



Idea Bank

February 2011, Tips and Techniques for Creative Teaching

Electronic BeeSpace

Recent press coverage of the decrease in worldwide honeybee population (Kaplan 2010) has significantly increased public awareness of its ecological and economic importance. Honeybees' social nature, novel method of gender determination, distinctive caste system, and behaviorally and chemically based language make them immediately interesting to students.

This Idea Bank describes Electronic BeeSpace, an online video curriculum resource focused on bee biology. The recent completion of the genome of the most commonly domesticated honeybee, *Apis mellifera*, (Weinstock and Robinson 2006) makes this resource all the more timely.

Electronic BeeSpace can be used in introductory biology, genetics, biotechnology, ecology, and Advanced Placement (AP) biology classes to teach students about bee biology, nature vs. nurture controversy, Colony Collapse Disorder, molecular biology techniques, and behavioral genomics. Teachers can also use it as a professional development tool.

About the BeeSpace Project

The BeeSpace Project (see "On the web"), led by researchers at the University of Illinois and Wake Forest University, explores the genetic basis of honeybee behavior. BeeSpace scientists analyze social behavior on an unprecedented whole-genome scale, using *A. mellifera* as the model organism.

These honeybees live in a complex society governed by an age-related division of labor; each worker honeybee assumes many roles during her lifetime. Both genetic and environmental conditions determine what role a bee



PHOTO COURTESY OF THE AUTHOR

European honeybee worker (*Apis mellifera*) with full pollen sacs entering a flower.

performs, and when she performs it. (Note: All worker honeybees are female.)

Behavioral changes occur over the course of a worker bee's lifetime. During her first two to three weeks of life, a newly emerged worker (i.e., nurse bee) cleans cells and cares for the young. Shortly thereafter, she shifts to foraging for nectar and pollen—her job for the rest of her six-week life span (Fox 2003).

As this transition occurs, the bee experiences changes in its brain structure and chemistry (Barlow 2003). Recent studies have established statistically significant differences in the genes that are expressed and suppressed in nurses' and foragers' brains; these differences correspond specifically to the activities of the worker bee, not her age (Whitfield, Cziko, and Robinson 2003).

Experimental findings show that genes and behavior are more closely related than commonly believed—nature and nurture are closely intertwined (Whitfield et al. 2003). About 40% of a honeybee's genes are turned on and off as she matures from a nurse to a forager in her short, busy life (Fox 2003). Ac-

cording to Gene Robinson, BeeSpace's principal investigator, the genome responds dramatically to changes in the bee's social environment.

Honeybees' genes and behavior go together so strongly that an individual bee's occupation can be predicted by knowing the profile of her brain's gene expression. "We have discovered a clear molecular signature in the bee brain that is robustly associated with behavior," Robinson says. "This provides a striking picture of the genome as a dynamic entity, more actively involved in modulating behavior in the adult brain than we previously thought (Barlow 2003)."

About Electronic BeeSpace

Electronic BeeSpace (see "On the web") is an offshoot of the BeeSpace Project. This comprehensive internet-based video curriculum allows users to tour a beeyard; delve into behavioral genomics and molecular biology; and access scientists' presentations on bee biology, beekeeping history, colony management, Colony Collapse Disorder, and cutting-edge research involving bees as model organisms.

Electronic BeeSpace’s customizable curriculum includes eight hours of video-based materials and downloadable background documents drawn from the summer 2008 “Experiencing BeeSpace” workshop. All of the site’s components align with National Science Education Standards (NRC 1996; see “Addressing the Standards”). A planning guide—accessible from the home page—provides recommendations for planning presentations for different audiences (e.g., middle or high school biology or social science classes, 4-H, extension, environmental awareness groups).

In the classroom

Electronic BeeSpace modules can be mixed and matched to meet teachers’ professional development needs and the needs of individual classrooms and can be readily integrated into existing curricula. Each module includes “viewing questions” that allow teachers and students to focus on the main concepts. These questions provide an excellent starting point for individual or group exploration.

Each module also has a significant video component. Clicking on the module title brings the user to a page that allows him or her to

- ◆ learn more about the presenter,
- ◆ access a navigable outline of the presentation’s components,
- ◆ view a written transcript of the presentation, and
- ◆ use a search feature to find a specific term within that presentation.

Those wishing to view specific short sections or incorporate components into their own presentations can click the

“about” link following the presenter’s name. Videos, MP3 audio, slide sets, and transcripts are available here.

