

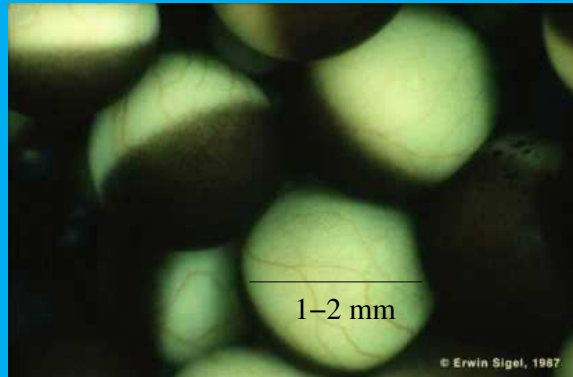
Graduate Colloquium

Bori Mazzag
Department of Mathematics
Humboldt State University

Research Interests

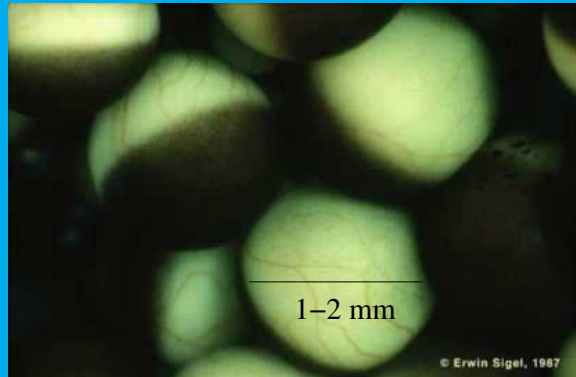
- Localized Ca^{2+} signaling
- Endothelial cell deformation
- Gravitropic response
- Other ideas

Why Ca^{2+} ?



(Erwin Sigel, University of
Bern, 1987)

Why Ca^{2+} ?

