ARABIDOPSIS: THE MODEL PLANT

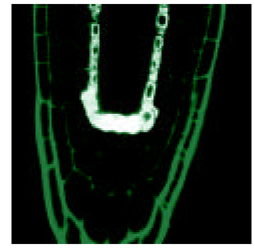
Photo credit: Luca Comai, University of Washington, USA

Arabidopsis thaliana is a small dicotyledonous species, a member of the *Brassicaceae* or mustard family. Although closely related to such economically important crop plants as turnip, cabbage, broccoli, and canola, *Arabidopsis* is not an economically important plant. Despite this, it has been the focus of intense genetic, biochemical and physiological study for over 40 years because of several traits that make it very desirable for laboratory study. As a photosynthetic organism, *Arabidopsis* requires only light, air, water and a few minerals to complete its life cycle. It has a fast life cycle, produces numerous self progeny, has very limited space requirements, and is easily grown in a greenhouse or indoor growth chamber. It possesses a relatively small, genetically tractable genome that can be manipulated through genetic engineering more easily and rapidly than any other plant genome.

Arabidopsis, like all flowering plants, dehydrates and stores its progeny at ambient temperature for long periods of time. This fact, together with a newly developed means of creating gene knockout lines, has made many basic biologists realize that *Arabidopsis* may be the best model system for basic research in the biology of all multicellular eukaryotes. A complete knockout collection of *Arabidopsis* seeds can be housed in a room no larger than a closet (see photo); to create and store a similar library of knockouts for mouse, flies and worms would be much more labor and space intensive. All together, these traits make *Arabidopsis* an ideal model organism for biological research and the species of choice for a large and growing community of scientists studying complex, advanced multicellular organisms.

Arabidopsis versus plants of economic significance

Why *Arabidopsis*? Why not concentrate our research efforts and resources on a species that will actually provide food for our world or useful products for industrial uses? In order to make the strides necessary to increase crop production in a relatively short time, we have to be able to move forward quickly and spend the available human and financial resources as efficiently as possible. This is the advantage of a model system: an organism that is easily manipulated, genetically tractable, and about which much is already known. By studying the biology of *Arabidopsis*, the model plant, we can gain comprehensive knowledge of a complete plant. In the laboratory, *Arabidopsis* offers the ability to test hypotheses quickly and efficiently. With the knowledge we gain from the model plant thus established as a reference system, we can move forward with research and rapidly initiate improvements in plants of economic and cultural importance.



One advantage offered to the plant researcher by *Arabidopsis* is its relatively small genome size. Many crop species have large genomes, often as a result of polyploidization events and accumulation of non-coding sequences during their evolution. Maize has a genome of approximately 2400 Megabase pairs (Mbp) – around 19 times the size of the *Arabidopsis* genome – with probably no more than double the number of genes, most of which occur in duplicate within the genome. The wheat genome is 16000 Mbp – 128 times larger than *Arabidopsis* and 5 times larger than *Homo sapiens* – and it has three copies of many of its genes. The large crop genomes pose challenges to the researcher, including difficulty in sequencing as well as in isolation and cloning of mutant loci.

Photo credit: Mike Sussman
University of Wisconsin

Evidence from the rice genome project suggests that the *Arabidopsis* genome may be missing some homologs of genes present in the rice genome. Despite this, most of the difference in gene number between *Arabidopsis* and crop species appears to result from polyploidy of crop species' genomes, rather than from large classes of genes present in crop species that are not present in *Arabidopsis*. Therefore, the genes present in *Arabidopsis* represent a reasonable model for the plant kingdom. However, it is clear that *Arabidopsis* represents a starting point rather than the finish line for utilizing the full power of genomics for crop improvement.

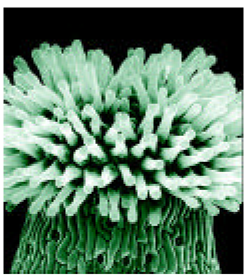
A tradition of Arabidopsis research

Arabidopsis has been the organism of choice for many plant biochemists, physiologists, developmental biologists and geneticists for several decades. In that time, a great deal of knowledge has been gained about the biology of this flowering plant. With the completion of the *Arabidopsis* genome sequencing project, we now have in hand the sequence of the approximately 25,500 genes in its genome. An extensive toolkit for manipulation has been developed over the last 20 years, including efficient mutagenesis, facile transformation technology, and DNA, RNA, protein, and metabolite isolation and detection methods. The biological reagents that have been made available to the community enable rapid research progress. Ongoing research within the community has resulted in working knowledge of many of the biochemical, physiological, and developmental processes of *Arabidopsis*.

Technological innovation and education

The availability of a broad base of knowledge about *Arabidopsis* and the previously developed research toolkit invites scientists to establish new techniques, develop new approaches, and test new concepts in *Arabidopsis* prior to their application in other species. The novel technologies made available in this way not only continually increase the efficiency of research done in *Arabidopsis*, but expose researchers, most importantly young scientists, to the most up-to-date methods in plant research, which they can apply to other species as they move forward in their career.

Arabidopsis research is the first step in an exciting future of plant improvement



Much work remains to be done before the goal of complete knowledge of the biology of even one plant species comes to fruition. It is essential that the work leading to the achievement of this goal be done as quickly and efficiently as possible. When we have achieved this ambitious goal, we will have the power to predict experimental results and the ability to efficiently make the rational improvements in crop species that will lead to increased food production, environmentally friendly agricultural practices, new uses for plants, and even totally new plant-based industries. The most efficient way to gain this understanding is by exploiting the scientific and practical advantages of the model organism *Arabidopsis thaliana*.