



Contribution ID : 64

Type : Oral

## Single-nuclei transcriptomics reveals a novel frond nutrient-uptake cell type in duckweeds

*martedì 29 settembre 2026 10:00 (15)*

Duckweeds are unusual among angiosperms in being able to acquire nutrients through the shoot rather than the root. We previously showed that their roots are dispensable for this ancestral function, and that they have lost root-biased nutrient transporter expression (Ware et al., 2023). The cellular biology underpinning shoot nutrient uptake, and its evolution, remain unknown.

To address this, we generated single-nucleus transcriptomic atlases of shoots and roots from *Spirodela polyrrhiza*, *Lemna minor* and *Wolffia australiana*, alongside the aroid *Pistia stratiotes*, which independently colonised the free-floating aquatic niche. Integration of these datasets across species revealed a previously undescribed cell population, conserved across all duckweed shoots, whose identity does not readily correspond to known cell types in terrestrial monocots. This novel cell type expresses a broad suite of nutrient-uptake genes canonically restricted to the root in terrestrial species. In *Lemna minor*, optimisation of whole-mount hybridisation chain reaction FISH has spatially localised this cell type to the underside of the frond, extending one to two cell layers deep into the abaxial frond body. The abundance of this cell type increases across the duckweed genera as the root is reduced, and it is scarce in root-reliant *Pistia*.

We propose that this cell population constitutes a dedicated nutrient-uptake tissue in the duckweed frond. Functional characterisation of the cell type, the transporters it expresses, and the evolution of the regulatory network governing its identity is now ongoing.

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### Scientific Session

Cell Biology, Physiology, Metabolisms

### Keywords

cell identity; single-nuclei transcriptomics

### References

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**Session Classification :** Cell Biology, Physiology & Metabolisms I