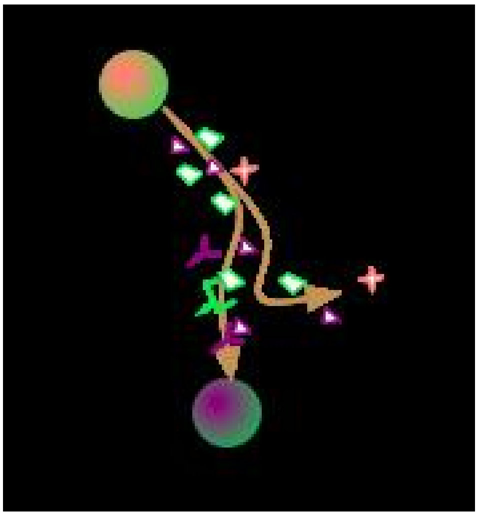
Digital Biological Neuron

Digital Biological Neuron (DBN) is a theoretical model instead of description of an observed neuron. The model is compatible with Digital Biological Cell (DBC), a theoretical model of a generic eukaryotic cell.

As any other Digital Biological Cell, Digital Biological Neuron laws have to conform with the following rules:
- Every cell has an internal state. This notion has not been observed; it was introduced.
- The internal state of the cell is determined by receptors (ρ) and ligands (λ).
- The production of the cell is determined by the internal state and genetic information

Before we get to the laws, we should get familiar with basic notions as shown on the picture. The definitions and the laws might seem vague, however it improves overall readability and presents the theory from a higher level. For those interested in exact mathematic formulations, please do not hesitate to contact us.



Neuron (DBN) is inspired by biological observations of an eukaryotic cell - neuron. We do not simulate neuron's behavior - we define it by four laws.

Mediator is the only mean of communication between neurons. Each neuron produces various types of mediators and when neuron fires, it releases them. Mediators could be caught later by other connected neurons.

Receptor is tightly connected to a neuron and allows the neuron to catch a mediator. For each type of transmitted mediator there is a different receptor.

Synapse. Neurons are connected to other neurons by receptors, and the place of connection is called synapse. The synapses are unidirectional; therefore if a neuron N is connected to another neuron M, every receptor in that synapse belongs to neuron N.

Internal state. Each neuron must be in exactly one state at a time.

Genetic information tells a neuron, which mediators are currently in production. Genetic information is the same for all the neurons within the simulation and does not change.

And here are the four laws of DBN:

Fire law: When a neuron catches mediators, later it fires mediators too. The type (and quantity) of fired mediators depends on internal state of the neuron and genetic information.

Mediator law: Neuron can catch mediators only if it has correspondent receptors. The amount of caught mediators depends on number of receptors and is the only information to set the internal state of the neuron.

Receptor law: If neuron's receptors caught some mediators lately, then the neuron will extend the number of these receptors. The receptors will be added to the same synapse, which caught the mediators. Number of receptors in a synapse is limited.

Synaptic law: If neuron has not been firing for some time, it can connect (create a synapse) to some neuron, which has been firing lately.

The fire law describes conditions when neuron "fires" and continues to spread signal over the network. This law alone allows to see how signals can spread across networks, how signals can quantitatively influence each other, how to simulate intensity of a signal and some thoughts over signal running in cycles.

The mediator law shows us that some types of mediators can be caught by connected neurons, while some other cannot. This behavior allows developing a theory of qualitative signal interaction. Some signals can be reinforced, why other can be suppressed.

The receptor law tells us the conditions when the receptors are added. This law is mostly used when the network is learning new signals.

The synaptic law explains us how the connections between neurons (synapses) are created. The law allows creating a whole network from scratch. The network is built depending just on incoming signals and genetic information.