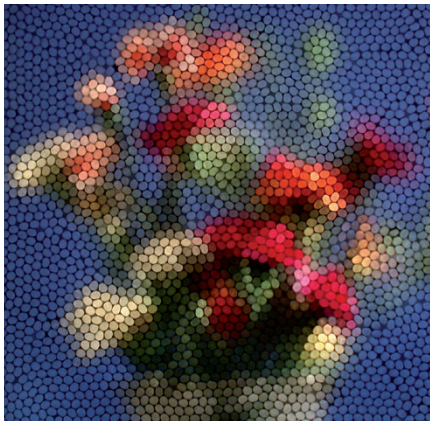
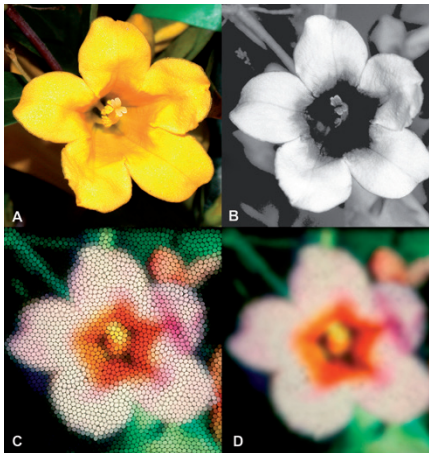
THROUGH INSECT EYES

Seeing like a bee is not only an entomologist's dream. Understanding how their vision works and the relevant processes in the insect brain may even help greenhouse pollination and the evolution of camera technology.



This is how a vase of flowers might appear to a bee considering **bee visual acuity.**



A | Shows how we humans might see a flower
B | Is the same flower photographed through a UV filter, as honey bees can see UV light
C | Is the flower captured through an array of straws to simulate insect compound vision
D | Shows a merge of the pictures processed on the computer and gives an idea of how a bee might see a flower

Having a thousand eyes instead of just two makes the world look a lot different: Honey bees and many other insects see through compound eyes. These consist of thousands of so-called ommatidia, each one acting like an individual simple eye. As they are located on an almost hemispherical surface on the head, they point in slightly different directions, offering a wide angle of sight.

The image the insects see is a combination of the input of all their ommatidia: The world through compound eyes doesn't look as sharp as through mammalian eyes, however, the insects can still easily detect very fast movements: Fast flying insects, such as the honey bee, see up to 300 pictures per second – while we humans can only manage up to 65.

What's more, the honey bee also sees ultraviolet (UV) light which is not normally visible to humans. This comes in handy when searching for food: Special pigments in flowers can absorb or reflect UV light, revealing a "landing strip" that guides the bee to a plant's store of nectar and pollen. The bee learns that the dark area in the middle of the flower or dots indicate where the nectar is stored.

Yet honey bees also have a weak point in their vision as they cannot see the color red.

The liverwort *(Hepatica nobilis)* for example looks pink to us but blue to bumble bees.

Understanding the vision of bees and the processing of images in their brain can also boost other research fields. The Australian researcher Associate Professor Adrian Dyer of the RMIT University in Melbourne analyzes how bees learn and how they can even recognize human faces. Associate Professor Dyer has developed the

AT A GLANCE

// Honey bees and other insects see through compound eyes.
// Perceiving UV light helps them to find nectar- and pollen-rich flowers.
// Research on how bees process visual images might help the future development of cameras and even aerial vehicles.

INTERVIEW

Associate Professor Adrian Dyer is a vision scientist at the RMIT University in Melbourne, Australia. As a researcher he is interested in understanding how visual systems learn perceptually difficult tasks.

Inside a bee's brain

What fascinates you about bees?

"These insects can solve amazingly complex problems with rather tiny brains. Some of the research done over the last twelve years even suggests that bees are able to solve problems at a level, which approaches what we see in mammalian systems."

How can technology benefit from your work?

"One of the things we're working on is flying in a complex environment without crashing against things. The issue here is speed: If you have sensors on the front of an aerial vehicle, the data needs to be processed by a computer, which then has to drive a different system to avoid a collision. By the time this happens you have already crashed. For insects this is not a problem. So we try to analyze how the bee's brain is able to do this. The goal is for example to maybe improve the ability of unmanned aerial vehicles."

"Bee Eye Camera" to see the world through the eyes of an insect. For this, he photographs e.g. a yellow flower through three special color filters and then overlays the pictures. This converts the light spectrum visible to humans into the UV-vision of honey bees, changes the contrast and transforms it into a colored version as a bee would perceive it; that is the yellow flower now appears pink. To simulate the compound eyes, the researcher uses a simple but effective method: He photographs the picture of the pink flower again through a wooden frame filled with thousands of straws. The result is a mosaic picture. With the aid of a computer, the bee researcher combines the different mosaic pieces into a normal picture, which appears slightly blurred.

Associate Professor Dyer is not only able to see like a bee. He also examines the way bees' process visual information in their brains. This might help the evolution of facial recognition in cameras: "There have been a lot of difficulties in producing algorithms that can reliably recognize people's faces when there is a change in viewpoint," he explains. So understanding how biological systems cope with these visual challenges could provide insights for software developers. Associate Professor Dyer: "The miniature insect brain may possibly provide some very efficient solutions that are easier to model than those we might derive from amazingly complex primate brains."

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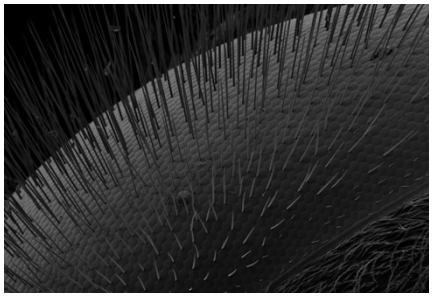

The picture above shows the eye of a honey bee in detail through an electron microscope. Also bumble bees see their world through compound eyes (below).