# TK-MODEL OF THE BEE HIVE

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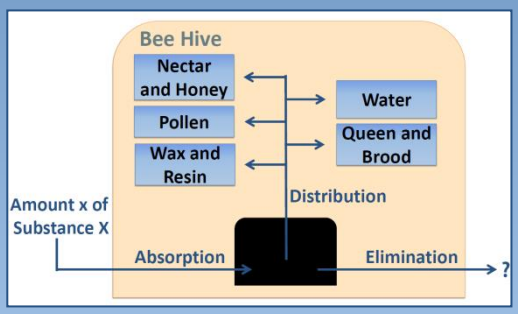
## 1. The Question and the Approach

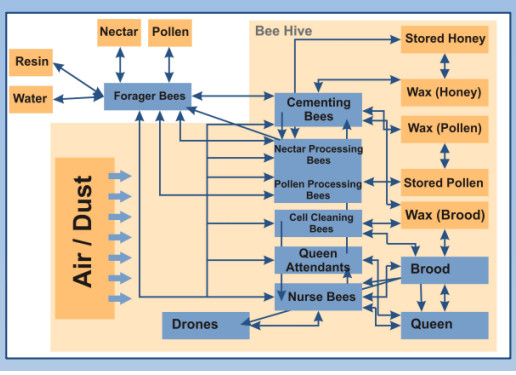
Within the current risk assessment of plant protection products regarding honey bees, one of the most important aspects is how to link pesticide exposure to potential effects within the colony [1].
This question can be tackled with three different modeling approaches:

**1)** Extrapolation of ecotoxicological results to the colony development
→ **Population Model**

**2)** Estimation of substance amounts that enter the hive from environmental exposure
→ **Landscape Based Foraging Simulation**

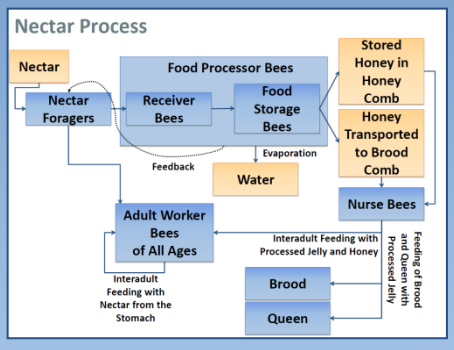
**3)** Calculation of substance distribution in the hive
→ **Toxicokinetic Model**

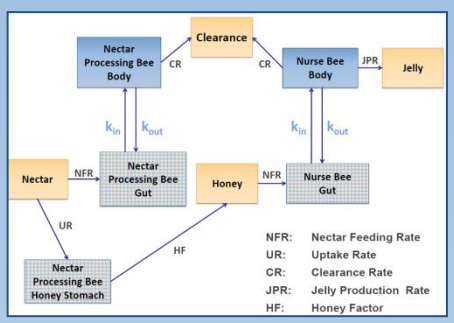



Our approach is the development of a mechanistic toxicokinetic model, that is inspired by **Physiologically-Based-Toxicokinetic-Models** to simulate the toxicokinetics of chemicals within a bee hive. This model will predict internal concentrations of bees and shall bring insight to the question through examining the absorption, distribution, and elimination routes in the bee hive.

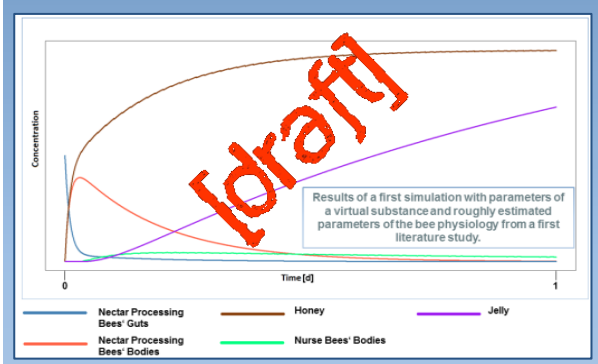
## 2. The Nectar Process as an Example for a Relevant Toxicokinetic Process in Detail




The nectar process is the first distribution process we implemented in our model. Among all resources entering the bee hive nectar accounts for the largest part, which makes the nectar process a factor, that has to be examined very carefully. The changes of the concentration of chemical substances in the different compartments are calculated by differential equations. The Nectar Feeding Rate, the Uptake Rate, the Clearance Rate, the Jelly Production Rate and the Honey Factor are parameters, that depend on the animal's physiology and they are therefore specific for honey bees. The coefficients $k_{in}$ and $k_{out}$ depend on the bees' physiology and the chemical properties of the specific substance. If the other parameters are known, $k_{in}$ and $k_{out}$ are the only ones that have to be changed when testing different substances.

## 3. Implementation and Results




The model will be implemented in **R**. To solve the differential equations (DE) the model uses the package **deSolve**, that is developed for solving ordinary DEs. The results are time courses of substance concentrations in the different compartments of the hive. The increase of substance concentration in the honey is a result of the volume loss of the contaminated nectar, without realistic honey dynamics of the hive in the background.

## 4. Outlook

Our future tasks will be the **implementation** of the remaining relevant toxicokinetic processes in the model. These processes will be connected to interact dynamically. A **sensitivity analysis** and a more detailed **parameterization** will follow. The goal is the integration of the three models.

**References:**
[1] EFSA(PPR), 2012. Scientific Opinion on the science behind the development of a risk assessment of Plant Protection Products on bees (Apis mellifera, Bombus spp. and solitary bees). EFSA Journal 10.