Lesson 18: Journal excerpt from
Molecular determinants of scouting behavior in honey bees.

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Molecular determinants of scouting behavior in honey bees.
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(excerpts below. Full text at http://science.sciencemag.org/content/335/6073/1225.full)

Abstract
Little is known about the molecular basis of differences in behavior among individuals. Here we report consistent novelty-seeking behavior, across different contexts, among honey bees in their tendency to scout for food sources and nest sites, and we reveal some of the molecular underpinnings of this behavior relative to foragers that do not scout. Food scouts showed extensive differences in brain gene expression relative to other foragers, including differences related to catecholamine, glutamate, and g-aminobutyric acid signaling. Octopamine and glutamate treatments increased the likelihood of scouting, whereas dopamine antagonist treatment decreased it. These findings demonstrate intriguing similarities in human and insect novelty seeking and suggest that this trait, which presumably evolved independently in these two lineages, may be subserved by conserved molecular components.

Introduction

An important challenge in behavioral biology is to elucidate the molecular basis of individual differences in behavior. Scouting behavior in the honey bee, Apis mellifera, provides an excellent opportunity to explore this issue for two reasons. First, there are striking individual differences in this behavior— some bees act as scouts and others never do so. Second, scouting is performed in two distinct contexts: scouting for new food sources or new nest sites, which suggests an underlying tendency to seek something new. Novelty-seeking behavior has been studied in vertebrates, including humans (1, 2), but not in insects.

Foragers are bees that are responsible for collecting food for the hive. Food scouts, who make up 5 to 25% of a colony's foraging force, search independently for new food sources and continue to do so even when plentiful sources have been found (3–5). Non-scouts do not search for novel food sources and instead rely on information from scouts (communicated via "dance language") to guide their foraging. By constantly discovering new flower patches, food scouts help ensure a high influx of food to their colony, despite the short-lived nature of each patch (5).

Experimental methods
A large screened outdoor enclosure provided experimental control of food sources under otherwise naturalistic conditions. Foragers from a glass-walled observation hive were trained to a training feeder that initially was the only food source available to them. After 2 to 3 days of training, a novel feeder with different visual and odor cues was placed at another location in the enclosure. The foraging bees thus had two possible food sources, familiar and novel; some bees discovered the novel feeder and switched to it. This procedure was repeated on several consecutive days, and each time the novel feeder was given new visual and odor cues and placed in a new location. Only bees that switched to two or more different novel feeders, after being seen at least once at the training feeder, were collected as

scouts. These rigorous criteria minimized the possibility of identifying scouts on the basis of an accidental discovery of a novel feeder. The proportion of scout bees identified with this assay

Bees that met our criteria for identifying food scouts were collected to compare their brain gene expression with that of control non- scouts (foragers that were never observed to switch to a novel feeder).

Results:

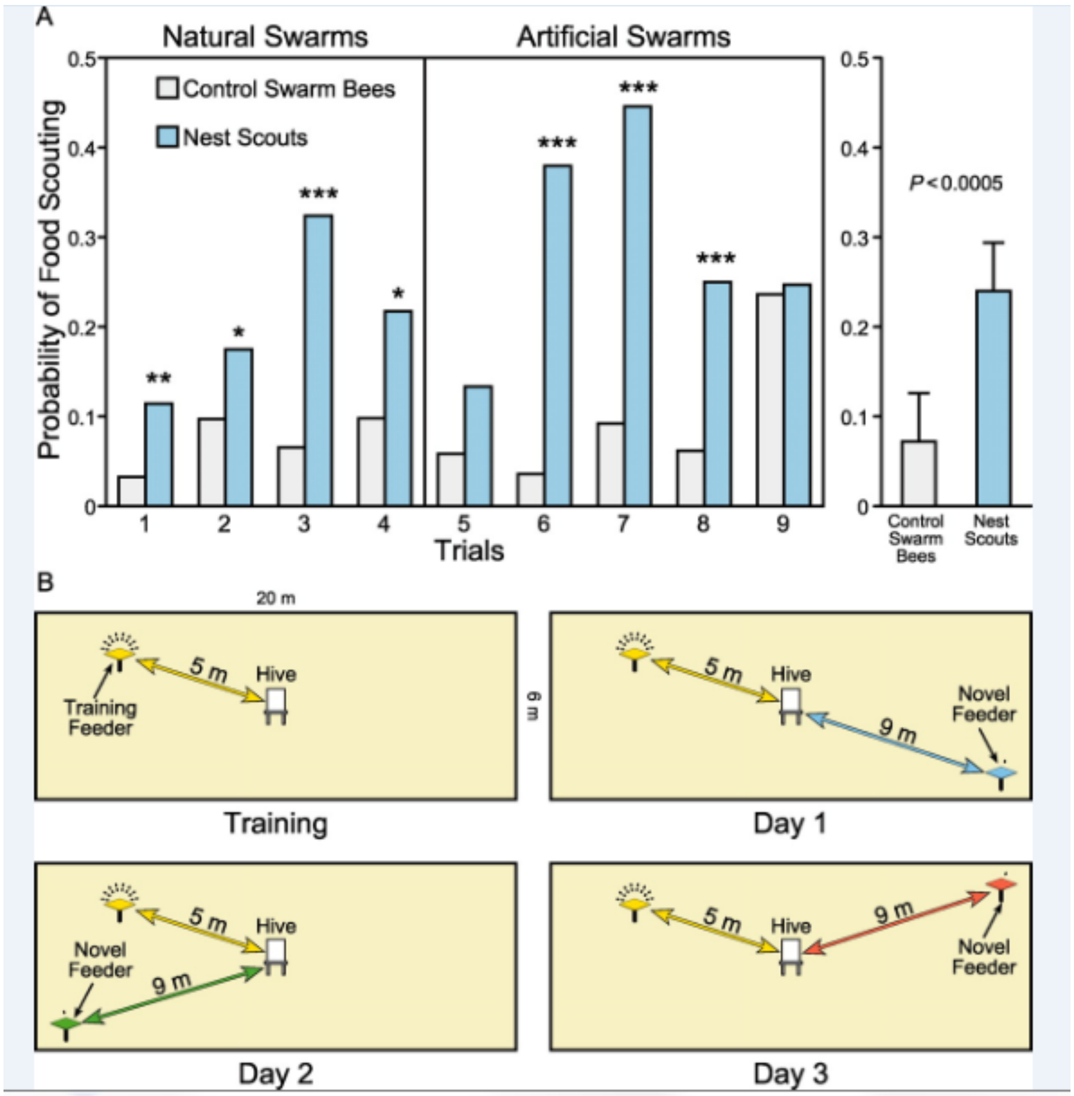

Fig. 1.

(A) Consistent novelty-seeking behavior across different contexts. Nest scouts were significantly more likely to later act as food scouts than were non-scout swarm members. The graph shows the probabilities of food scouting for nine trials: four natural swarms and five artificial swarms, with eight different colonies (Fisher's exact test, 2-tailed test; *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$), and the overall mean probabilities [least-square means and standard errors; mixed-model analysis of variance (ANOVA), 2-tailed test].

(B) Feeder-discovery assay for identifying food scouts. Additional details are in the text and supporting online material.

When regular foragers and scouts are put together in an enclosed chamber, the scouts still continue to show novelty seeking behavior, and the foragers tend to stick with the familiar feeder and do not show the same novelty-seeking behavior as the scouts.

Among the differentially expressed genes were several related to catecholamine, glutamate, and g-aminobutyric acid (GABA) signaling, which are involved in regulating novelty seeking and reward in vertebrates (1, 2, 8). For example, the down-regulation of a dopamine receptor gene in honey bee scouts parallels results for a similar gene in individual mammals that are prone to novelty seeking (9). These signaling systems also are implicated in personality differences between humans that are related to novelty seeking (10, 11).

Our results demonstrate intriguing parallels between honey bees and humans in novelty- seeking behavior.