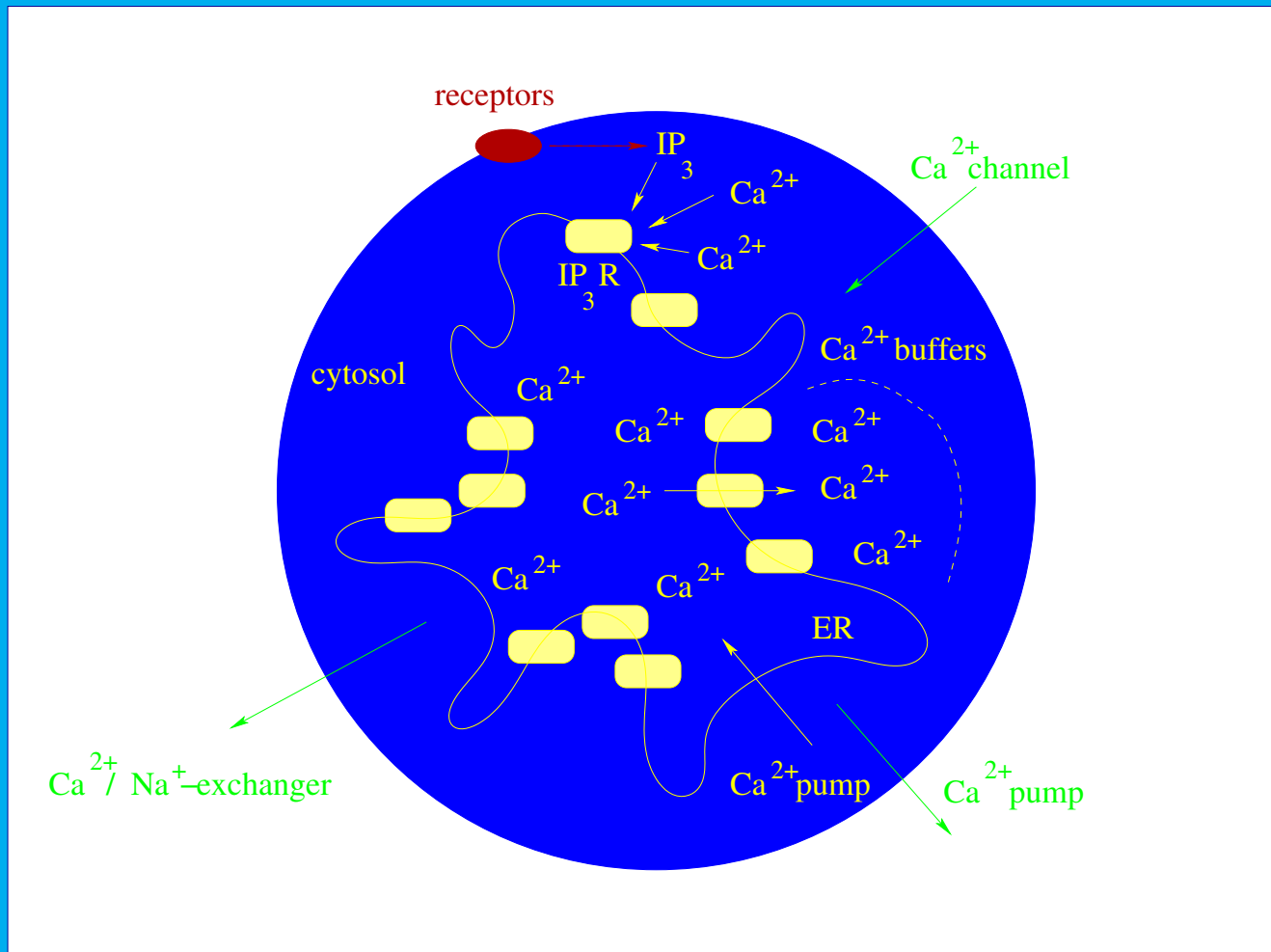


- Axon guidance during development
- Fertilization of *Xenopus* oocyte
- Cardiac muscle cells

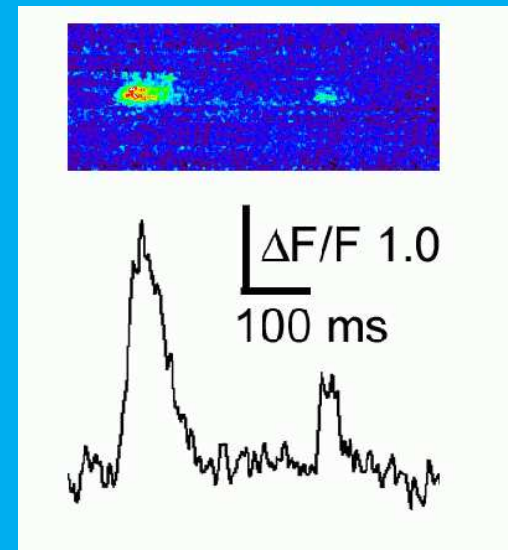
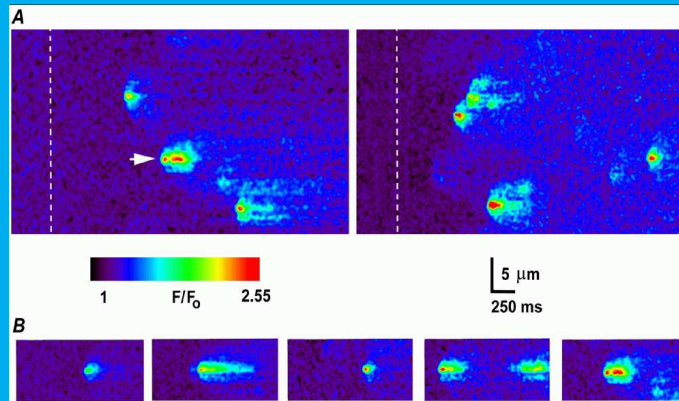
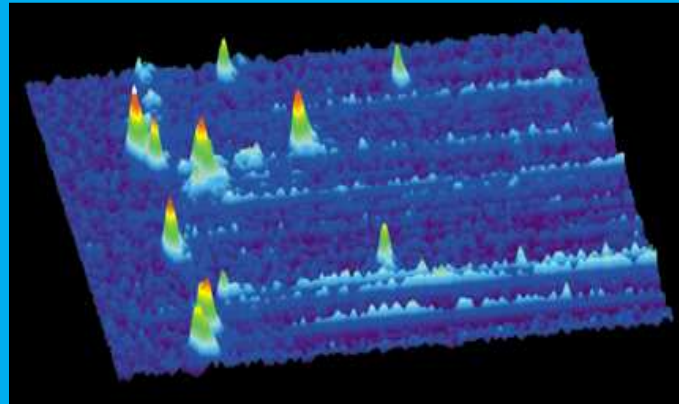


(Erwin Sigel, University of
Bern, 1987)

Ca^{2+} signalling in cells



Ca²⁺ puffs



Figures from the Parker lab: Sun, et al., J. Physiol.1998, Parker and Callamaras, cover of Molecular Probes

Modeling assumptions and goals

Assumptions

- Channel gating is stochastic
- Feedback of Ca^{2+} -domain on the opening (and closing) of channels and channel clusters is dynamic ($[\text{Ca}^{2+}(t)]$ or $[\text{Ca}^{2+}(t,x)]$)

