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# The distinct roles of insulin signaling in polyphenic development

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**Abstract/Preamble**
Many insects have the ability to develop alternative morphologies in response to specific environmental signals such as photoperiod, temperature, nutrition and crowding. These signals are integrated by the brain and result in alternative patterns of secretion of developmental hormones like ecdysone, juvenile hormone and insulin-like growth factors, which, in turn, direct alternative developmental trajectories. Insulin signaling appears to be particularly important when the polyphenism involves differences in the sizes of the body, appendages and other structures, such as wings, mandibles and horns. Here we review recent advances in understanding the role of insulin signaling, and its interaction with other hormones, in the development of polyphenisms.

**Introduction**
Polyphenisms are a specialized form of phenotypic plasticity in which insects develop discrete alternative phenotypes in response to specific environmental signals. The seasonal forms of butterflies, the castes of social insects, and the winged/wingless and sexual/parthenogenetic forms of aphids are among the well-known examples. The alternative forms are believed to have adaptations that suit them to alternative environments. Polyphenic development in insects has several well-defined stages. First there is a period during which the environmental signal is received and integrated into the nervous system. This is followed by a period during which the alternative morphology and physiology develop.

The relevant environmental signal that induces the switch to an alternative developmental pathway is species-specific and can include day length, temperature, nutrition and pheromones. Environment-sensitive periods usually occur in the larval stage, often in the last larval instar, and sometimes in earlier instars. The actual developmental switch, by contrast, typically occurs at the time of molting, and usually during the metamorphic molts.

Little is known about how the environmental information is stored, but it must involve some change in the central nervous system, probably the brain. The switch to alternative developmental pathways that follows environmental induction has been shown to be controlled by hormones in all cases that have been studied. Juvenile hormone (JH) and ecdysone are the most common hormones involved in controlling the polyphenic switch.