Translating the abstract language of bees

Amidst discussion that behavioral scientists may be neglecting such mental experiences in animals as self-awareness, intentions and beliefs, James L. Gould takes a firm stand on the subjects of his research. "Honeybees are basically machines," the Princeton University scientist told the recent meeting in Atlanta of the Society for Neuroscience. He says that the genes of the bees build and wire the nervous system to produce the behaviors appropriate, ultimately, for reproducing the genes.

"Under all that superficial complexity is charming simplicity," Gould says. To illustrate a simple program underlying seemingly intelligent behavior, Gould describes his work with Michael L. Brines of Rockefeller University, which has uncovered rules by which bees communicate the location of a food source, even on an overcast day.

More than 30 years ago Karl von Frisch observed that a bee returning to the hive tells others where food is located by doing a "waggle" dance. The number of waggles, and also of accompanying sound bursts, tells the distance to the food and the orientation of the dance tells the direction to follow from the hive.

"The dance is full of arbitrary conventions," Gould says. Thus, bee communication is an abstract language, he suggests. In the code for distance, races of bees dance different dialects. To German bees one "waggle" represents 75 meters, whereas to Egyptian bees it only represents 5 meters, Gould says.

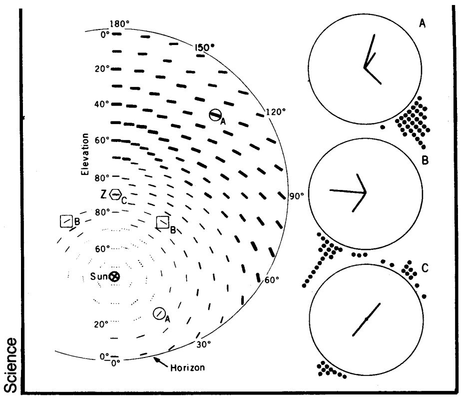
Gould tags bees with numbers in order to observe individuals as they go about their business in what he refers to as "the bucolic real world of bees." He says, "The hive looks like a team wearing football jerseys.

To accurately communicate information through the waggle dance, the bees take into account an impressive variety of factors. They still convey the true distance and direction if they have flown against the wind or have gone around a building to find food. (However, they overestimate distance if they are weighted down.) They also learn in the first few days of flight to take into account the movement of the sun, which varies in speed during the day. All that is impressive for an insect that will never find its hive if the hive is moved 4 meters while the bee is away.

For times when the sun is not visible, bees have a modified strategy to communicate the location of food. The alternative conventions go into effect when the amount of ultraviolet light and of polarization cue the bee to treat a light stimulus as a patch of sky rather than as the sun. The strategy relies on the circular pattern of polarized light scattered by the atmosphere.

Bees use the characteristics of the polarized light to identify which part of the sky they see, and then use the patch of sky to orient their dance. Since a given polarization pattern exists at two places in the sky, the bees follow an arbitrary rule. They consistently interpret the patch to be the possibility further from the sun. Half the time, therefore, they are wrong, but because both the sender and receiver of the message make the same mistake, it doesn't matter at all. If the two polarization patterns happen to be equal distances from the sun, the bees interpret the light as the patch to the right of the sun. "Again, the errors are systemic so that no mistakes occur during the flight out," Brines and Gould say in the Nov. 2 SCIENCE. Only at one point in the sky, the zenith, is the situation ambiguous.

Further back-up systems, perhaps for dancing with no cues from the sky, may depend on the bee's magnetic compass, Gould suggests. "You look at a complicated behavior, poke at it, and it turns out to be simple," he says. □



Science

Sunlight scatters in the sky into a circular pattern of polarized light. Bees on a horizontal surface dance to an artificial pattern of polarized light. The dots around the circles at the right represent the orientation of a dance. The data demonstrate that, except at the zenith (C), the bees generally agree on the representation of the light. The longer line in the circle shows the direction of the dance expected if the bees had interpreted the light as the sun. The short lines show the orientations expected if the light is regarded as each of two possible patches of sky. The bees interpret the light as the patch nearest the sun (A) or to the right of the sun (B).

Molecules within molecules in the brain

More and more in the views of scientists seeking to understand the brain, the complex circuitry of cell connections is overlaid with a multi-hued mosaic of chemicals. Much research is focusing on peptides, the short chains of amino acids that are suspected of carrying signals between nerve cells. The enkephalin peptides were first shown to play a role in neuronal communication in 1975. Now more than two dozen are under examination, say scientists at the meeting in Atlanta of the Society for Neuroscience. A recurrent theme is developing about the peptides' cellular origin. Peptides seem to be snipped from precursor proteins that contain several biologically active molecules.

The short peptide called methionine enkephalin, for instance, is contained in the larger active molecule, beta-endorphin, which is itself contained in the protein called beta-lipotropin. Three other biologically active segments of beta-lipotropin have also been identified (SN: 11/25/79, p. 374). But beta-lipotropin itself more recently has been found to be a segment of an even larger molecule called "31K." (Its molecular weight is 31,000 daltons.) All those bilogically active segments of 31K are located toward one end of the molecule. Floyd E. Bloom of the Salk Institute now describes work done by Stanley N. Cohen at Stanford University, who used recombinant DNA techniques to explore 31K's other region.

Cohen produced large quantities of the DNA that codes for the 31K protein and analyzed its nucleotide sequence. From that information he was able to deduce amino acid sequences of its possible products. One potential product resembles a peptide contained in the other region of 31 K. Scientists synthesized the new suspected hormone and discovered that it has very potent biological activity. Using antibodies, they located that peptide, naturally produced, in the same brain cells that contain beta-endorphin.

Another instance of hormones within larger peptides, was reported by Michael J. Brownstein of the National Institutes of Health. The peptide hormones vasopressin and oxytocin are made by certain nerve cells, as well as by the pituitary gland. Each of those molecules is associated with a protein, called neurophysin, which binds it very strongly. Brownstein now finds that vasopressin and its neurophysin are combined in a precursor molecule that also contains the sugar fucose. Oxytocin and its neurophysin are linked in another precursor protein, this one containing no sugar group.

Brownstein and collaborators have shown that the large precursors are produced in the bodies of nerve cells. They are packaged into spherical granules and shipped out of the cell body and down the long process known as the axon. En route, the precursors are broken down by enzymes into the smaller, biologically active molecules that are finally released at the nerve endings. Newly discovered brain molecules that modulate the action of neurotransmitter GABA are also peptides that appear to be clipped from a precursor molecule (see p. 345). The question remains how a cell controls which peptides will be produced from a precursor with many options. □