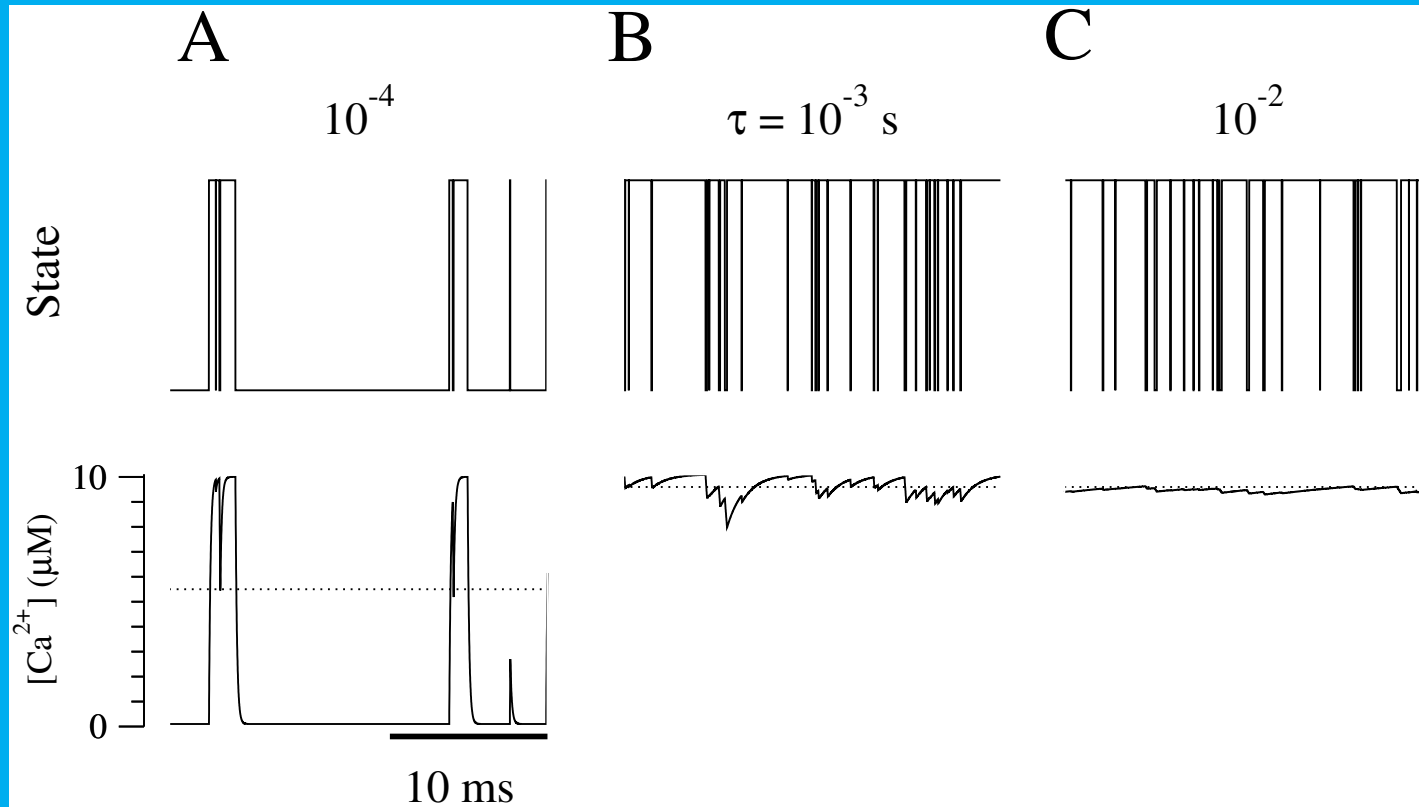
Modeling assumptions and goals

Assumptions

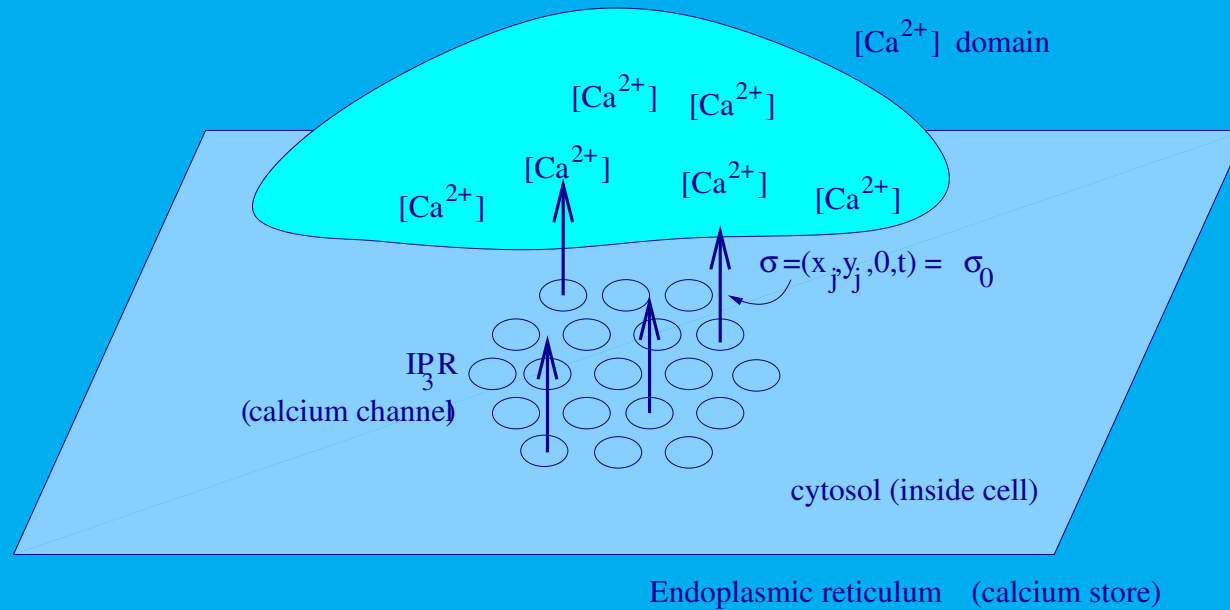
- Channel gating is stochastic
- Feedback of Ca^{2+} -domain on the opening (and closing) of channels and channel clusters is dynamic ($[\text{Ca}^{2+}(t)]$ or $[\text{Ca}^{2+}(t,x)]$)

