Epigenetic patterns determine if honeybee larvae become queens or workers

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Honeybee larvae. Credit: Ryszard Maleszka

Scientists at Queen Mary University of London and Australian National University have unravelled how changes in nutrition in the early

development of honeybees can result in vastly different adult characteristics.

Queen and worker honeybees are almost genetically identical but are fed a different diet as larvae. The researchers have found that specific protein patterns on their genome play an important role in determining which one they develop into.

These proteins, known as histones, act as switches that control how the larvae develop and the diet determines which switches are activated. They found that the queen develops faster and the worker developmental pathway is actively switched on from a default queen developmental programme.

This change is caused by epigenetics—a dynamic set of instructions that exist 'on top' of the genetic information, that encode and direct the programme of events that leads to differential gene expression and worker or queen developmental outcome.

The study, published in *Genome Research*, describes the first genome wide map of histone patterns in the honeybee and the first between any organism of the same sex that differs in reproductive division of labour.

Bees are also very important pollinators—so it is crucial to understand their molecular biology, how they develop and the mechanisms that regulate this.

Honeybee larvae. Credit: Ryszard Maleszka

Lead author Dr. Paul Hurd, from Queen Mary University of London, said: "The ability of an individual larva to become a worker or a queen is due to the way genes are switched on or off in response to the specific diet; this determines such differing outcomes from the same genome."

"We show that queens and workers have specific histone patterns even though their DNAs are the same. These proteins control both structural and functional aspects of the organism's genetic material and have the capacity to determine which part of the genome, and when, has to be activated to respond to both internal and external stimuli."

The histones have small chemical tags, or epigenetic modifications, that allow them to act differently to those that do not, usually by allowing access to the DNA and genes. This enables identical DNA to behave in different ways because it is wrapped around histones with different chemical (epigenetic) tags.

Co-author Professor Ryszard Maleszka, from Australian National University, added: "The extent of histone modifications uncovered by this study was remarkable and exceeded our expectations. We were able to identify where the important differences are in the genomes of workers and queen."

Epigenetic information can be altered by environmental factors, including diet. In the case of the honeybee, the queen larvae are fed a diet of royal jelly, a potent substance capable of changing developmental instructions.

Honeybee larvae. Credit: Ryszard Maleszka

Dr. Hurd said: "Think of the genome as the instruction book of everything that is possible but the epigenetics is the way in which those instructions are read. Epigenetics is about interpretation and of course there are many different ways to interpret these instructions and when and in response to what."

The authors found that some of the most important epigenetic differences are in regions of the honeybee genome that are not part of genes. For the first time, these caste-specific regulatory DNA regions that are so important in making a queen or a worker have been

identified.

Professor Maleszka said: "Our findings are important because a high level of similarity of epigenetic tool kits between honeybees and mammals makes this familiar insect an invaluable system to investigate the sophistications of epigenetic regulation that cannot be addressed in humans or other mammals."

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