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WP3 DigiOmica collaborative learning in Integrated omics for environmental sustainability

Module 2: *Transcriptomics: addressing ecological niches*

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- **Educational goals**: the aim of this module is to present knowledge about
  - Transcriptomics and Landscape transcriptomics essentials
  - Performance of transcriptomic studies of non-model microorganisms in natural environments
  - Challenges and perspectives of landscape transcriptomics

Summary

Landscape transcriptomics explores RNA transcripts (mRNA and different small RNAs) in a given environmental sample at the time of its collection. This emerging branch of transcriptomics reveals the links between genetic and phenotypic variations and landscape-scale processes to determine how genome expression patters reflect the environmental landscape through organismal functioning and genetic differentiation among populations. Landscape transcriptomics performs gene flow, genetic drift, and local adaptation studies across large spatial scales. It explores high-throughput, standardized, and readily applied to a diversity of organisms, techniques (DNA microarrays and RNAseq technology). Landscape transcriptomics assesses the impact of natural environmental stimuli and their fluctuations (e.g., stress conditions) on gene expression and transcriptomic responses at population level. Furthermore, it provides useful data for organism - environment relations in conservation practices management. Landscape transcriptomics possesses great potential to study organisms with no genomic resources, identify novel transcripts, and elucidate the role of transcriptional modulation.

- **Expected learning outcomes**: Upon completion of this Module the learners will be able to:
  - Describe the principles of transcriptomics / landscape transcriptomics
  - Apply Landscape transcriptomics approaches in ecology, evolution, and conservation
  - Define the main categories of Landscape transcriptomics studies of wild systems in natural environments
  - Explain the approaches for collection, analysis, and explanation of transcriptomics data from natural environments
  - Understand the gene expression as a time-based and tissue specific process

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Presentation of the learning content

1. Introduction

- **What is Transcriptomics** and its contribution to the understanding of the cellular processes, pathways, and mechanisms regulation through specific gene expression
- **Overview of Transcriptomic technologies** advancement
- **Transcriptomics *vs.* traditional phenotypic and physiological response** measurements
- **The genes expression as a principle definer of the fundamental niche of an organism** in conjunction with abiotic and biotic factors

Presentation of the learning content

2. Landscape transcriptomics – the essentials

2.1 What is landscape transcriptomics

- Enabling gene flow, genetic drift, and local adaptation studies across large spatial scales
- Revealing the links between genetic and phenotypic variation, and landscape-scale processes

- Uses high-throughput, standardized, and readily applied to a diversity of organisms techniques, which makes this approach accessible and versatile

Presentation of the learning content

2. Landscape transcriptomics – the essentials

2.2 Landscape transcriptomics approaches in ecology, evolution, and conservation

- Transcriptome changes in compliance with environmental factors variations
- Transcriptomic responses to environmental changes at population level
- Transcriptome - environment relations in conservation practices management
- Landscape transcriptomics in practical context

Presentation of the learning content

3. Landscape transcriptomics studies of wild systems in natural environments

3.1 Studies trough whole-genome quantification techniques

- **DNA microarrays** - simultaneously measured genome-wide gene expression on large numbers of individuals in wild populations
- **RNAseq technology -** next-generation sequencing of a cDNA library to characterize RNA transcripts.

3.2 Gene expression variation in evolutionary background

- Review of the useful tools for identifying the **main expression variation** within populations, incl. contribution of neutral and adaptive processes to differential expression patterns

Presentation of the learning content

3. Landscape transcriptomics studies of wild systems in natural environments

3.3 Gene expression variation in response to environmental stimuli

- Effect of environmental stimuli on gene expression
- Impact of natural environmental fluctuations
- Gene expression responds to environmental stress

3.4 Gene expression and phenotype relationship

- Ecological and evolutionary processes influence on phenotypes – revealing the molecular mechanism

Presentation of the learning content

4. Challenges and perspectives of landscape transcriptomics

4.1 Collection, analysis, and explanation of transcriptomics data from natural environments

- The problem of environmental stochasticity
- Difficult detection of an average population response to the environment
- Pooling samples amplifies mean differences between populations and downplay individual variation

Presentation of the learning content

4. Challenges and perspectives of landscape transcriptomics

4.2 The gene expression as a time-based process

- Designing experiments that include multiple time-points and account for temporal environmental changes
- Use of microbial systems as experimentally tractable models for probing landscape transcriptomic questions relevant to macroscopic organisms

4.3 Tissue specific responses and transcriptomics studies

- Tissue-specific differences in gene expression - limits of extrapolation

Presentation of the learning content

4. Challenges and perspectives of landscape transcriptomics

4.4 The future of landscape transcriptomics

- Studies of organisms with no genomic resources
- Identification of novel transcripts - surveying ecologically relevant candidate genes of interest for disease and response to environmental conditions
- Application of landscape transcriptomics for identification of the causal elements of phenotypic change in wild populations
- Use of landscape transcriptomics to elucidate the role of genomic elements that precede, regulate, and follow transcriptional modulation
- Use of landscape transcriptomics as a tool for measuring the final impact of gene regulation on phenotype

Presentation of the learning content

7. References

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