Goal: To understand localized Ca^{2+} dynamics near channel clusters and how each level of organization from individual channel properties to cluster structure contribute to it

Some old results



Current projects – Modeling a Ca^{2+} -channel cluster

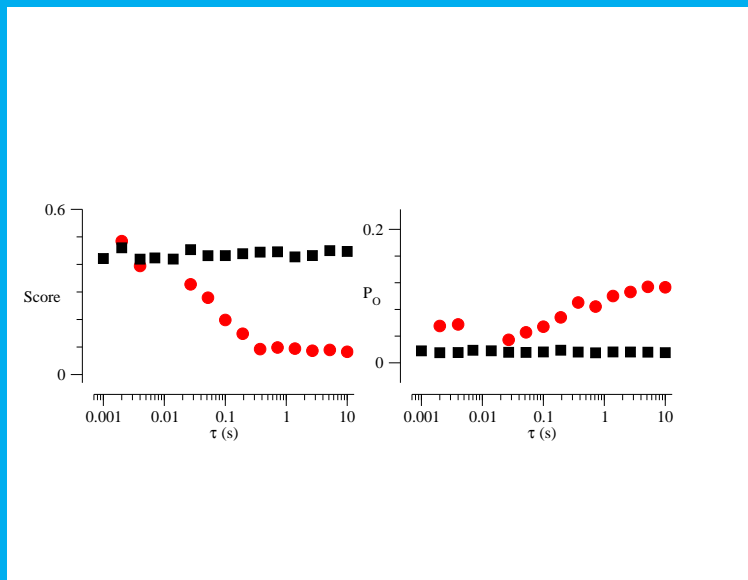


Channel cluster Ca^{2+} dynamics

Faster computational methods exist when the channel gating is very fast compared to the domain dynamics or when channel gating is very slow.

Channel cluster Ca^{2+} dynamics

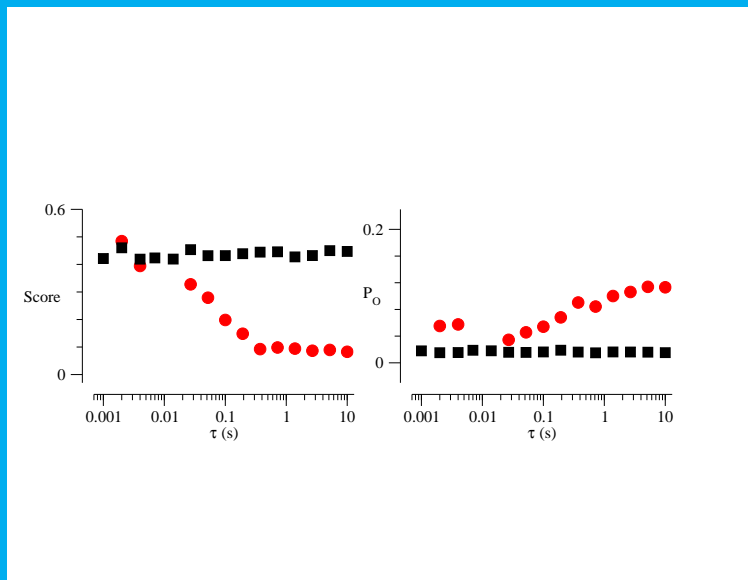
Faster computational methods exist when the channel gating is very fast compared to the domain dynamics or when channel gating is very slow. (simulations)



(1) When are these approximations good?

