Modelling Memory Across Scales

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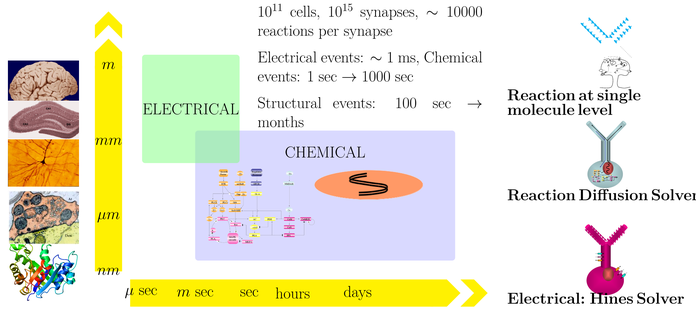
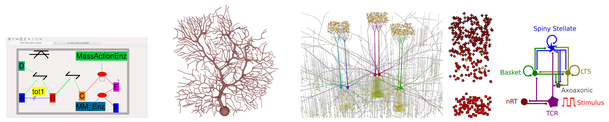
1. Why Multiscale?

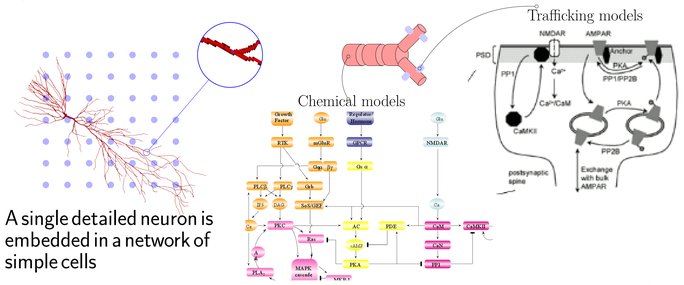
- Memory and plasticity involve brain mechanisms from molecular scale to enormous networks.
- We have developed MOOSE: the Multiscale Object Oriented Simulation Environment, to model plasticity and brain computation across scales.



2. Some projects using MOOSE

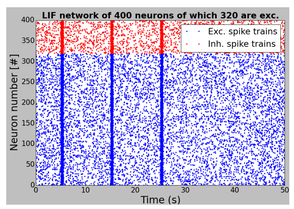


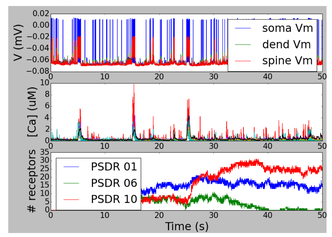
2.1 Modelling Memory



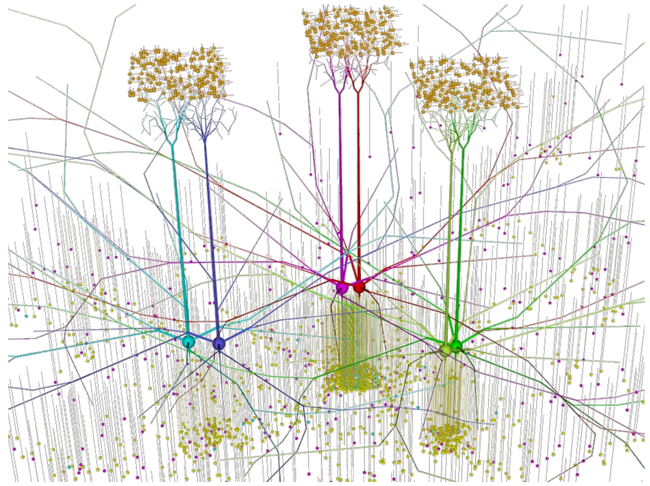
A single detailed neuron is embedded in a network of simple cells

