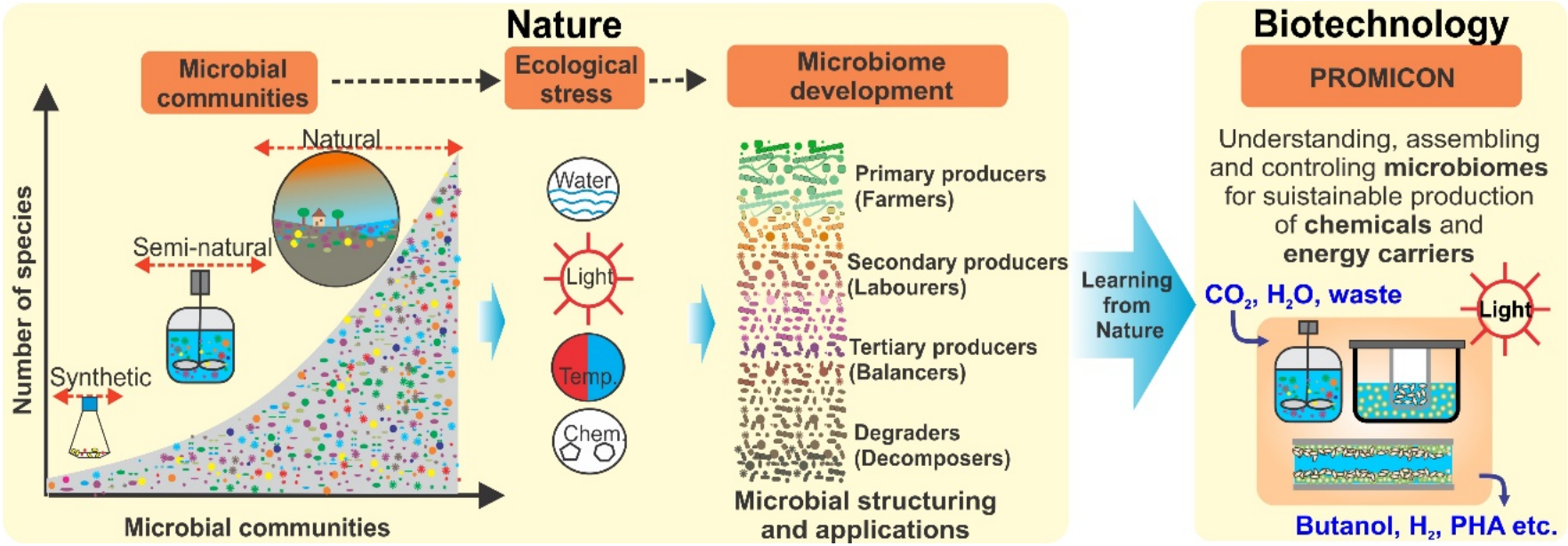
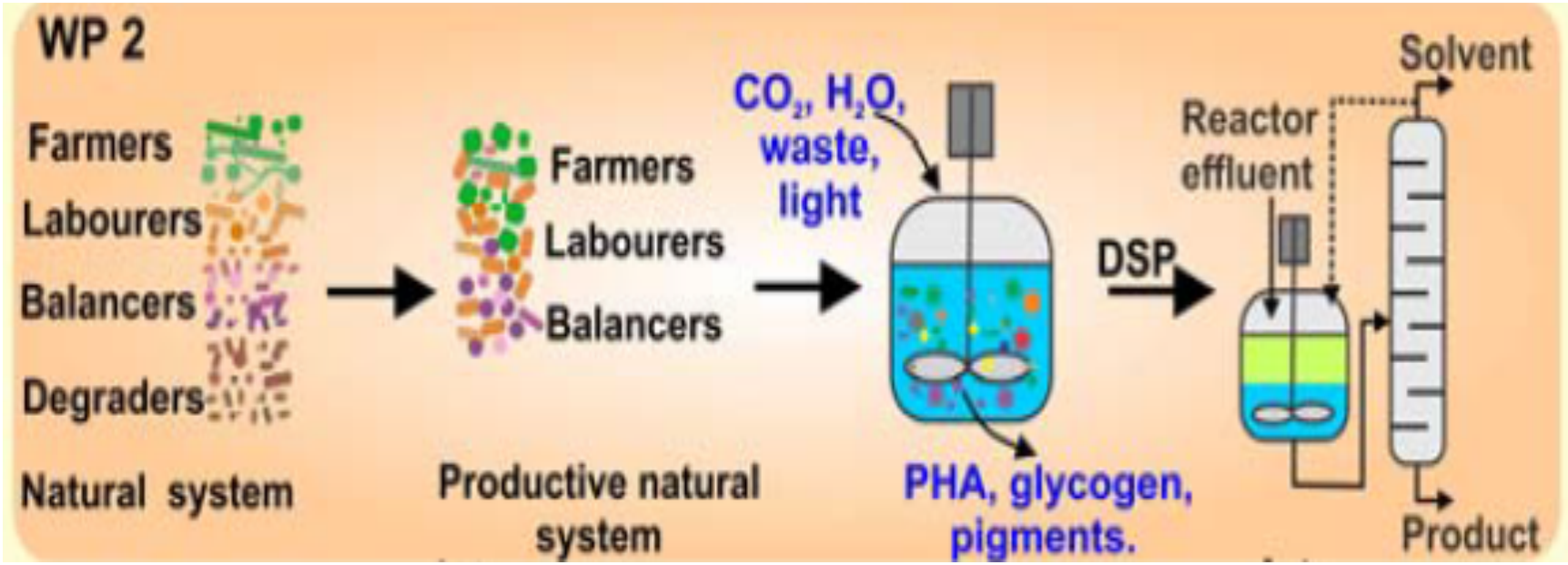


PROMICON will develop advanced characterization tools to learn from nature which modules are needed for a successful microbiome.

