iTAG Barley STEM training advances hands-on science for secondary-school students

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Most students decide to pursue STEM careers in high school rather than college. Thus, professional researchers need to reach out to these students and their teachers what it means to "do science."

The Wise lab has developed iTAG Barley (iTAG = **I**nheritance of **T**raits and **G**enes), a grade 7-12 STEM outreach program, to help students understand the relationship between genotype (i.e., the genes contained within an organism) and phenotype (the organisms outward appearance). In other words, how does one's DNA affect how it looks and grows.

The iTAG Barley program is available with teacher and student versions in PDF or digital textbook format [**iTAG for iPad** (McGhee *et al.* 2016a, McGhee *et al.* 2016b)], and includes NSF-funded lab equipment to enable students to perform the experiments.

Figure 1 illustrates the extraordinary diversity exhibited by the Oregon Wolfe barley population, which forms the foundation for iTAG. These lines originate from a wide cross and have dramatic phenotypes, making it ideal for teaching phenotypic diversity, genetics, and genomics. Students observe plants for several traits, including two-row vs. six-row seed heads (encoded by *Vrs*, a

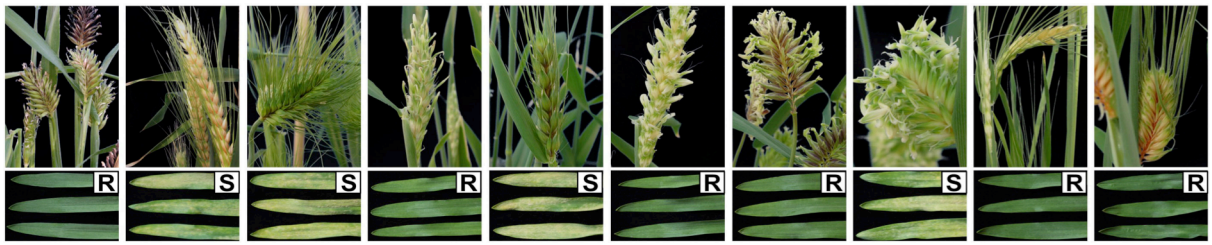


Figure 1. Oregon Wolfe Barley Informative and Spectacular Subset: Top: Spikes (flowers). Bottom: Powdery mildew infection phenotypes.

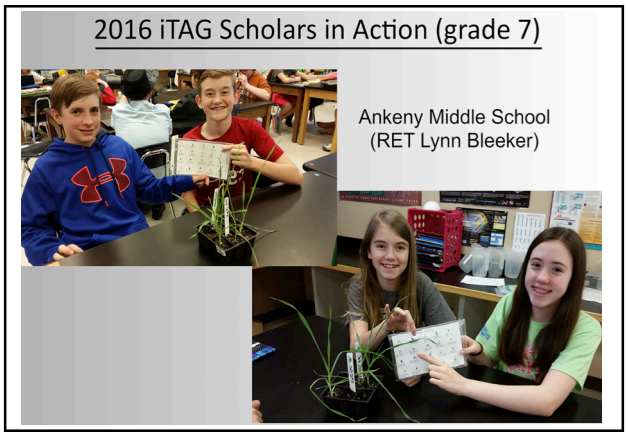
domestication trait) and hooded vs. non-hooded (encoded by *BKn3* - a homoeotic mutation where another spikelet replaces the awn). These phenotypes are discussed in the context of developmental mutations, grain domestication, and cellular pathways. Students grow plants, isolate DNA, perform PCR of the *Vrs*/*BKn3* genes, and visualize the PCR result on agarose gels. Inquiry-based activities have been designed to link gene function with the biological phenotypes. iTAG Barley is aligned to the national Next Generation Science Standards (NGSS) and is adaptable to any state science education standards.

iPath - Extending iTAG Barley into host-pathogen interactions for grades 7-12: The Oregon Wolfe barley lines also segregate for powdery mildew resistance (R) or susceptibility (S), due to the presence or absence of the *Mla6* allele, respectively (**phenotypes in Figure 1 above**]. This makes a natural connection between the genetics of the plant and its resistance to disease. We plan on adding a plant disease component by having students PCR-genotype *Mla* alleles in addition to the *Vrs/BKn3* genes. These PCR-genotypes can then be associated with OWB *Mla6* (resistant) vs. OWB *mla* (susceptible) plants.

Broader impacts: Young students are subjected to health/medical fields daily, but are not readily exposed to the fundamental concept of plant diseases in agriculture. The iPath experience will make students aware of the role of basic research in the sustainability of their food supply. iPath concepts will also be incorporated into our ongoing "Research Experience for Teachers" (RET) training. Each summer secondary school teachers have trained with the Wise group in 6-week sessions, over consecutive years. These RETs enhance the iTAG/iPath curriculum by incorporating new discoveries into the secondary school curriculum, using plant host-pathogen interactions to teach foundational concepts in heredity and ecological interactions.

These trainings have included workshops with our partners at Iowa State University, Ames, IA

(2014), Tuskegee University, Tuskegee, Alabama (2015) and Des Moines Area Community College, Ankeny, IA (2017). Collectively, 40 summer "Research Experience for Teachers" (RETs) have implemented the iTAG Barley curriculum in >170 classrooms from 2010-2017, impacting **over 4,200 students**, 1/3 of which were underrepresented from urban to rural communities**.**



RESOURCES:

McGhee, L., Hayes, N., Schuck, R., Maffin, L., Hall, G., Hubbard, T., Whigham, E., Fuerst, G. and Wise, R. (2016a) iTAG Barley: A grade 7-12 curriculum to explore inheritance of traits and genes using Oregon Wolfe barley v6 Student Edition. iBooks > Science & Nature > Life Sciences > Wise Lab: iTunes, pp. 46.

McGhee, L., Hayes, N., Schuck, R., Maffin, L., Hall, G., Hubbard, T., Whigham, E., Fuerst, G. and Wise, R. (2016b) iTAG Barley: A grade 7-12 curriculum to explore inheritance of traits and genes using Oregon Wolfe barley v6 Teacher Edition. iBooks > Science & Nature > Life Sciences > Wise Lab: iTunes, pp. 80.

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Joint NSF-PGRP / ERA-CAPS 1339348 'Host targets of fungal effectors as keys to durable disease resistance' 4/1/14 - 3/31/18, **R. Wise**, R. Innes, A. Bogdanove, D. Nettleton, F. Altpeter, A. Leshem, J. Jackson (in partnership with ERA-CAPS 'DURESTrit' investigators, P. Schweizer, IPK, Germany and P. Spanu, Imperial College, UK).