

## **Phytoestrogen signaling: Insights from plant/bacteria symbiosis.**

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Flavonoids are hormone-like compounds produced by leguminous plants, including soybean and alfalfa, that regulate the symbiosis between these plants and nitrogen-fixing bacteria. Due to the ability of some phytoestrogens and synthetic chemicals to mimic the activity of steroid hormones in various animal species, they are classified as endocrine-disrupters. Additionally, it has been suggested that phytoestrogens, such as isoflavones, may be protective against breast cancer. Although plant hormones have been reported to affect numerous signaling pathways, there is little known about the biological function of these chemicals. We have taken an evolutionary approach in understanding the effects of phytoestrogens on biological systems from bacteria to mammals. To this end, we have constructed nitrogen-fixing bacteria, *Rhizobium meliloti*, to contain a reporter gene construct under the control of the *NodD* transcription factor. We examine the possibility that synthetic hormonally active chemicals in the environment may alter the signaling required between leguminous plants and nitrogen-fixing bacteria. In order to study the disruption of this signaling, a variety of synthetic chemicals were evaluated for their effect on activation of nodulation genes that regulate the plant-bacteria symbiosis in the nitrogen-fixing bacteria, *Rhizobium meliloti*. Many of the synthetic chemicals tested function as anti-inducers, partially suppressing normal expression of the *Rhizobium NodD* gene. The most potent anti-inducers were the insecticides DDT and its metabolites. Our results indicate that some synthetic chemicals can modulate the symbiosis between nitrogen-fixing bacteria and leguminous plants, suggesting that the signaling components used by plants and pathways present in nitrogen-fixing bacteria may have previously unrecognized similarities to those in animals.