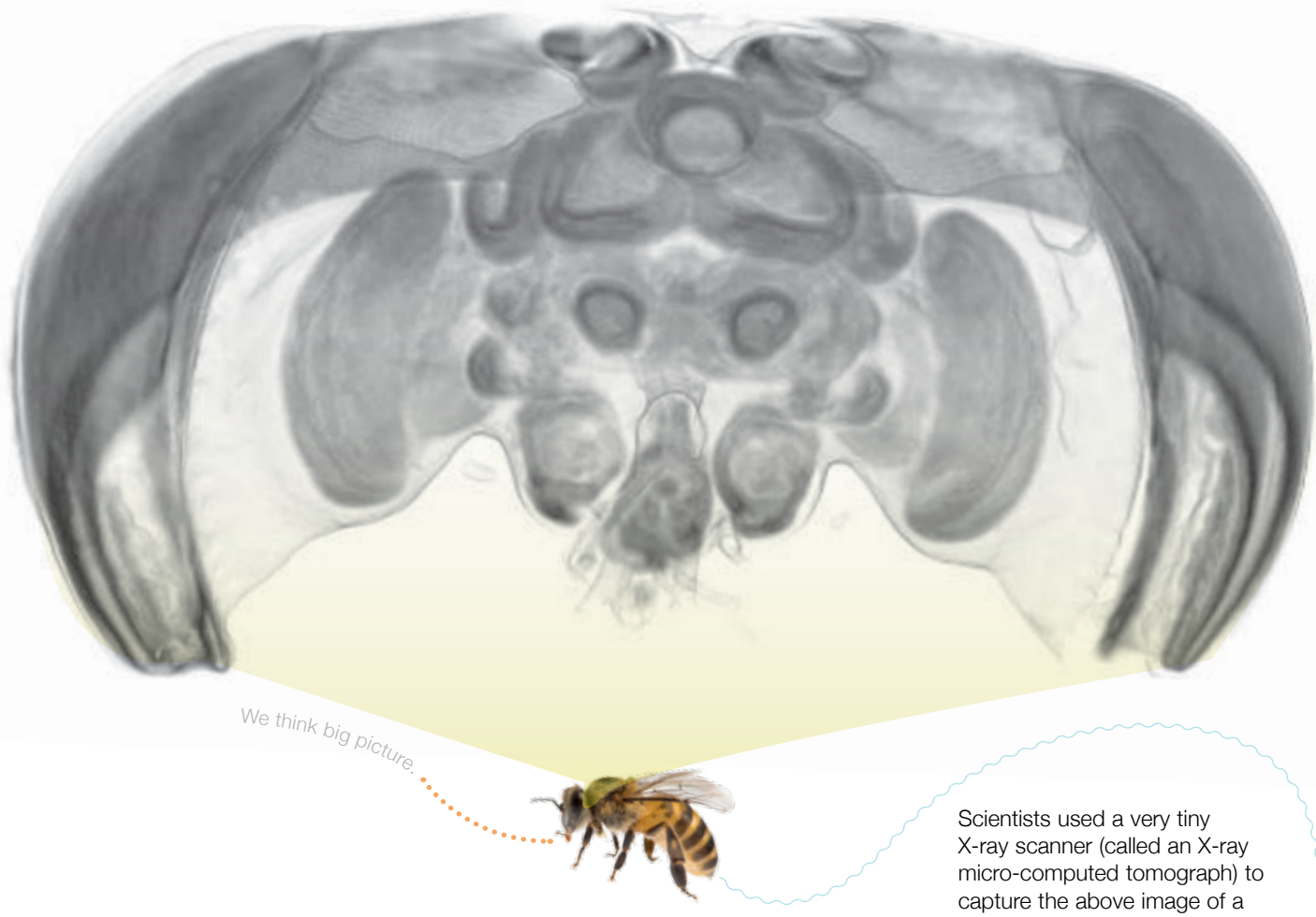
The Hive Mind

by Avery Elizabeth Hurt

Honeybees are the picture of hard work and cooperation. They pollinate plants, helping to ensure that humans will have enough food to eat. They also make honey, protect themselves from predators, and keep the interiors of their hives at just the right temperature. But even though they are pretty impressive as a group, individual bees don't have much going on in the mental department—or so science has always thought. What would you expect from a single bee, anyway? It has a brain roughly the size of one of the sesame seeds on your hamburger bun.



Scientists used a very tiny X-ray scanner (called an X-ray micro-computed tomograph) to capture the above image of a bee brain.

It has only about one million neurons, compared to the 90 billion neurons of the human brain. It's only by working together as a colony that bees manage to pull off the impressive feats they are so well known for. A colony of bees is like one big brain, and the bees are like brain cells, explains animal behaviorist and bee expert Thomas Seeley. "Even though each unit (bee or neuron) has limited information and limited intelligence, the group as a whole makes first-rate collective decisions," Seeley writes in a description of his research.