Neighbouring spines are modified differently

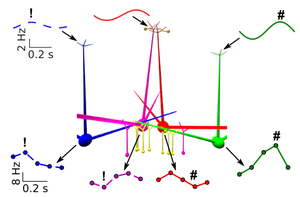




2.2 Modelling Olfactory Bulb



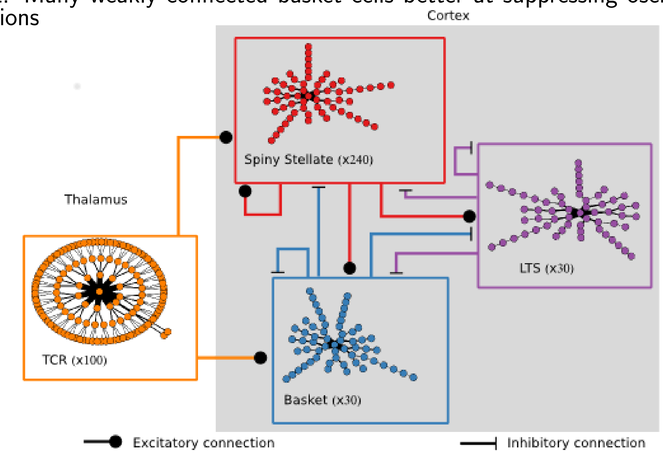
The bulb model explains linear coding and phase-decorrelation and predicts connectivity, lateral dendrite output structure.



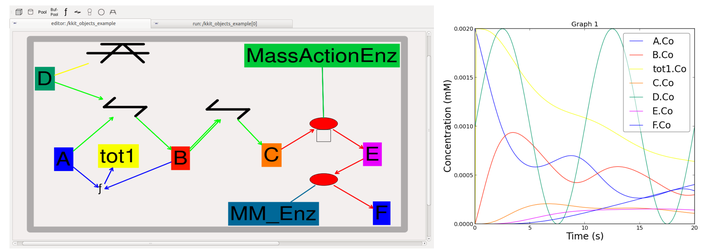
2.3 Modelling Cortex

Predicts:

1. Excitatory-Inhibitory balance needed to avoid strongly oscillatory behaviour
2. Many weakly connected basket cells better at suppressing oscillations

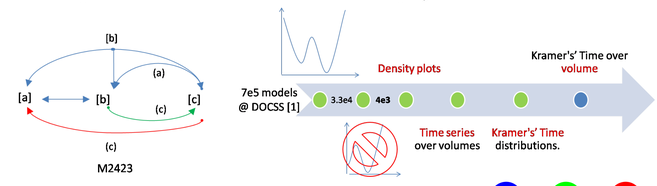


2.4 Modelling Chemical Signalling Pathways

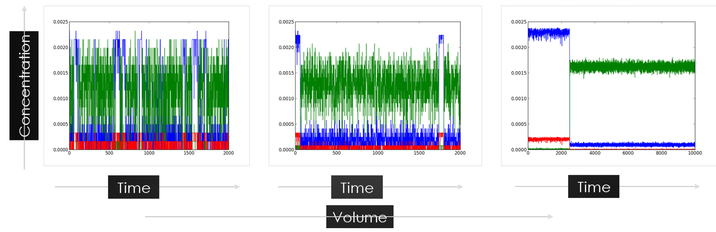


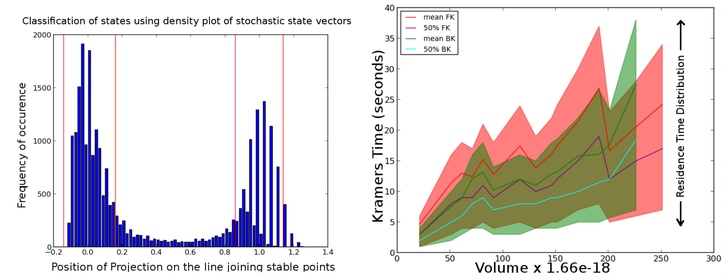
2.5 Robustness of Chemical Switches

Does parameter robustness imply noise robustness?



Stochastic simulation of bistable chemical models a b c





3. 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*.