

*Arabidopsis thaliana* AS A TOOL TO TEACH PLANT GENETICS,  
THE RELATIONSHIP OF PLANTS WITH THE ENVIRONMENT,  
AND PLANT DEVELOPMENT

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Dear Science Teachers,

We are the **ABRC (Arabidopsis Biological Resource Center)**, a stock center that operates within the Ohio State University with a goal to collect, multiply and distribute seeds and DNA resources of the plant *Arabidopsis thaliana* to the research community.

*Arabidopsis thaliana* (Arabidopsis) has become not only a model plant, but also the reference plant as a result of 20 years of research. Arabidopsis is a relatively small, easy to grow plant with a fast generation time of about 6 weeks. Although a weed by systematic criteria, it is the most widely used plant model for geneticists, molecular biologists, developmental biologists and more recently, for all applied plant research. Thanks to its fully sequenced relatively small genome, self-fertility and other attributes, Arabidopsis is the plant with the most publications in leading scientific journals and also the third model organism (after mouse and fruit fly) ranked by number of publications in “Nature” and “Science” magazines in the last five years.

The ABRC hosts and manages more than 400,000 Arabidopsis seed stocks. This represents the largest collection of Arabidopsis seeds in the world and it is located just next door to your local school in the Plant Biotechnology Center at OSU. Many high school science curricula around the country have already started to use Arabidopsis as a way to introduce basic concepts in plant biology, development and genetics. As the global scientific and technological interest shifts towards plants, due to their unique property of CO<sub>2</sub> fixation and recently discovered potential in the field of biofuels, we feel that it is part of our duty to increase students’ awareness of these highly important organisms.

We propose 1-3 modules of research/demonstration classes, dependent on the complexity of the topic and the interest of the teachers/students. These modules could be introduced in grades 10-12, one per year. All the modules cover the theoretical basis of the biological phenomenon observed, as well as providing hands-on experience as a way to better understand the scientific process and underlying principles.

## Module 1

In the first module, students will be introduced to Mendelian genetics and the concepts of inheritance, segregation and variation. This will be achieved using four different Arabidopsis mutants that will be compared with the “wild-type” (normal) plant. The first goal of this module will be to observe and take records of various features of the Arabidopsis mutants (“phenotypes”). The four mutants (Figure 1) were selected to demonstrate a spectrum of various phenotypes that are easy to observe.

1. *glabra1* (lacks leaf hairs on stems and leaves)
2. *agamous* (flowers are characterized by the presence of petals and sepals only, without stamens or carpels as a result of a mutation in one of the genes that determines floral organ identity)
3. *apetala1* (sepals are converted to bracts, there are few or no petals)
4. *apetala1 cauliflower1* double mutant (inflorescence resembles a cauliflower)
5. wild-type (Landsberg erecta (Ler) accession).

In addition to observing phenotypes, some or all of the mutants could be used to follow segregation and inheritance, to better understand dominant and recessive characteristics and even to engage in crossing the mutant and wild-type individuals and observing their progeny in the F1 and F2 generations. The *glabra1* mutant has already been recognized as a good example, illustrating segregation and phenotypic variation, and an effective tool for teaching genetics at the high school level (Zheng, 2006).

### Main concepts:

- ❖ Inheritance
- ❖ Variation
- ❖ Segregation
- ❖ Dominant and recessive traits

## Module 2

In the second module, the concept of the influence of environmental conditions and other factors on Arabidopsis growth and development will be introduced. Students will observe the influence of light, temperature (chilling and heating), water supply, gravity, salt concentration and heavy metal concentration on plant stature, biomass, stem elongation, flowering time, movement, chlorophyll content and other determinants. The list of possible treatments does not end here. This just represents an example of some of the many environmental factors that influence the growth of wild-type Arabidopsis and the list could be modified and/or extended based on your specific needs. Positive experiences with studying gravitropism in the classroom have been published (Kiss et al., 2000). Furthermore, we can envision usage of another Arabidopsis mutant, called *chilling sensitive1*, to demonstrate the difference in cold temperature tolerance of this mutant in comparison to wild-type. A similar approach to test the influence of various environmental factors on growth of a series of Arabidopsis natural accessions (“ecotypes”) has already been successfully implemented in the classroom (Wyatt and Ballard, 2007).

### Main concepts:

- ❖ Growth
- ❖ Environmental conditions
- ❖ Natural variation

## Module 3

Module 3 presents the mutants in various hormone pathways and other developmental mutants. A few examples include *brassinosteroid insensitive1* (a semi-fertile dwarf), *auxin resistant1* (a dwarf with irregular rosette leaves), *clavata1* (having an increased number of floral organs and enlarged floral meristem), *brevipedicellus* (having short pedicels and downward curving siliques). In this module students would gain wide theoretical knowledge of the genes/proteins/small molecules that take part in the control of developmental processes. They

can also start picturing complex networks of pathways that act together resulting in a defined and recognizable ontogenic and phylogenic process of development.