II- How to improve the performance of biological processes using microbial consortiums



Knowledge be used to reduce complexity of natural microbiomes to optimize the **production of PPP, EPS and PHA** in a **top-down** approach and to assemble synthetic microbiomes with increasing complexity in **bottom-up** approach for the production of **butanol, H_2** and **PHACOS**[23].

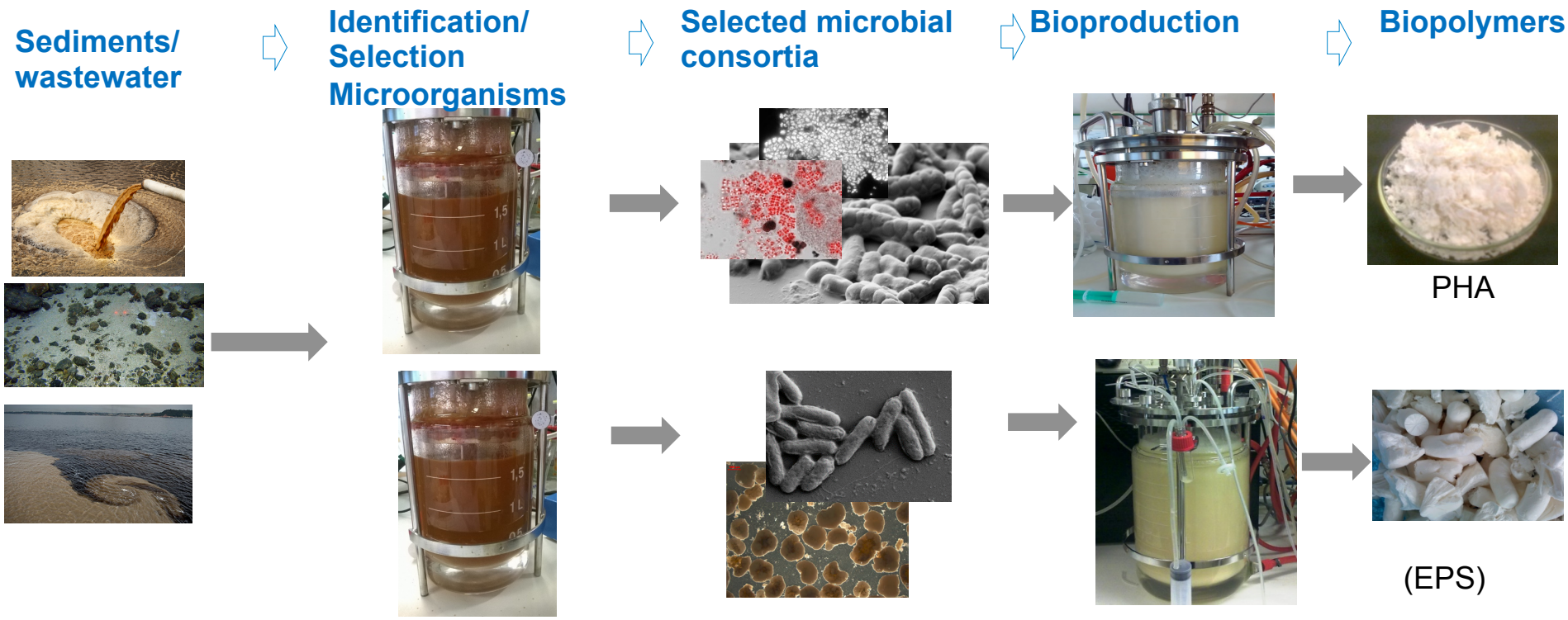
II- How to improve the performance of biological processes using microbial consortiums

Approach

- **1) a top-down approach** to develop and optimize existing microbiomes from nature for the production of **polyhydroxyalkanoates (PHA), exo-polysaccharides (EPS),** phycobiliproteins (PPP) useable in the materials and biomaterials sectors as well as pigments for the feed and food industry;

- **2) a bottom-up approach** in which **new synthetic productive microbiomes** will be generated through an iterative design-build-test-learn cycle using **systems metabolic engineering.** These microbial consortia inspired by natural microbiomes will be used for the **biotechnological production of butanol and H2** for the chemical and fuel industry and functionalized bacterial polyester **(antimicrobial PHACOS).**

II- How to improve the performance of biological processes using microbial consortiums



II- How to improve the performance of biological processes using microbial consortiums

Methods based on **quantitative physiology**, **imaging, cell sorting and analysis** and **systems biology** tools will be used to characterize the samples' microbial composition and function:

-online flow cytometric analysis, and high-throughput cell sorting, fluorescence in situ hybridization (FISH) and microautoradiography (MAR)-FISH techniques, 16s rRNA, NMR and in silico metabolic potential analysis

This data will feed in silico models for the design of novel eco-selection strategies for efficient microbiome development.

Advances in **systems biology and high-throughput 'omics' techniques (metagenomics, meta-transcriptomics, metabolomics)** will provide new opportunities for studying bacterial physiology on a microbiome level from a holistic standpoint

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PROMICON
Harnessing the power of nature through productive microbial consortia in biotechnology – Measure, model, master

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PORTUGAL 2020

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