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WP3 DigiOmica collaborative learning in Integrated omics for environmental sustainability

Module 1: *Genomics: environmental DNA and sampling*

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- **Educational goals**: the aim of this module is to present knowledge about
  - eDNA as a tool for monitoring species, populations and communities at molecular level
  - eDNA sampling ant its technical challenges and drawbackse
  - DNA application areas and future potential

Summary

The advancement of DNA-based approaches for genome data generation and interpretation encompasses, among others, the study of the genomes at an environmental scale using environmental DNA (eDNA). eDNA is the genetic material of nuclear and mitochondrial origin released from an organism in the environment. It is obtained directly from environmental samples (terrestrial or aquatic) without the necessity of biomaterial availability and used as an efficient, easy-to-manipulate, and standardized, non-invasive sampling approach. Thus, eDNA sampling is applied for species distribution monitoring and operates through sensitive and cost-effective protocols. Although the current technical challenges and drawbacks that scientists face are related mainly to the pitfalls in eDNA obtaining, sequencing, and data interpretation, the potential of eDNA applications is undoubtful. The perspectives on eDNA applications cover the field methods and laboratory protocols improvement for its detection and technical advancements in eDNA application as a biodiversity inventory and monitoring tool.

- **Expected learning outcomes**: Upon completion of this Module the learners will be able to:
  - Define eDNA as a tool for monitoring species, populations and communities at molecular level
  - Explain the application areas of eDNA of microbial origin and macro-organisms in different habitats and time frames
  - Recognize and apply eDNA sampling protocols for monitoring species distribution
  - Explain the technical challenges and drawbacks of eDNA sampling and data interpretation
  - Understand the eDNA applications potential

Provisional Table of contents:

Module 1

Presentation of the learning content

1. Introduction

- Sampling, extraction and analysis of DNA persisting in the environment - essential technological and scientific innovation of the last decade
- eDNA application in fundamental and applied research in molecular biology, environmental science, ecology, palaeontology, etc.
- NGS and DNA metabarcoding – powerful multiple-species eDNA approach

2. Genomics at a glance: DNA-based approach for genome data generation and interpretation

Presentation of the learning content

3. Environmental DNA

3.1. Definition – eDNA as a tool for monitoring species, populations and communities at molecular level

- eDNA approaches and their achievements in describing ecosystems biodiversity and use for its conservation
- Proving the universality of the eDNA approach for studying micro- and macro-organisms in various environments and time frames

Presentation of the learning content

3. Environmental DNA

3.2. eDNA application areas

- eDNA of microbial origin in terrestrial and aquatic habitats for biodiversity monitoring: studying the microbial populations incl. non-culturable representative
- eDNA of macro-organisms: biodiversity assessment in ancient and modern times context: exploring ancient terrestrial and aquatic sediments; modern surface soil, fresh and sea water, ice cores

- **Presentation of the learning content**

4. eDNA sampling for monitoring species distribution

4.1. eDNA protocols development

- Site occupancy detection models and optimal survey design methods

- eDNA sampling and extraction, primers and probe design; qPCR amplification; data storage and analyses

Presentation of the learning content

4. eDNA sampling for monitoring species distribution

4.2. Technical challenges and drawbacks

- Pitfalls in eDNA obtaining and sequencing:

  - ✓ field-based sampling sources of errors
  - ✓ design of molecular assays
  - ✓ contamination and inhibition errors

Presentation of the learning content

4. eDNA sampling for monitoring species distribution

4.2. Technical challenges and drawbacks

- Data interpretation challenges:

  - ✓ Detection of single species *vs.* DNA barcoding approach
  - ✓ DNA sequence errors
  - ✓ Reference DNA databases
  - ✓ Results interpretation

Presentation of the learning content

5. The eDNA applications potential

5.1 Improvement of field methods and laboratory protocols for eDNA detection

- Detection probability and field-negative controls: detection lower limits; dependence on species density, size, behavior, and habitat
- eDNA spatial and temporal distribution optimization
- The exact sources of eDNA variations and obtaining DNA fragments longer than 100–200 bp

Presentation of the learning content

5. The eDNA applications potential

5.2 Advancements in eDNA application as a biodiversity inventory and monitoring tool

- Tissue-specific differences in gene expression - limits of extrapolation
- Precise links between eDNA concentration and species abundance
- Physical/chemical factors influencing eDNA availability and degradation

Presentation of the learning content

7. References

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