Channel cluster Ca^{2+} dynamics

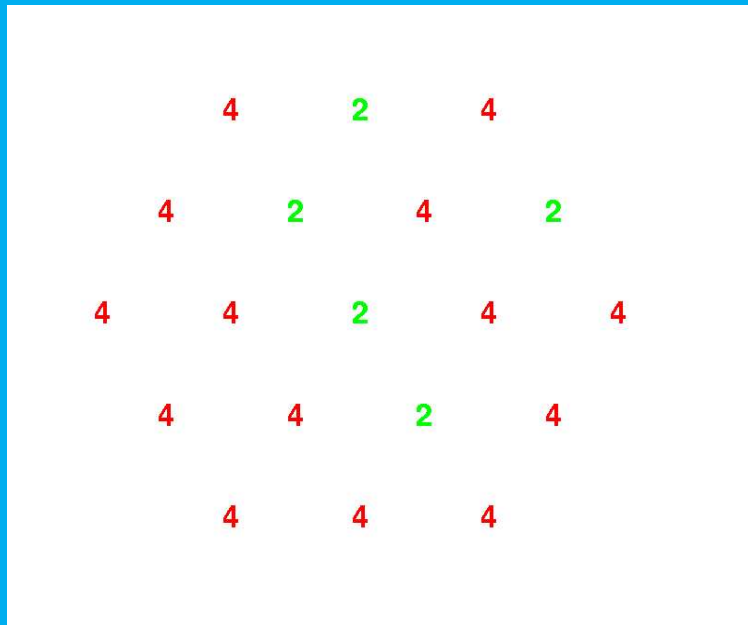
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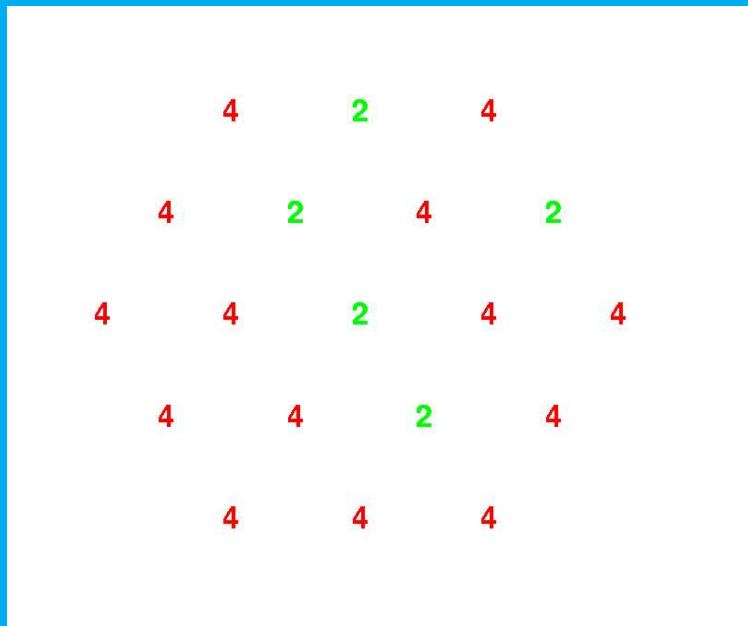
- (1) When are these approximations good?
- (2) How does convergence depend on the types of channel models?

Mixed release sites

Is there a threshold proportion of channels with inactivation in a cluster that allows Ca^{2+} puffs?



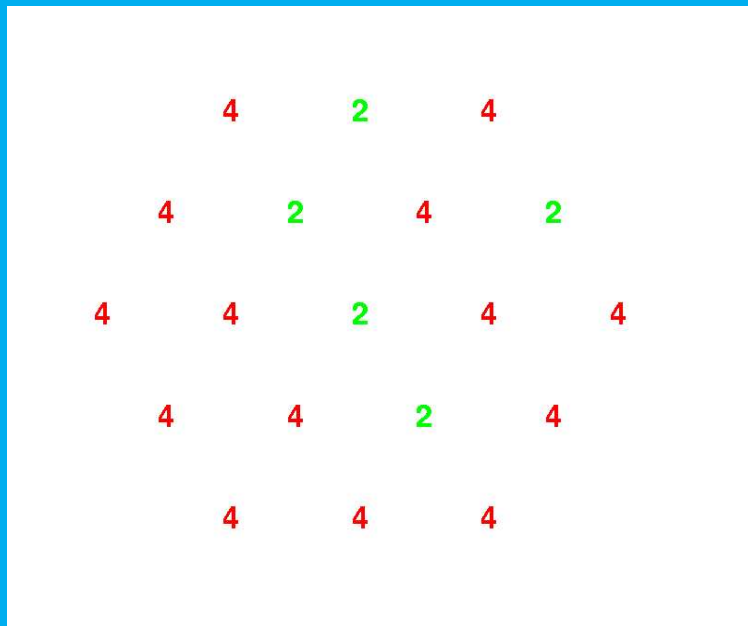
Mixed release sites



Is there a threshold proportion of channels with inactivation in a cluster that allows Ca^{2+} puffs?

How does the precise spatial position of channels determine the threshold?

Mixed release sites



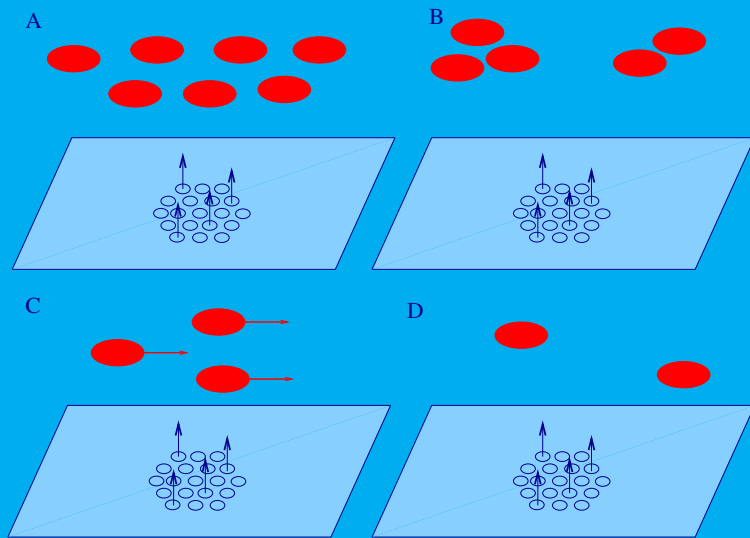
Is there a threshold proportion of channels with inactivation in a cluster that allows Ca^{2+} puffs?

