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Escape in Time: the Biology of Overwintering in Insects

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Only a brief season of the year, usually summer, is suitable for insect development and reproduction. The remainder of the year, including the months of winter, is spent in a period of developmental arrest referred to as diapause. The short daylengths of late summer and early autumn accurately predict the onset of winter, and a brain-based clock system is used to measure the length of the day and set into motion a cascade of developmental switches that result not only in the arrest of development but also a suite of other characteristics such as fat accumulation, water-proofing of the cuticle, suppression of oxygen consumption, and adaptations for survival at low temperatures. At the molecular level diapause represents both a shut-down in the expression of many genes in the brain, as well as the unique upregulation of a select group of genes. Among genes that are shut down are certain cell cycle regulators. Diapause upregulated genes include a number of heat shock proteins that appear to contribute to the cold hardiness associated with diapause. Results from microarrays, proteomics and metabolomics reveal the involvement of numerous genes and gene products in the regulation of diapause. Our studies have focused primarily on temperate-zone adaptations but also compare results from tropical and Antarctic species.