It turns out, however, that the members of a beehive aren't quite the dimwitted robots we've imagined for so long. Bees can do surprising things with their tiny brains. Individually, they have mental skills that may rival or outdo those of many mammals.

What a Bee Knows

In the first half of the 20th century, Karl von Frisch, an Austrian scientist who studied animal behavior, forever changed our impression of honeybees by discovering the "waggle dance." It's a complex series of movements bees use to tell one another where to find food. This discovery made the human community sit up and take notice. The waggle dance may not qualify as a language, but it is a sophisticated form of communication. It was one of our first hints that bees do something very like what we call "thinking."

Researchers have also shown that bees can appreciate art. Well, at least they can tell the difference

between a Picasso and a Monet. When bees had to choose between a painting by Monet and one by Picasso to get a sugary treat researchers had hidden behind a hole in one of the paintings, the bees easily figured it out. They couldn't have been doing this based on the colors in the paintings (bees are good at seeing color, a talent that comes in handy when you work with flowers) because they solved the puzzle even when the paintings were in black and white. The researchers think the bees could tell the difference between the artists' styles.

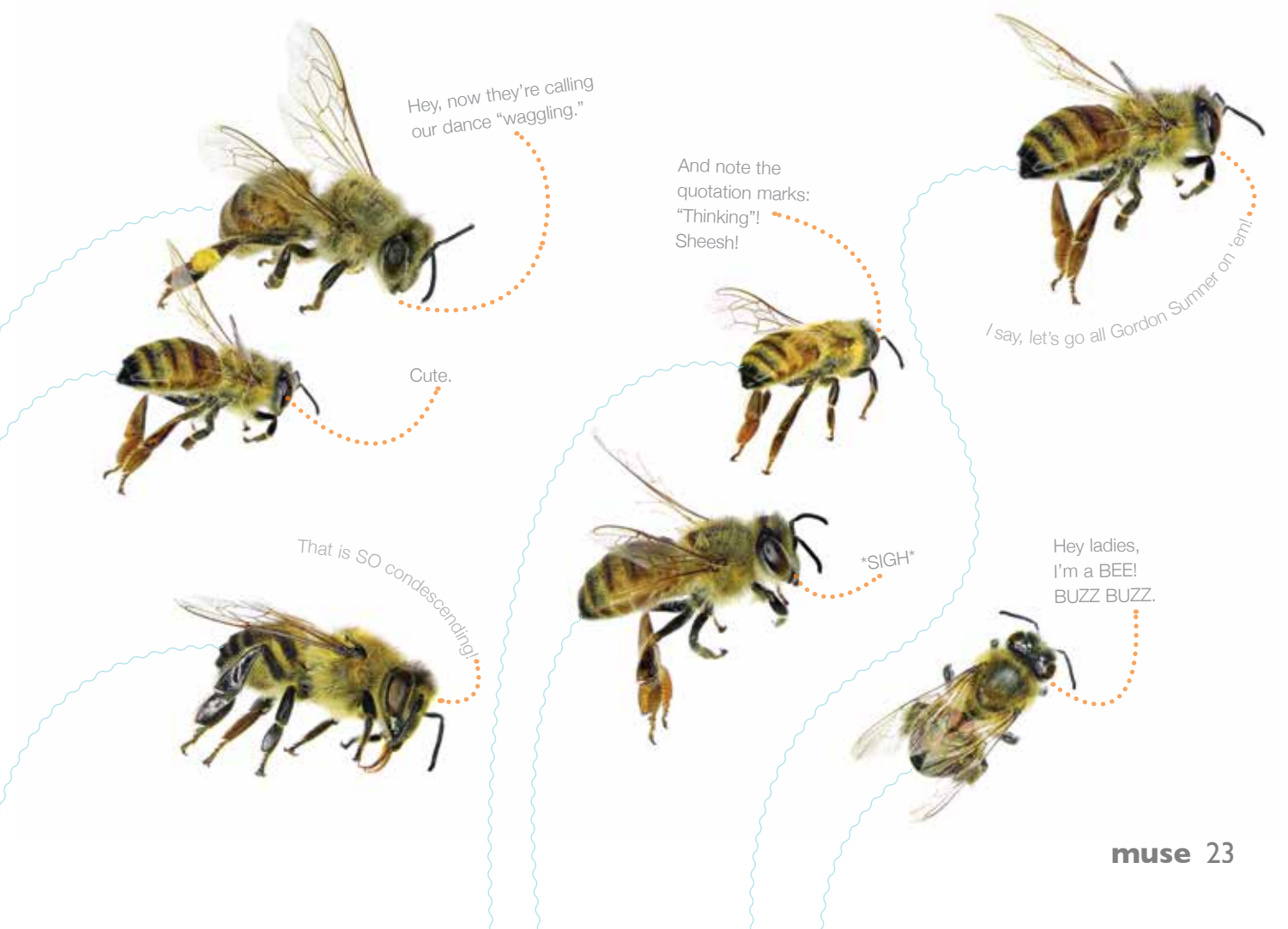
Bees can also count. Not only can they be taught to recognize the symbols representing numbers, but they seem to understand the numbers those symbols represent. In one experiment, for example, bees had to pass a certain number of markers in a tunnel to get a food reward. The bees could easily find the reward, even when the researchers moved the markers around or changed their shapes and colors. This meant that bees were actually counting the number of markers they passed, rather than simply memorizing the pattern of the markers. Bees only seem to be able to count up to four, though.

