



DigiOmica

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WP3 DigiOmica collaborative learning in
Integrated omics for environmental
sustainability

Module 4: *Metabolomics: study microorganisms' response to environmental stressors*

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➤ **Educational goals:** the aim of this module is to present knowledge about

- Environmental Metabolomics

- Major categories of environmental metabolomics and related methodological and technical innovations

- Challenges and prospects of ecological metabolomic applications

➤ Summary

Metabolomics provides qualitative and quantitative analysis of thousands of naturally occurring small molecules (metabolites) required for maintenance, growth, and normal cellular function. Despite their size, they can cause severe disease, clean up contaminated soil and water, and drive biogeochemical cycles that shape the global climate. Microbial Metabolomics finds application in environmental, medical, and biotechnological fields. Environmental metabolomics studies the effects of the growth environment on the development of an organism in natural, uncontrolled conditions. Environmental metabolomics studies also the impact of environmental stress (pollution and climate change) on the health of organisms that live in our natural environment. Application areas of environmental metabolomics include aquatic and terrestrial toxicology, organism diseases, environmental monitoring, and ecological risk assessment. Tools used to measure metabolite levels include nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry. Due to the huge amount of data collected from the experiments, mathematics and computer science are applied to analyze them.

- **Expected learning outcomes:** Upon completion of this Module the learners will be able to:
 - Describe the principles of metabolomics/environmental metabolomics
 - Apply metabolomics studies to assess metabolites and ecosystems and communities diversity
 - Define the major categories of environmental metabolomics research
 - Explain the environmental metabolomics application for metabolic engineering, microbial ecology, and environmental research
 - Define the challenges, limits, and perspective of environmental metabolomics

➤ **Provisional Table of contents:**

1. Introduction
2. Metabolomic diversity of ecosystems
3. Metabolomics and environmental microbiology
4. Modeling laboratory studies of environmental metabolites
 - 4.1. Categories of environmental metabolomic studies
5. Metabolic engineering
6. Resistance to environmental stress factors
 - 6.1. Environmental metabolomics : the body's responses to stressors
 - 6.2. Metabolomics analyses on microbial primary and secondary oxidative stress responses
 - 6.3. Metabolic stress in bacteria caused by environmental metal pollution
7. Methodological and technical novelties
8. Challenges and prospects of ecological metabolomics
 - 8.1. Application of microbial metabolomics - Creative Proteomics
 - 8.2. Application of metabolomics to characterize environmental pollutant toxicity and disease risks
9. References

➤ Presentation of the learning content

1. Introduction

- **What is metabolomics** and its contribution to the identification and quantification of metabolites in the cell and the discovery of the mechanisms of basic cellular processes
- **What is environmental metabolomics** - an application area of metabolomics studying the effects of the growth environment on the development of the organism in natural, uncontrolled conditions.
- **Potential of environmental metabolomics**
- **Challenges of environmental metabolomics** in data presentation and interpretation

➤ Presentation of the learning content

2. Metabolomic diversity of ecosystems

3. Metabolomics and environmental microbiology

3.1 Metabolomic studies of natural microbial communities:

➤ Meta metabolomics - analysis of the collective metabolome of microbial communities

➤ Natural microbial communities - surface water (specific ecological niches), groundwater, soil, etc.

➤ Unraveling the functional significance of microbiome diversity - characterizing and summarizing metabolomic diversity through a specialized toolkit of statistical methods

➤ Presentation of the learning content

4. Modeling of laboratory studies of metabolites from the environment

- Categories of environmental metabolomic studies
- Methodological and technical innovations
- Summary of new developments in the technology, progress in identification and structural characterization of the metabolome
- Advantages and obstacles in the application of the various techniques (NMR, mass spectrometry, and others.)
- Bioinformatics

➤ **Presentation of the learning content**

5. Metabolic engineering

6. Resistance to environmental stress factors

6.1 . Environmental metabolomics : the body's responses to stressors

6.2 . Metabolomics analyses on microbial primary and secondary oxidative stress responses

6.3 . Metabolic stress in bacteria caused by environmental metal pollution

➤ **Presentation of the learning content**

7. Methodological and technical innovations

➤ Metabolomics Advances in Aquatic Ecotoxicology

➤ New statistical challenges

8. Challenges and perspectives of the ecological metabolomics

8.1. Application of microbial metabolomics - Creative Proteomics

8.2. Application of metabolomics to characterize environmental pollutant toxicity and disease risks

9. References

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