Electronic BeeSpace allows for great flexibility in audience focus and starting point. A particularly engaging starting point is the “Nature vs. Nurture” module, in which Robinson clearly explains recent findings from a variety of insect- and mammal-based research projects. After viewing instructor-selected components of the video and participating in a class discussion, students can pursue contributions of nature and nurture to human conditions such as heart disease, obesity, eating disorders, intelligence, drug addiction, depression, and schizophrenia.

Reed Larson’s “Colony Collapse Disorder” module introduces science as a collaborative effort in solving world problems. Colony Collapse Disorder is a phenomenon in which honeybees abruptly disappear from their hives (Kaplan 2010).

After viewing the teacher-selected components and participating in a class discussion, students can research current updates or investigate one of the factors thought to contribute to Colony Collapse Disorder. The *2010 Colony Collapse Disorder Progress Report* supports the hypothesis that the disorder is caused by a multitude of factors that differ from colony to colony (Kaplan 2010).

Through Nick Naeger’s “Molecular Biology Techniques” module, biotechnology, genetics, and AP biology teachers can introduce students to the use and integration of molecular biology tools (e.g., polymerase chain reaction, spectrophotometry, microarrays) in answering scientific ques-

tions. Students can then investigate the use of these technologies in forensic or crime scene–related situations.

Conclusion

Electronic BeeSpace provides a wide array of video and text-based resources that allow a great deal of flexibility in learning about honeybee biology, molecular biology lab techniques, and the use of those techniques to better understand the genetic basis of behavior in a model species. The economic importance of *A. mellifera* and the significance of its decline makes this area of biology research all the more timely and important.

David Stone (stone2@uni.uiuc.edu) is a teaching associate at University Laboratory High School in Urbana, Illinois; James

Addressing the Standards.

Electronic BeeSpace addresses the following National Science Education Standards (NRC 1996):

Science as Inquiry (p. 173)

- ◆ Abilities necessary to do scientific inquiry
- ◆ Understandings about scientific inquiry

Science and Technology (p. 190)

- ◆ Understandings about science and technology

Science in Personal and Social Perspectives (p. 193)

- ◆ Environmental quality
- ◆ Natural and human-induced hazards
- ◆ Science and technology in local, national, and global challenges



Idea Bank

Buell (jbuell@uiuc.edu) is a graduate student of educational psychology and Nicholas Naeger (nnaeger2@uiuc.edu) is a research assistant in entomology, both at the University of Illinois in Urbana.

Acknowledgment

The BeeSpace Project is a five-year, \$5 million project that began in 2004 and was funded by the National Science Foundation (FIBR Award #0425852).

On the web

BeeSpace Project: www.beespace.uiuc.edu

Electronic Beespace: www.beespace.uiuc.edu/ebeespace

References

Barlow, J. 2003. Gene expression tied to social behavior in honey bees. EurekaAlert. www.eurekaalert.org/pub_releases/2003-10/uoia-get100603.php

Fox, M. 2003. Gene scan tracks a bee as she grows up. PlanetArk World Environment News. www.planetark.org

Kaplan, K. 2010. USDA releases 2010 honeybee Colony Collapse Disorder progress report. United States Depart-

ment of Agriculture Agricultural Research Service. www.ars.usda.gov/is/pr/2010/101217.htm

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

Weinstock, G., and G. Robinson. 2006. Insights into social insects from the genome of the honeybee *Apis mellifera*. *Science* 443: 931–934.

Whitfield, C.W., A-M. Cziko, and G. Robinson. 2003. Gene expression profiles in the brain predict behavior in individual honeybees. *Science* 302 (5643): 296–299.

TEACHERS IN GEOSCIENCES

Mississippi State University offers a unique and exciting M.S. degree program through distance learning—the Teachers in Geosciences (TIG) program. Students who successfully complete this two-year, 12-course, 36-hour curriculum are awarded an **M.S. degree in Geosciences**. The core courses in meteorology, geology, hydrology, oceanography, planetary science and environmental geoscience are taught via the internet. Over 300 students from across the country and around the world are enrolled.



Arizona field course

Program highlights include:

- DVD lectures created by Geoscience faculty
- course materials presented online
- Master of Science degree earned in two years
- little time spent away from home (8-10 days in the field)
- MSU in-state tuition rate offered to all students

GEOSCIENCES DISTANCE LEARNING PROGRAMS
distance.msstate.edu/geosciences

Mississippi State University is fully accredited by the Southern Association of Colleges and Schools (SACS). Prospective students should check with the Department of Education in their states for local certification policies.



MISSISSIPPI STATE
UNIVERSITY™

Division of Academic Outreach & Continuing Education

Mississippi State University is an equal opportunity employer.