Millisecond synchrony can be seen during a depolarized state (Wang et al. 2009).

An axonal plexus: a network of pyramidal cell axons connected by gap junctions can produce VFOs with ms synchrony (Traub et al. 1999, Lewis & Rinzel 2006). External drive can evoke VFOs in a realistic cortical axonal plexus (Munro & Börgers 2010).

Gaps in the IS and main axon can be controlled when somata are depolarized: 
- Simulate an axonal plexus and gap junctions are open
- Set fixed somatic voltage (V soma)
- Simulate collateral
- See if AP propagates through main axon
- Find threshold gj where propagation occurs for a number of collaterals in 6 representative 3D cell reconstructions.

Re-entrant VFOs are seen:
- If AP propagation fails occasionally
- If there are cycles in the network
- Hypothetically, more often in an axonal plexus (Munro & Börgers 2010)

Graphs:
- Set fixed somatic voltage (V soma)
- Simulate one cell
- See if AP propagates to other cell
- Find threshold gj where propagation occurs, varying the distance of the gap junction from the soma
- Propagation is very sensitive to gj in the IS
- Propagation is less sensitive further from the soma, but can still be controlled by V soma
- One electrotonic length corresponds to 120-175 μm in our model

Questions & Goals:
Goal: to elucidate how a realistic axonal plexus functions, and to answer:
- How can somatic voltage control network behavior so that we see VFOs and synchrony only when cells are depolarized?
- Could normal spreading promote epilepsy? Yes!

Our Model
We hypothesize that gap junctions could be placed on any length of unmyelinated axon, including:
- Collaterals
- The initial segment (IS)
- Main axon

Collaterals:
- Assume a gap junction on a collateral can propagate an AP from another axon
- Using 3D cell reconstructions with Hodgkin-Huxley kinetics taken from Traub et al. (2003), we simulate APs propagating from collateral to IS to main axon, varying sodium conductance (g Na) in the axon to determine the threshold for propagation failure

Gaps in the IS and main axon:
- Simulate a simplified axon with the same Hodgkin-Huxley kinetics to determine the gj, threshold where an AP can propagate through a gap junction
- Place gap junction along the IS, vary gj, in the IS and distance from soma
- Place gap junction along main axon, vary gj, in the IS and electronic distance from IS

Network properties:
- Generate networks with MATLAB
  - group cells into a cluster
  - place columns in a hexagonal grid
  - IS and main axon gap junction connections made within columns randomly
  - collateral gap junction connections made between columns randomly
  - restricted by distance (based on the average width of cell reconstruction axons)
  - weighted probability (based on total reconstruction axon length)
- Analyze networks to determine size of clusters and existence of cycles

Network produces VFOs only if IS and main axon gap junctions are open:
- Collaterals
- Axiomatic number of cells in a cluster
- Average number of cells in a cycle

Discussion
Neocortical computation with an axonal plexus:
- cell output can be amplified with or without a VFO
- Groups of dendritic cells can form cell-assemblies acting together
- Cluster sizes in model network can be randomly, may not be ideal for computation

Could gap junction connections be purposeful in the neocortex?
- Markram, Staiger, and Svoboda labs for providing their cell reconstructions on neuromorpho.org.
- Could cells fire together, wire together gap junctionally?"