Even more remarkably, bees can combine several things they've learned in one situation and call on that knowledge in new situations. For example, after learning to recognize abstract signs to guide them through mazes, bees can learn that the signs mean something different in a different maze.

Honeybees have one impressive talent that gets them into a club that so far only includes a few mammals as members. To learn more about that, we have to take a closer look at their minds.

How to Study a Bee Brain

It's hard enough to study the minds of humans, who can actually tell you what they're thinking. So how does one look into a bee's brain?



Collapsing Colonies

Bees may be smart, but they are in trouble. In 2006 beekeepers began to notice unusually large losses in their bee colonies. A colony would be found with a live queen but few, if any, other adult bees present. No dead bodies were found, a detail that makes the problem sound like something out of a Sherlock Holmes mystery.

The phenomenon has been labeled colony collapse disorder (CCD), and despite what you may have seen on Facebook, we still do not know what is causing it. Experts are researching possible causes, from pesticide use to cell phone interference with bees' navigation systems, but so far they've found no definite answers.

What we do know, however, is that if we continue to lose honeybees at this rate, the nation's farms are in dire trouble. Bees aren't the only insects that pollinate food crops, but they do the bulk of the work. According to the United States Department of Agriculture (USDA), "about one mouthful in three in our diet directly or indirectly benefits from honey bee pollination."

The USDA says the public can help by not applying pesticides during midday hours, when bees are most likely to be out foraging. It's also helpful to plant flowers and herbs that are good sources of pollen and nectar, such as red clover, bee balm, foxglove, and other native plants. Maybe with our much bigger brains, we can soon figure out a way to help the bees face this problem.

Clint Perry, a scientist working at Queen Mary University of London, has spent a lot of time studying how bees think. He says studying bees is not very different from studying other animals. "A major difficulty is designing an experiment that will actually test what we want," he says. "With humans, we can ask them a question and get an answer. But bees don't know that we want to know what they are thinking. They are just trying to get sugar. Bees like sugar."

This fact can be very helpful when designing experiments to study bees. For example, in one experiment, Perry gave bees a choice between landing on a spot above a black bar or a spot below it. If they landed above the bar, they would find a delicious sugary drink. If they chose the spot below the black bar, they found a nasty-tasting bitter liquid. (Perry made the test easier or harder by moving the landing spots farther from or closer to the black bar.)

Most experiments with bees involve training them to go to a particular spot to find a reward. Many studies use artificial flowers with sugar water at their centers. In some experiments bees even learn to go through mazes.

So experiments with bees are not that different from experiments with our favorite lab mammal, the rat. Rats press bars to get food pellets; bees land on targets to get sugary drinks. And humans try to figure out what it all means.

Am I Ready for the Test?

Perry's research suggests that bees have something called "metacognition." Metacognition is the awareness of your own thought processes—in other

words, knowing what you know and what you don't know. Only a few other animals, including humans, dolphins, rats, and some monkeys, are thought to have at least some level of metacognition.

Perry tested this using the experiment with the black bars described above. Bees got a sweet drink if they succeeded and a bitter one if they failed. But they also had the option of avoiding the task if they weren't sure they would succeed. Perry found that bees avoided the test when it was difficult and gave it a try when it was easy.

If you had the choice, you might choose to skip a history test on a day when you hadn't studied and take it on a day when you were better prepared. In the same way, the bees seemed to make a decision based on what they thought their chances were of "passing" the test. "With their behavior," says Perry, "the bees were telling us if they 'did know' or if they 'didn't know.' Our results show that bees use their uncertainty to guide their decisions, which is considered a basic form of metacognition."

That's not bad for a scant one million neurons. Perry points out that we can't know for sure from tests like this whether bees are actually judging their own knowledge or simply opting out of the task because of an unpleasant association with the yucky-tasting liquid. It might have been more of an instinct than a thoughtful choice. But here's the thing: we look for metacognition in other animals based on tests very similar to this one. If dolphins and rats are in the metacognition club, then bees should be let in too.

Scientists still do not know how bees manage to do so much with their tiny brains. It could be that skills such as simple math and navigation take far less actual brainpower than we previously thought. No one is suggesting that bees are as smart as mammals, at least not when it comes to things like memory and language. But learning more about how bees' brains work could help us learn more about how our own brains process information.

We may also have to rethink how we view the rest of the insect world. There are an awful lot of small creatures flying around in the garden and crawling around the basement. Who knows what those tiny minds might be capable of?

Avery Elizabeth Hurt is a science writer living in Alabama. Her last Muse *article was about déjà vu, in case you could swear you'd heard her name before.*