

Unveiling the Dynamic Interactions: Genomics, Metabolomics, and Morphological Assessment



Gamete and Embryo Selection: Genomics, Metabolomics and Morphological Assessment (SpringerBriefs in Reproductive Biology)

★★★★★ 5 out of 5

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In the realm of scientific exploration, the intersection of multiple disciplines holds the potential to unlock unparalleled insights into the complexities of living organisms. ***Genomics, Metabolomics, and Morphological Assessment***, a groundbreaking publication from Springer, delves into this fertile interdisciplinary space, showcasing the transformative power of integrating these distinct approaches to unravel the mysteries of biological systems.

Genomics: Decoding the Blueprint of Life

Genomics, the study of an organism's entire genetic material, has revolutionized our understanding of biological processes. By sequencing and analyzing genomes, scientists can uncover the intricate genetic

architecture that underlies an organism's traits, development, and response to environmental cues. This knowledge has profound implications for fields ranging from medicine to evolutionary biology.



Metabolomics: Capturing the Metabolic Fingerprint

Metabolomics, the study of small molecules within an organism, offers a complementary lens into biological systems. These metabolites are the

building blocks and end products of cellular processes, providing a real-time snapshot of an organism's metabolic state. By analyzing metabolomes, researchers can gain insights into metabolic pathways, disease biomarkers, and responses to environmental stimuli.

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OPEN **Influences of chemotype and parental genotype on metabolic fingerprints of tansy plants uncovered by predictive metabolomics**

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Intraspecific plant chemodiversity shapes plant-environment interactions. Within species, chemotypes can be defined according to variations in dominant specialized metabolites belonging to certain classes. Different ecological functions could be assigned to these distinct chemotypes. However, the roles of other metabolic pathways and the parental origin (or genotype) of the chemotypes remain poorly explored. Here, we first compared the capacity of terpenoid profiles and metabolic fingerprints to distinguish four chemotypes of common tansy (*Tanacetum vulgare*) and depict metabolic differences. Metabolic fingerprints captured higher variation in metabolites while preserving the ability to define chemotypes. These differences might influence plant performance and interactions with the environment. Next, to characterize the influence of the maternal origin on chemodiversity, we performed variance partitioning and generalized linear modeling. Our findings revealed that maternal origin was a higher source of chemical variation than chemotype. Predictive metabolomics unveiled 134 markers predicting maternal origin with 82% accuracy. These markers included, among others, phenolics, whose functions in plant-environment interactions are well established. Hence, these findings place parental genotype at the forefront of intraspecific chemodiversity. We recommend considering this factor when comparing the ecology of various chemotypes. Additionally, the combined inclusion of inherited variation in main terpenoids and other metabolites in computational models may help connect chemodiversity and evolutionary principles.

The evolution of plant metabolism has affected the diversity of systems for decades^{1–3}. Chemical diversity in plants is dynamic, while exploration of its role and impacts are still elucidated especially regarding intraspecific chemodiversity⁴. Previous studies revealed high intraspecific chemodiversity in various species and linked metabolic variation to individual ecological strategies^{5–7}. In some plant species displaying high intraspecific chemodiversity, individuals cluster in breeding and distinct chemotype groups that are comprised of sets of individual compounds belonging to a specific group and cluster class such as tricyclic sesquiterpenes (chemotaxa) or flavonoids (chemovariants) available for “resource sharing”⁸. The strategy of resource sharing might account for their chemodiversity and could be interpreted as a consequence of the ecology and evolution of plant life chemotypes. For instance, single plant families can produce a variety of different metabolites (chemotypes), which are determined by their geographical origin. Evolution in the chemotype pool could be induced by the surrounding biotic pressure and could result in a “resource sharing” between “close species”⁹. Moreover, high intraspecific diversity in plant species can be caused by different factors and different chemotypes may share phenotypic traits^{10,11}. However, this study does not capture a significant number of intraspecific observations. As a result, it fails to cover the “chemotype limit”, i.e., the “least distinct ecological function”¹². However, the literature clarifies very well between chemotypes and least distinct ecological functions¹³.

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Morphological Assessment: Unveiling Physical Form and Function

Morphological assessment involves the detailed examination and measurement of an organism's physical characteristics. This approach complements genomics and metabolomics by providing direct information about an organism's shape, size, and structural features. Morphological data can reveal insights into an organism's adaptations, evolutionary relationships, and health status.

The Integrative Approach: Unveiling the Interconnected Web of Life

By combining genomics, metabolomics, and morphological assessment, researchers can gain a holistic view of biological systems that transcends the limitations of any single approach. This integrative approach allows scientists to:

- Identify the genetic basis of morphological traits
- Understand how metabolic pathways influence physical development
- Determine the impact of environmental factors on genomic, metabolic, and morphological profiles
- Develop novel diagnostic and therapeutic strategies based on a comprehensive understanding of biological systems

Applications Across Diverse Disciplines

The integration of genomics, metabolomics, and morphological assessment finds applications in a wide range of scientific fields, including:

- **Medicine:** Identifying genetic and metabolic biomarkers for disease diagnosis and prognosis, developing personalized treatments, and understanding the genetic basis of complex diseases
- **Evolutionary Biology:** Tracing evolutionary relationships and adaptations by comparing genomic, metabolic, and morphological profiles across species
- **Ecology:** Assessing the impact of environmental pollutants and climate change on organisms by monitoring their genomic, metabolic, and morphological responses

- **Agriculture:** Optimizing crop yield and resilience by studying the genetic and metabolic basis of plant traits

Challenges and Future Directions

While the integration of genomics, metabolomics, and morphological assessment offers tremendous potential, it also presents challenges. These include:

- Data integration: Managing and analyzing large and complex datasets from multiple sources
- Methodological standardization: Ensuring consistency and comparability of data across different studies
- Computational tools: Developing advanced algorithms and software to facilitate data analysis and interpretation
- Collaboration: Fostering interdisciplinary collaborations between geneticists, metabolomics experts, morphologists, and computational scientists

Overcoming these challenges will pave the way for even more transformative discoveries in the future. The continued advancement of genomics, metabolomics, and morphological assessment, both individually and in combination, holds the promise of deepening our understanding of life's intricacies and unlocking new frontiers in scientific exploration.

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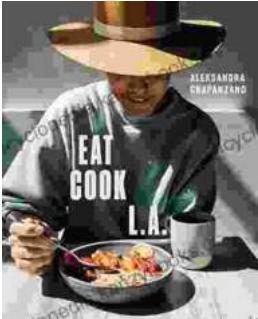
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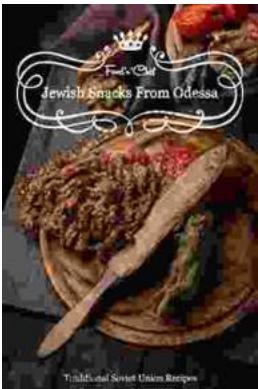
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