How does the precise spatial position of channels determine the threshold?

How does the threshold depend on the Ca^{2+} domain?

Other possible student projects

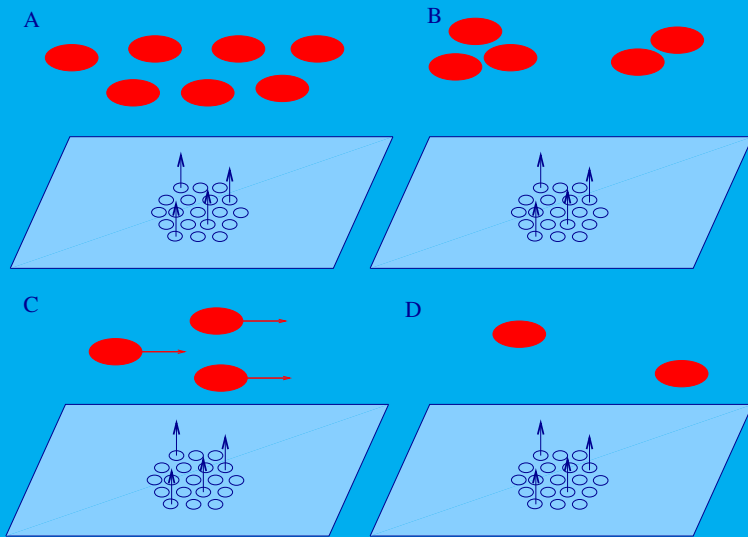
A: Uniform spatial distribution of signaling molecules