**Main concepts:**

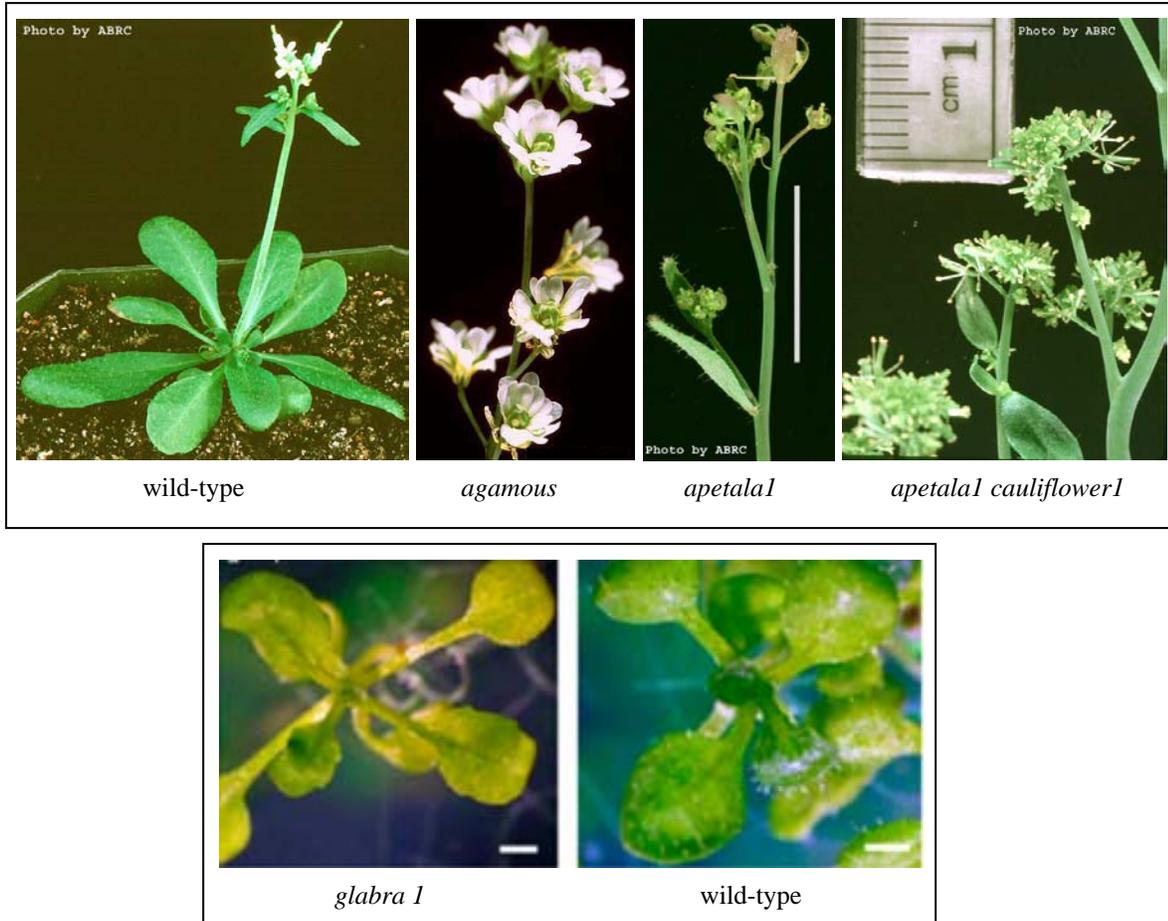
- ❖ Development
- ❖ Hormones
- ❖ Pathways and their cross-talk
- ❖ Molecular control of development

**References:**

Kiss, J., Weise, S.E., and Kiss, H. (2000). How Can Plants Tell Which Way Is Up? *The American Biology Teacher* 62(1): 59-63.

Wyatt, S., and Ballard, H.E. (2007). Arabidopsis Ecotypes: A Model for Course Projects in Organismal Plant Biology & Evolution. *The American Biology Teacher* 69(8): 477-481.

Zhang, Z.-L. (2006). Use of the *gll* Mutant & the *CA-rop2* Transgenic Plants of *Arabidopsis thaliana* in the Biology Laboratory Course. *The American Biology Teacher* online publication November/December: 148-153.



**Figure 1**

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