Alternatives beyond *Arabidopsis*?

You're likely familiar with *Arabidopsis thaliana*, often referred to as the lab rat of plant science. It has all the traits of a traditional biological model - and also has a small genome - an important characteristic for models over the last 50 years as the fields of genetics and genomics have grown.

While research using *Arabidopsis* has greatly expanded our knowledge of plants and biology more broadly, **some questions can't be answered using this model alone**. And sometimes it's fun to work with other organisms as well!

So here you will find an overview of some **lesser-known and emerging model systems for plant biology** that you might consider for your next project. Take a look!

4 HOT & NEW ✨

PLANT MODELS FOR 2024

A new year begins and also new projects in plant sciences. Whether you are a PhD student or a PI, **selecting the right model organism could be a decision that impacts your work and what kind of questions can you answer**. Do you want to know what new plant model options are out of there?

By Andy Hempton, Alicia Quinn & Isabel Pochet
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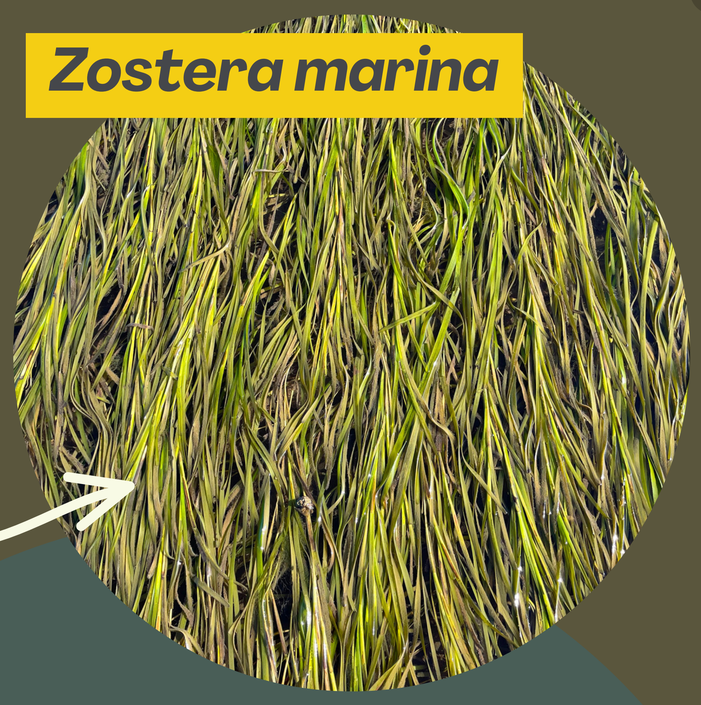
Zostera is the most studied seagrass to date! What makes this plant interesting is that it is not only a keystone species in its environment, with essential structural (providing habitats for animals and invertebrates) and functional (erosion prevention, absorption of pollutants, and sequestration of carbon) roles, but also plants in this family achieved the **single most extreme habitat shift among angiosperms**, which makes them excellent organisms to study plant adaptation to environmental change.



Zostera marina

Hot traits:

- Capable of **both clonal and sexual reproduction**.
- Extreme habitat provides a wealth of anatomical adaptations, providing **insights into the evolution and/or loss of key morphological features**.
- Long-lived clonal populations provide a unique genetic resource in the investigations of species-to-population level responses to environmental change.
- **Fully sequenced genome**.
- A long history of **cultivation in the lab**.

Important facts:

- Used as a model to study a **broad range of topics** (ecological, organismal, physiological, and genetic), being unique among many modern model species.

Marchantia polymorpha

How not to love the common liverwort, *Marchantia polymorpha*? This plant is not new to plant science - it's been used for hundreds of years to investigate topics in botany, developmental biology, and cell theory!

But over the last 20 years, it has reemerged as a **model for genetics and genomic studies**, with its place in the bryophyte lineage making it a great tool to study **questions related to plant evolution**.

Hot traits:

- Can **be easily propagated by spores** (sexual) or gemmae (vegetatively).
- It has **female & male individuals** that reproduce by specialized reproductive structures (antheridia & archegonia) that develop on the body of the thallus.
- Can **reproduce vegetatively** through 'gemmea', which are clonal structures produced on the thallus body.
- Can grow on agar media. Easy settable grow conditions.
- **Full genome sequenced**. Small genome size & small gene number.
- Several genetic tools and bioinformatic platforms are available.

Important facts:

- Has rhizoids (not roots).
- Lacks vasculature and lignification.
- Slow grow rate.

Duckweeds (Lemnaceae)

The duckweeds encompass different aquatic plant species, all of them with similar habits and traits. These little plants are used as a **bioremediation system and their potential for capturing water pollutants such as nitrogen, phosphorus, and carbon has been explored**. Their rapid growth and size make these plants attractive to adopt as model organisms!

Hot traits:

- **Fastest growing** flowering plants.
- Small size, easy culture, and growth systems.
- **Sequenced genomes** and epigenomes.

Important facts:

- Used in photosynthesis studies.
- Commercial potential. This plant has a high % of protein and is used to produce plant-based protein isolates for bulking and sportsman biomass gain.

Physcomitrium patens

Being the sister to vascular plants, *P. patens* is a **valuable system to study the evolution of genes**, tissues, and organs, crucial to the radiation of land plants! Anatomically simple, this plant is emerging as a platform whose genes can be easily manipulated, offering information about plant evolution and adaptation.

Hot traits:

- Reproduction can be **easily manipulated through photoperiod**. A short-day photoperiod quickly induces the formation of sexual reproductive organs in individuals.
- Plants can be **fully regenerated** from a single protoplast in tissue culture.
- **Minimal needs** for optimal growth conditions.
- Small plant. Llend to an **ease of use in microscopic** observations.
- **A fully sequenced genome** is available. At least three well-annotated accessions are available**.**

Important facts:

- Minimal requirements for growth and small stature have also facilitated the **adoption of microfluidic imaging techniques**, allowing live imaging of *P. patens* to observe continuous maturation of tissues, and even allowing for the live viewing of sub-cellular processes.
- Strong research history as a **genetic system** in which to isolate and study the effect of mutations.
- Efficient pipeline for the **establishment of transgenic lines and quick adoption of CRISPR/Cas9** mediated mutagenesis.

More resources

- https://www.marchantia.org/
  https://www.openplant.org/marchantia
- https://www.lemna.org/

- Olsen et al., The genome of the seagrass Zostera marina reveals angiosperm adaptation to the sea. Nature 2016; doi: https://doi.org/10.1038/nature16548
- Rensing et al., The Moss Physcomitrium (Physcomitrella) patens: A Model Organism for Non-Seed Plants. The Plant Cell 2020. doi: https://doi.org/10.1105/tpc.19.00828
- Ernst et al., The genomes and epigenomes of aquatic plants (Lemnaceae) promote triploid hybridization and clonal reproduction(link is external). bioRxiv 2023.08.02.551673; doi: https://doi.org/10.1101/2023.08.02.551673
- Bowman et al., The renaissance and enlightenment of Marchantia as a model system. The Plant Cell 2022; doi: https://doi.org/10.1093/plcell/koac219