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Juvenile hormone signaling pathways and the social physiology of the bumblebee Bombus terrestris

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The evolution of advanced sociality in bees was apparently associated with significant modifications in juvenile hormone (JH) functions. By contrast to most insects in which JH is a gonadotropin regulating female fertility, in the highly eusocial honeybee (*Apis mellifera*) JH has lost its gonadotropic function in adult females and instead it regulates age-related division of labor among worker bees. This variation in JH function provides an excellent model system for understanding major evolutionary changes that are mediated by modifications in endocrine signaling pathways. We manipulated JH levels in workers of the 'primitively eusocial' bumblebee *Bombus terrestris* by removing the sole JH producing glands, the corpora allata (CA). Allatectomized bees showed strong reduction in several behavioral, physiological, and molecular systems: egg laying, egg-cell construction, ovarian development, hemolymph vitellogenin protein abundance, wax secretion, and vitellogenin and the transcription factor krüppel homolog 1 fat body transcript levels. These effects were reversed, at least partially, by treating the allatectomized bees with JH-III, the natural JH of bees. By combining these manipulations with RNA-seq transcriptomic analyses we identified hundreds of brain transcripts that are regulated by JH. These include krüppel homolog 1 and many genes of the insulin/ insulin-like signaling pathway. JH also influenced the splicing pattern of several dozen transcripts. By contrast, manipulations of JH levels by the CA inhibitor precocene and replacement therapy treatments, which did inhibit ovaries, had no effect on foraging or nursing activities. These results provide the strongest available support for the hypothesis that JH is a gonadotropin in *B. terrestris* and start to reveal the molecular processes it regulates in the bumblebee brain. Our study lends credence to the hypothesis that the evolution of eusociality was associated with major modifications in JH signaling in honeybees but not in bumblebees.