Modelling Memory Across Scales

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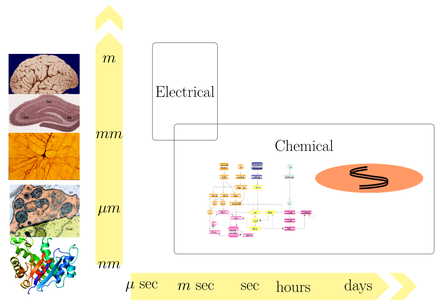
1. Why Multiscale?

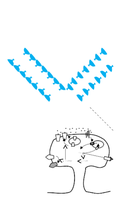
Memory and plasticity involve brain mechanisms from molecular scale to enormous networks.

- 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

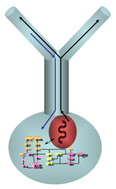


We have developed MOOSE the Multiscale Object Oriented Simulation Environment, to model plasticity and brain computation across scales.

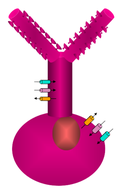
Modular solvers available in MOOSE



Reaction at single molecule level



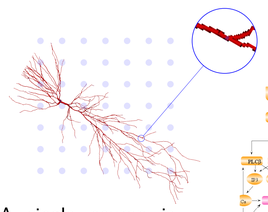
Reaction Diffusion Solver



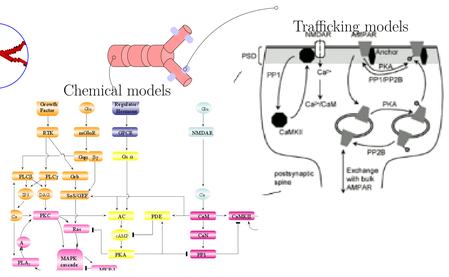
Electrical: Hines Solver

2. Some projects using MOOSE

2.1 Modelling Memory

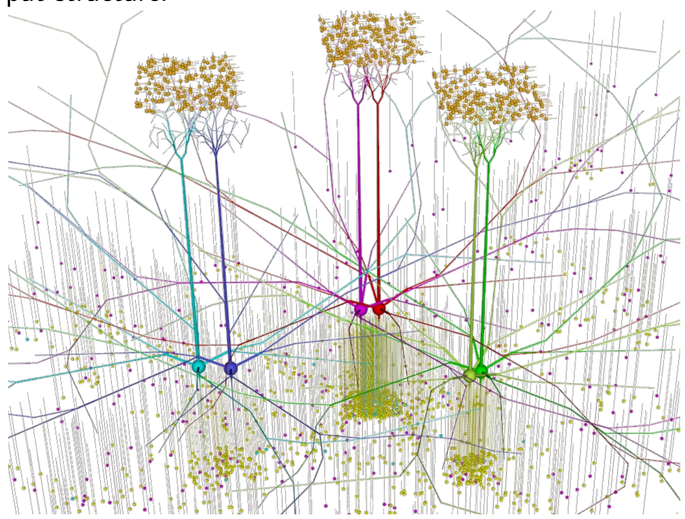


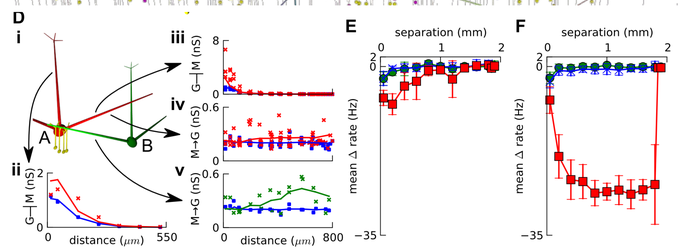
A single neuron is embedded in a lattice of a neural network



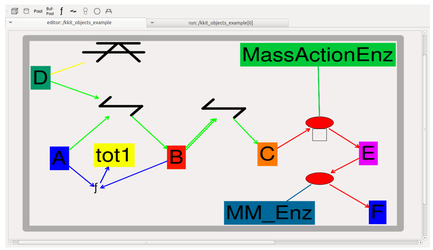
2.2 Modelling Olfactory Bulb

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

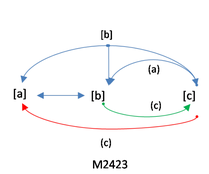


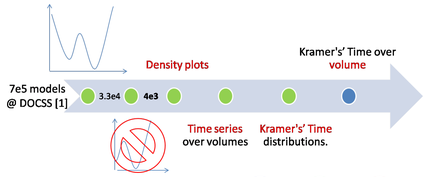


2.3 Modelling Signalling Pathways

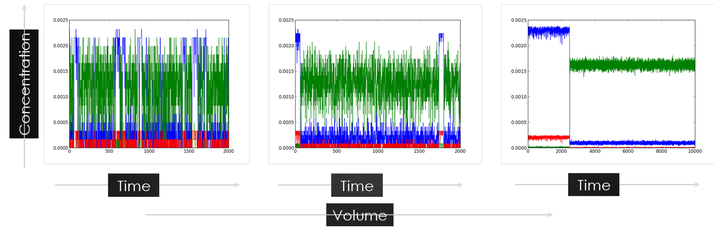


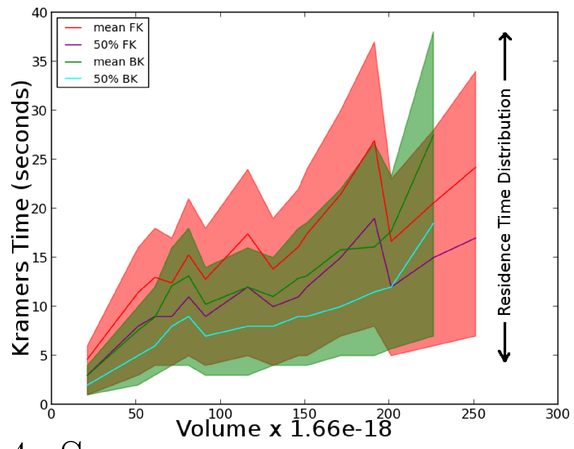
2.4 Robustness of Chemical Switches





Stochastic simulation of bistable chemical model 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*.