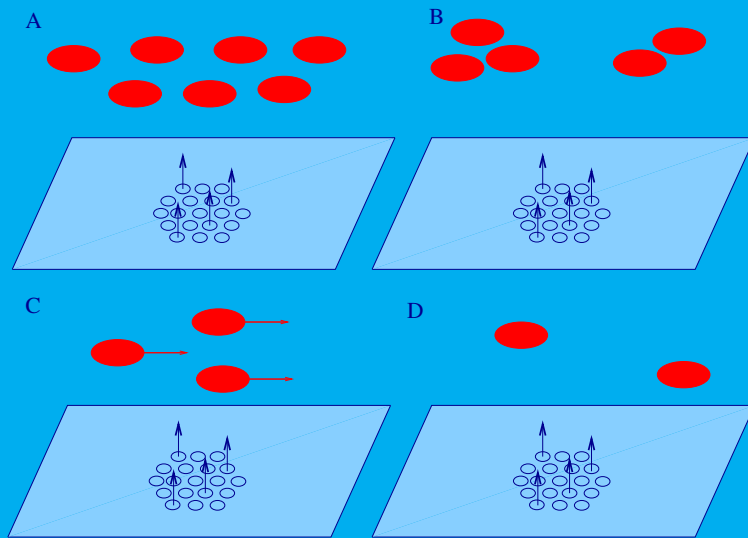
Other possible student projects

A: Uniform spatial distribution of signaling molecules

B: Clusters of signaling molecules



Other possible student projects

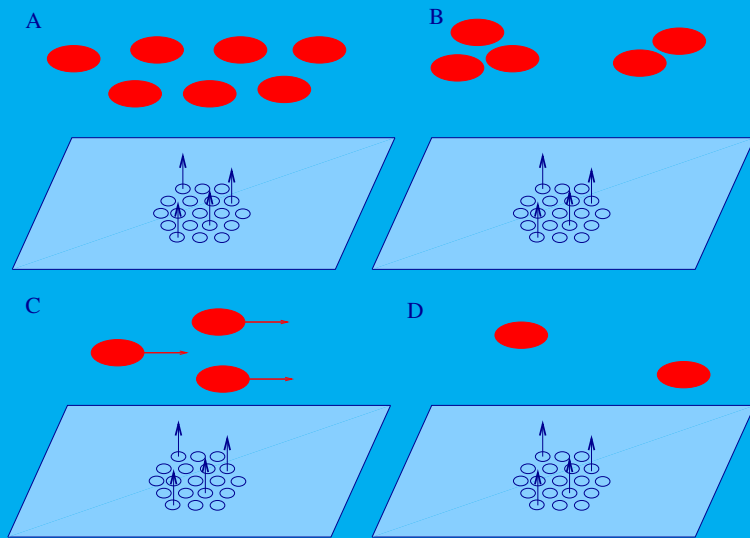


A: Uniform spatial distribution of signaling molecules

B: Clusters of signaling molecules

C: Mobile/diffusing signaling molecules

Other possible student projects



A: Uniform spatial distribution of signaling molecules

B: Clusters of signaling molecules

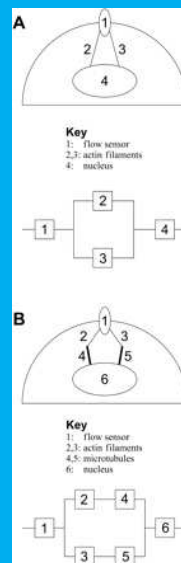
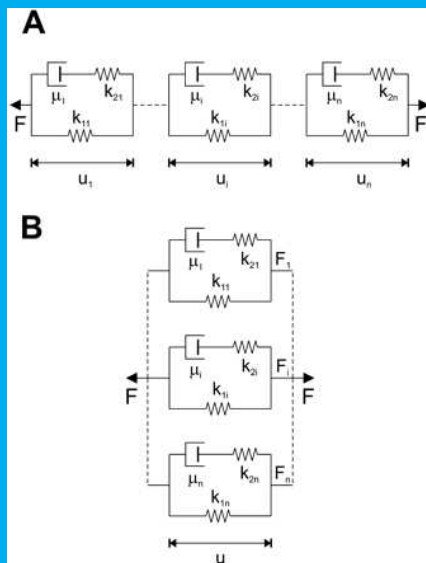
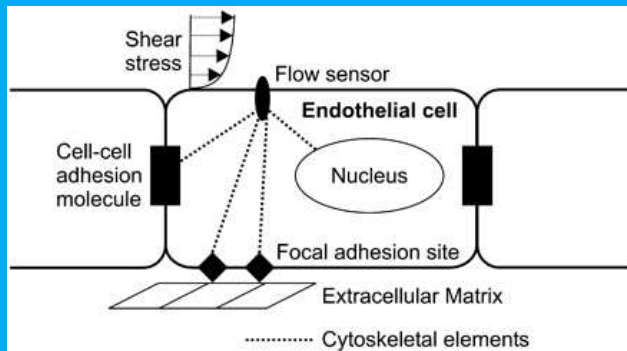
C: Mobile/diffusing signaling molecules

D: Few signaling molecules – stochastic reactions

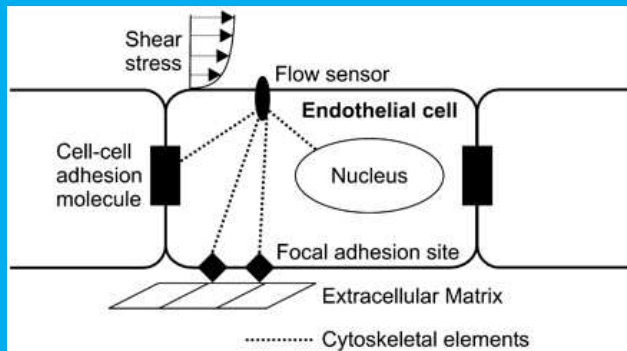
More ideas for student projects

- Can a cluster be replaced by a single channel, and if so, under what conditions? (e.g. a tight cluster with much faster channel kinetics than the time scale of Ca^{2+} diffusion)
- Ca^{2+} dynamics in the heart muscle: interaction between voltage-gated channels and channel clusters of our interest

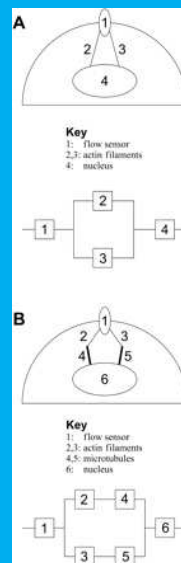
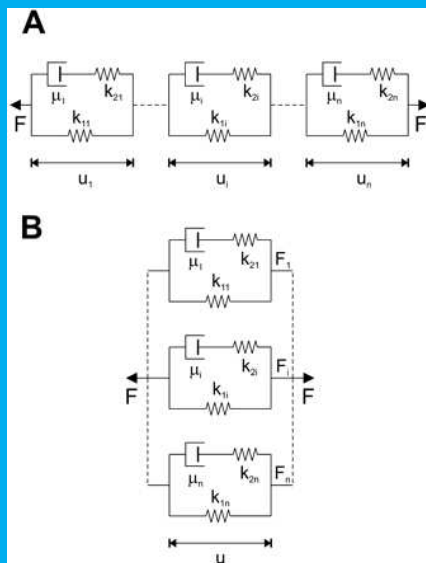
Endothelial cell deformation



