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WP3 DigiOmica collaborative learning in Integrated omics for environmental sustainability

Module 11: *Omics techniques for biotechnological applications*

- **Authors & Affiliation**

Lyudmila Velkova, Pavlina Dolashka, and Aleksandar Dolashki
Institute of Organic Chemistry with Centre of Phytochemistry - BAS

- **Educational goals**: the aim of this module is to present knowledge about the
  - Multiomics holistical approach in ecological research by using omics technologies
  - Omics techniques and approaches for biotechnological applications: biodegradation, bioremediation, sustainable agriculture, reduction/mitigation environmental damage
  - Prospects and challenges in bio-technological application of ”omics“ techniques

Summary

Contemporary environmental protection has emphasized how molecular and "omics" technologies can be used to determine the nature, behavior, and functions of microbial communities present in ecosystems to limit and eliminate pollution.Environmental "omics" aim to understand better the metabolic processes of a wide range of organisms and/or complex microbial communities to improve phenotype-genotype relationships, thereby providing new insights into the key molecules and processes responsible for the adaptation of organisms in response to environmental changes. Advances in new omics approaches (metagenomics, metatranscriptomics, metaproteomics, metabolomics, and fluxomics) and the applied multi-omics approach have led to invaluable information on microbial communities and essential biotechnological applications - from pollutant bioremediation to the design of innovative biosensors, screening for new catalysts or biological production of materials and products. The progress in "omics" technologies will allow us to explore and characterize new environments and processes to develop and optimize new biotechnological applications.

- **Expected learning outcomes**: Upon completion of this Module the learners will be able to:
  - Describe the omics approaches in ecological research
  - Present the role of a holistic multiomics approach for bioremediation and environmental protection.
  - Reveal the potential of multiomics techniques and approaches for biotechnological applications in an environmental context
  - Explain a multimix solution for developing biotechnology to reduce oil pollution and mitigate environmental damage
  - Define the main perspectives and challenges in the application of Omics techniques for biotechnological applications in an environmental context.

Provisional Table of contents

Presentation of the learning content

1. Introduction

1.1. **Major environmental problems** resulting from industrialization and anthropogenic activity

- High levels of toxic chemicals, non-degradable pollutants, and industrial waste
- Climate changes.
- Environmental pollution - impact on biodiversity and human health

1.2. **Bioremediation** – potential for restoration of polluted regions through nature-friendly practices

- Using different types of organisms to remove pollutants from soil, water, and air
- Main methods: natural attenuation, biostimulation, bioaugmentation

Presentation of the learning content

2. Findings - Omics approach in ecological research

2.1. **Basic omics techniques related to ecological applications and holistic multi-omics approach**

- Metagenomics, metatranscriptomics, metaproteomics, metabolomics and fluxomics
- A holistic approach to better understand the role of the microbiome

2.2. **Major biotechnological applications of environmental omics**

- Bioremediation, Biosensors, Discovery of therapeutic drugs, Bioproduction

Presentation of the learning content

3. Alternatives - omics techniques and approaches for biotechnological applications

3.1 Biodegradation of hazardous pollutants

- New opportunities for biodegradation of trichloroethene , trichloroethene and the toxic metabolite cis-dichloroethene (cDCE) accumulated in groundwater .
- *Polaromonas sp*. strain JS666 - the only bacterial isolate capable of using cis-dichloroethene (cDCE) as the sole source of carbon and energy.

3.2. Biodegradation and bioremediation of heavy metals

- Haloarchaeon *Haloferax mediterranei* - a good candidate for designing a bioremediation technology to remove copper in wastewater, enriched with nitrates, nitrites and (per)chlorates that are toxic to most living things

Presentation of the learning content

3. Alternatives - omics techniques and approaches for biotechnological applications

3.3 Development of inovation biosensors

- Identification of cell wall components of *Saccharomyces cerevisiae* responsible for distinguishing between light and heavy lanthanides

3.4. Ecological omics to increase crops yield, develop biofertilizers, and produce biostimulants

- Development of biostimulants – revealing the molecular 6mechanism by which *Herbaspirillum seropedicae* stimulates the early stage of development and increase yields in corn
- Biofertilizers - revealing the mechanism by which rhizobacteria in rice roots stimulate its growth and increase tolerance to NaCl in polluted soils

Presentation of the learning content

4. Solutions

4.1 A multiomix solution to reduce oil pollution and mitigate environmental damage

- Development of effective methods to reduce oil pollution and mitigate environmental damage by hydrocarbon-degrading microorganisms
- *De novo* transcriptomics, based on RNA-seq, and metagenomic analysis of *Achromobacter sp.* HZ01 - efficiently degrading hydrocarbons and producing biosurfactants
- Better understanding of the potential of hydrocarbon-degrading bacteria - future design of rational strategies for oil-contaminated bioremediation

Presentation of the learning content

5. Recommendations

- Omics approaches have made it possible to observe and measure biological systems with unprecedented precision and at continuously decreasing costs, it is only a matter of time before these approaches are fully integrated into environmental sciences.
- Single and multi-omics approaches enable researchers to provide novel insights regarding key biotechnologies to achieve One Health
- Multiomics and integromics approaches - the most promising for application in biotechnologies and progression in this field.
- Use of machine learning and big data for analysis of the vast amount and complexity of data generated through Single and multi-omics approaches

Presentation of the learning content

6. References

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