Modelling Memory Across Scales

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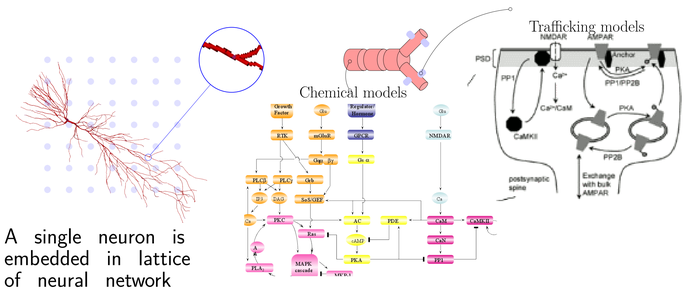
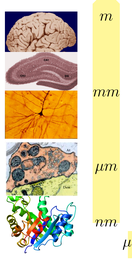
Why Multiscale?

- 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.

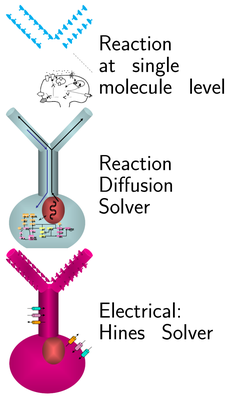


A single neuron is embedded in lattice of neural network

Multiscale Modeling in MOOSE



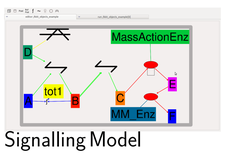
- 10^{11} cells, 10^{15} synapses, 10000? reactions per synapse
- **Electrical events:** < 1 ms, **Chemical events:** 1 sec $\rightarrow$ 1000 sec
- **Structural events:** 100 sec $\rightarrow$ months



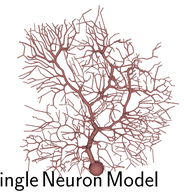
Reaction at single molecule level

Reaction Diffusion Solver

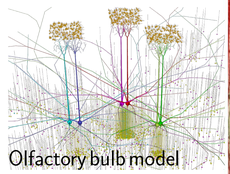
Electrical: Hines Solver



Signalling Model



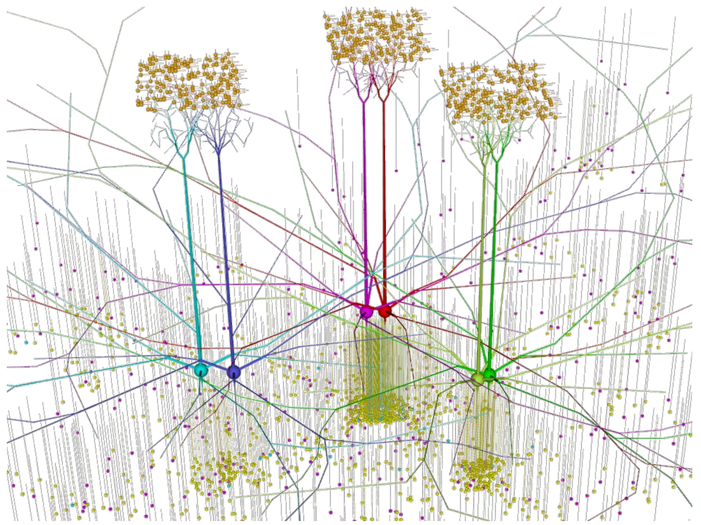
Single Neuron Model



Olfactory bulb model

Some projects using MOOSE

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



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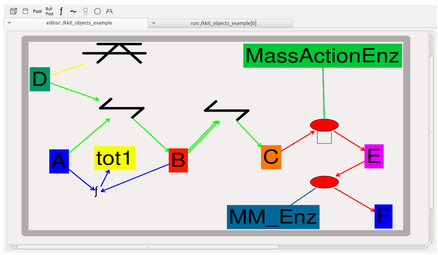
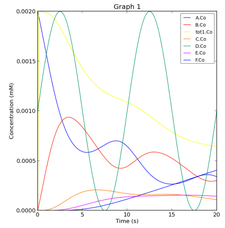
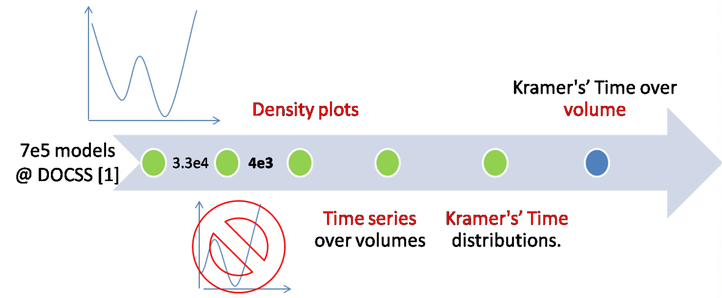
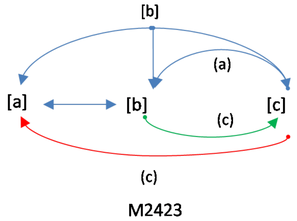




Robustness of Chemical Switches





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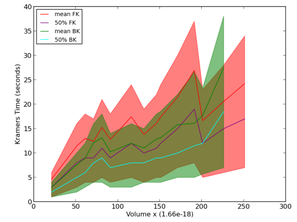

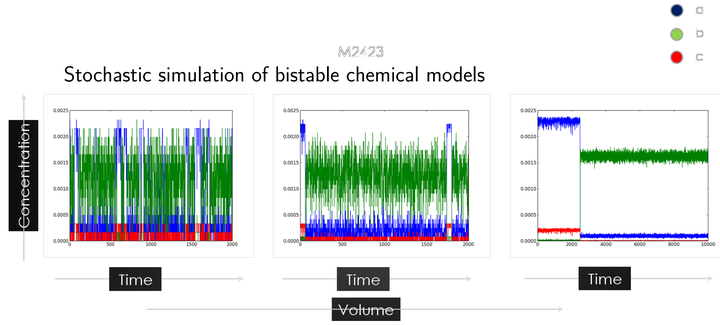

Stochastic simulation of bistable chemical models

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*.

We have developed MOOSE to carry out these simulations.