# Modelling Memory Across Scales

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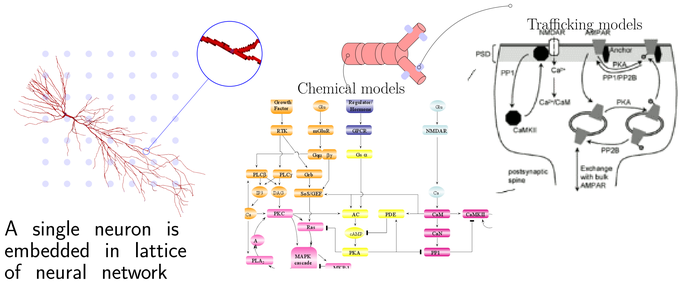
## 1. Why Multiscale?

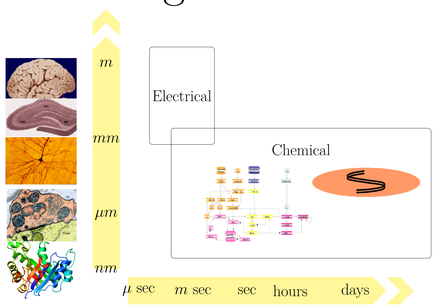
- Memory and plasticity involve brain mechanisms from molecular scale to enormous networks.
- We have developed MOOSE the Multiscale Object Oriented Simulation Environment, to model plasticity across scales.

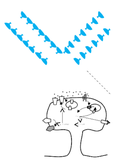



A single neuron is embedded in lattice of neural network

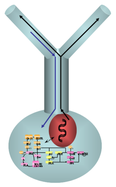
## 2. Multiscale Modeling in MOOSE

- $10^{11}$ cells, $10^{15}$ synapses, 10000? reactions per synapse
- Electrical events: $< 1$ ms, Chemical events: 1 sec $\rightarrow$ 1000 sec
- Structural events: 100 sec $\rightarrow$ months

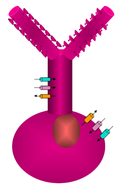


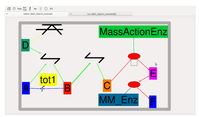
Reaction at single molecule level



Reaction Diffusion Solver

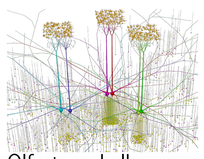


Electrical: Hines Solver




Signalling Model

Single Neuron Model

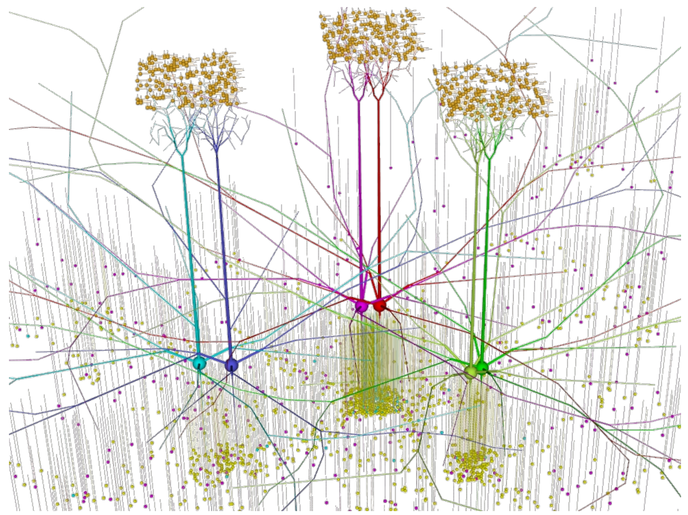


Olfactory bulb model

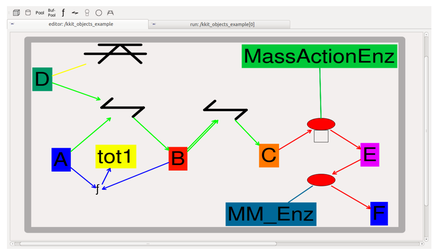
## 3. Some projects using MOOSE

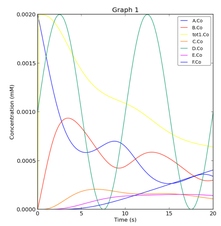
### 3.1 Olfactory bulb project

Network coding and computation in olfaction and somatosensory cortex. It explains linear coding and phase-decorrelation and predicts connectivity, lateral dendrite output structure.

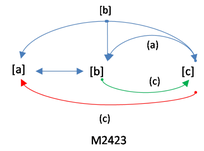


### 3.2 Signalling Pathways




### 3.3 Robustness of Chemical Switches

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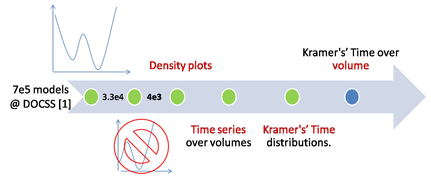
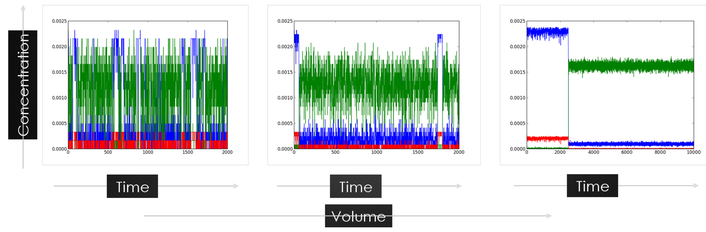
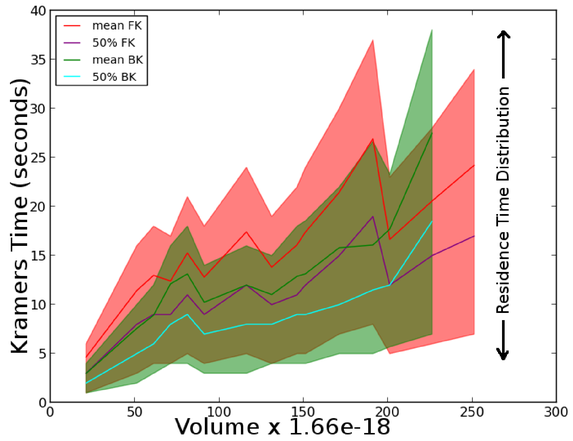



Stochastic simulation of bistable chemical models a b c




## 4. Summary

**We use models to,**

- Integrate many scales of neuronal data with basic physical/chemical principles.
- Explain phenomena of plasticity, activity and neuronal coding.
- Predict circuit mechanisms, plasticity rules, and emergent phenomena such as *decorrelation*, *robustness*, and *memory decay*.