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WP3 DigiOmica collaborative learning in Integrated omics for environmental sustainability

Module 3: *Advanced environmental proteomics*

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- **Educational goals**: the aim of this module is to present knowledge about
  - Proteomics and Environmental proteomics essentials
  - Main categories of environmental proteomics and the relevant to them methodological and technical innovations
  - Challenges, frontiers, and perspective of environmental proteomics applications

Summary

Environmental proteomics is a proteomics application area studying the effects of growth environments on organism development in natural, non-controlled conditions. This proteomics branch contributes to the proteins expressed in the cell, identification and quantitative determination, the discovery of the mechanisms of essential cellular processes, and the elucidation of phenomena like syntrophy, gene exchange, and cell-to-cell communication at the molecular level. Environmental proteomics investigates microbial-dominated organisms' assemblages and designs differential protein production and expression patterns that reflect physiological responses to environmental changes (*in norma* and under stress). It performs laboratory surveys with model environmental microorganisms and studies natural microbial communities, analysing their collective proteome (metaproteomics). Environmental proteomics has diverse research and application areas (e.g., metabolic engineering, microbial ecology, environmental stress tolerance, etc.) due to the methodological and technical innovations (e.g., 2D PAGE, LC, ICAT, MS, phage display, bioinformatics. etc.) that allow protein identification and structural characterization.

- **Expected learning outcomes**: Upon completion of this Module the learners will be able to:
  - Describe the principles of proteomics / environmental proteomics
  - Apply proteiomics studies for assessment of protein diversity of ecosystems and communities
  - Define the main categories of environmental proteomics studies
  - Explain the application of environmental proteomics for metabolic engineering, microbial ecology surveys and environmental stress tolerance assessment
  - Specify the challenges, frontiers, and perspective of environmental proteomics

Provisional Table of contents:

Presentation of the learning content

1. Introduction

- **What is Proteomics** and its contribution to the identification and quantitative determination of the proteins expressed in the cell and the discovery of the mechanisms of essential cellular processes.
- **What is Environmental proteomics** – a proteomics application area studying the effects of growth environments on organism development in natural, non-controlled conditions.
- **Environmental proteomics potential** to bring insight at the molecular level into phenomena like syntrophy, gene exchange, and cell-to-cell communication
- **Environmental proteomics challenges** in performance and data interpretation

Presentation of the learning content

2. The protein diversity of ecosystems and communities

- The **proteins use** as:
  - The most closely related to functioning of the ecosystems
  - The most direct measure of molecular phenotypes

- **Community proteomics & Environmental proteomics** - survey microbial-dominated organisms assemblages and design of patterns of differential protein production and expression that reflect physiological responses to environmental changes (*in norma* and under stressful conditions)

- **Scaling the results** from microbial assemblages to more complex ecological systems

Presentation of the learning content

3. Categories of environmental proteomics studies

3.1 Model environmental microorganisms' laboratory surveys:

- g. *Bacillus* – sporulation and biofilm formation
- g. *Pseudomonas* – toxic substances degradation, biofilm formation, flexible metabolism
- *g. Halobacteria* and g. *Haloarchaea* – atypical metabolism
- Genera with bioremediation potential – *Shewanella, Desulfovibrio*, sulphate-reducers, etc.
- Genera with methanogenesis, denitrification and dehalogenation potential
- Fermenting organisms – LAB, Saccharomyces yeasts
- Cyanobacteria – proteomics on different life styles (especially under stress conditions)

Presentation of the learning content

3. Categories of environmental proteomics studies

3.2 Proteomic studies of natural microbial communities:

- Metaproteomics - analysis of the collective proteome of microbial communities
- Natural microbial communities - surface waters (specific ecological niches), ground water, soil
- Revealing functional significance of protein diversity - characterizing and summarizing proteomic diversity through specialized toolbox of statistical methods

Presentation of the learning content

4. Environmental proteomics research and application areas

4.1 Metabolic engineering

- *E. coli* – biodegration potential, insertion of protective enzymes

4.2 Microbial ecology

- Insights into the mechanisms of adaptation (high- and cold-temperature extremities

4.3. Environmental stress tolerance

- Studying the regulation of stress responses – detoxification/adaptation strategies

Presentation of the learning content

5. Environmental proteomics potential

5.1 Methodological and technical innovations

- Synopsis of new developments in technology, critical to the advancement of protein identification and structural characterization
- Advantages and obstacles in the application of the various techniques (2D PAGE, LC, ICAT, MS, phage display, etc.)
- Bioinformatics

Presentation of the learning content

5. Environmental proteomics potential

5.2 Experimental environmental proteomics in a glance

- Molecular phenotyping - insight into recognizing the functions of proteins
- Measuring the ecological proteome in response to species removals/additions
- New statistical challenges

Presentation of the learning content

6. Challenges, frontiers, and perspective of environmental proteomics

- **Challenges** - the proteins nature compared to DNA, the extraction of cellular proteins from high-solids matrices and composite media, the complex instrumentation, the need for improved bioinformatics tools, and the integration of proteomics with genomics and metabolomics data

- **Frontiers** – approaches in studying microorganisms in environments of interest in medicine, practice differential proteomics, promise in novel drug discovery

- **Perspective** - make accurate predictions about microbial activities and apply this knowledge to improve environmental quality

Presentation of the learning content

7. References

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