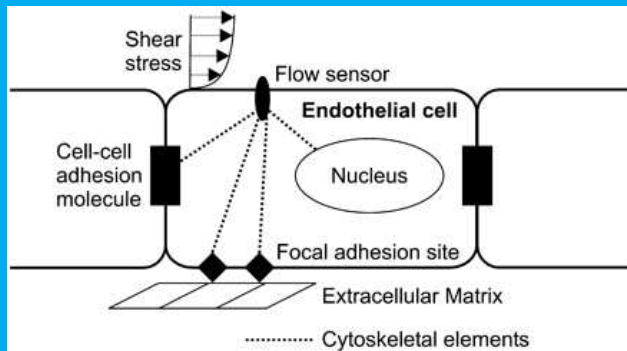
Endothelial cell deformation



What happens if the force applied is stochastic

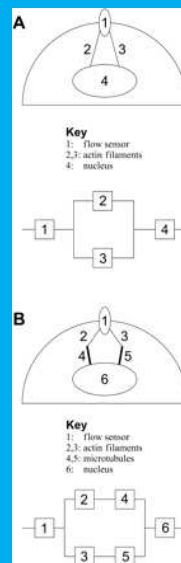
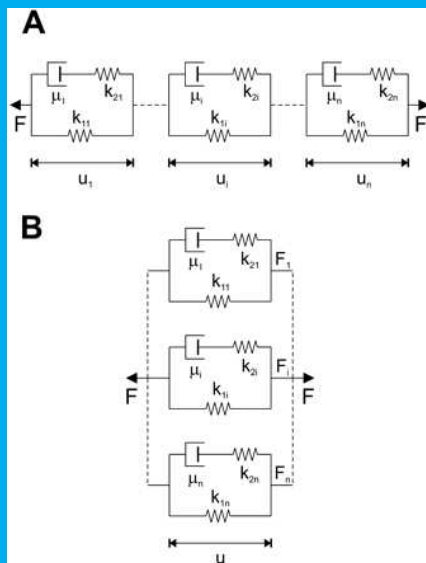


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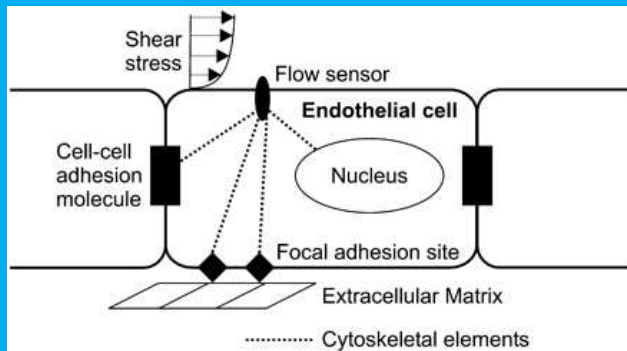


What happens if the force applied is stochastic

More complicated networks of Kelvin bodies?



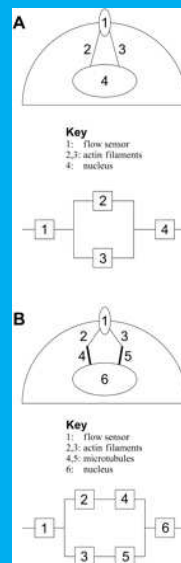
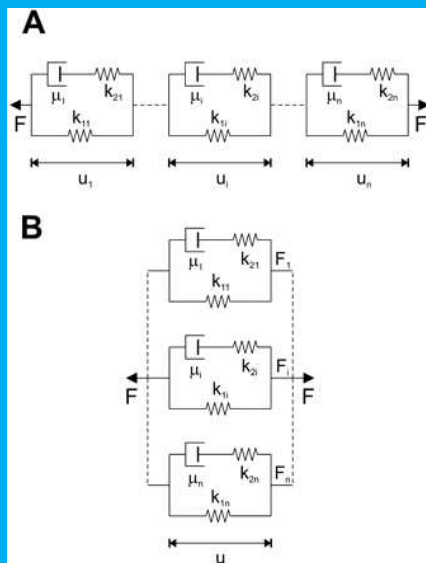
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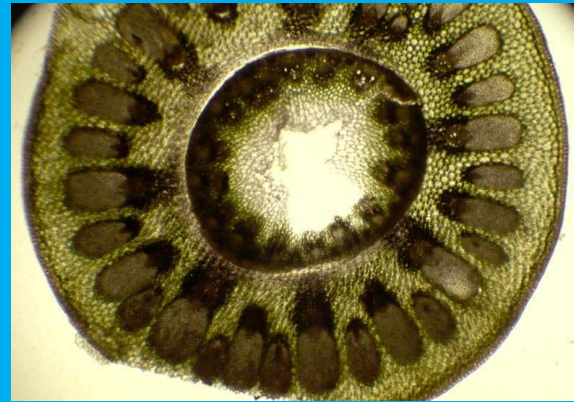
What happens if the force applied is stochastic

More complicated networks of Kelvin bodies?

How to model very large networks?



Gravitropism – Project with Ari Kornfeld



Mixed deterministic and stochastic models in different settings

- Studying interactions (competition, predation) of a rare species with commonly occurring species. Dr. Jeff White (HSU Biology Dept.): Study of rare plant species distribution. (Data for spatial distribution of species.)

Mixed deterministic and stochastic models in different settings

- Studying interactions (competition, predation) of a rare species with commonly occurring species. Dr. Jeff White (HSU Biology Dept.): Study of rare plant species distribution. (Data for spatial distribution of species.)
- Studying the effects of stochastic events (such as mutations) on deterministic processes (fertilization of a large number of eggs by a large number of sperm). Dr. Edward Metz (HSU Biology Dept.): Molecular evolution of sperm-egg recognition.

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