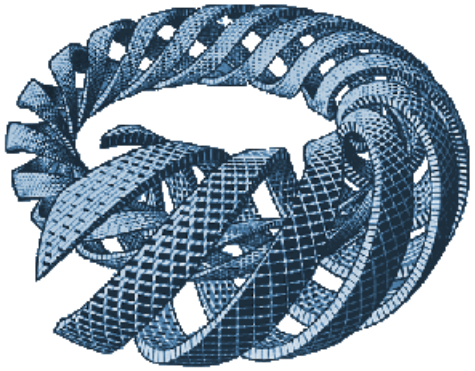


Self-Organizing Maps

Gute Ideen in der Systembiologie

Marten Jäger & Thomas Schüler

Outline

- Self Organization in the nervous system
- SOMs in artificial neuronal networks
  - Kohonen nets

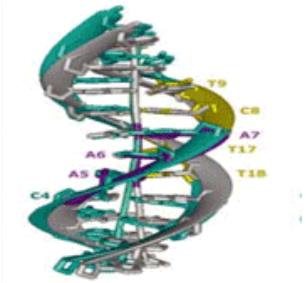
SOMs in the Nervous System

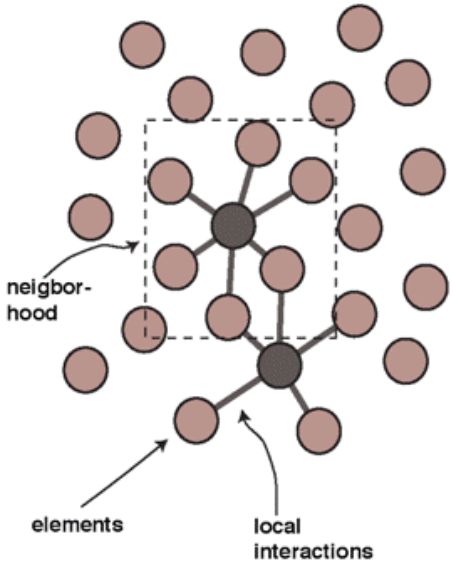
- David Willshaw. Self- Organization in the Nervous System. *Research Review, 2003*

- K. Obermayer. Statistical-mechanical analysis of self-organization and pattern formation during the development of visual maps. *Physical Review A, 1992*

Self Organization

- process by which individuals organize their communal behavior
- no external influences
- examples:
  - molecular self-assembly (DNA)
  - flocking behavior (fish swarms)
  - human society
    - group thinking
    - herd behavior





http://www.faculty.iu-bremen.de/mhuett/images/research1.gif

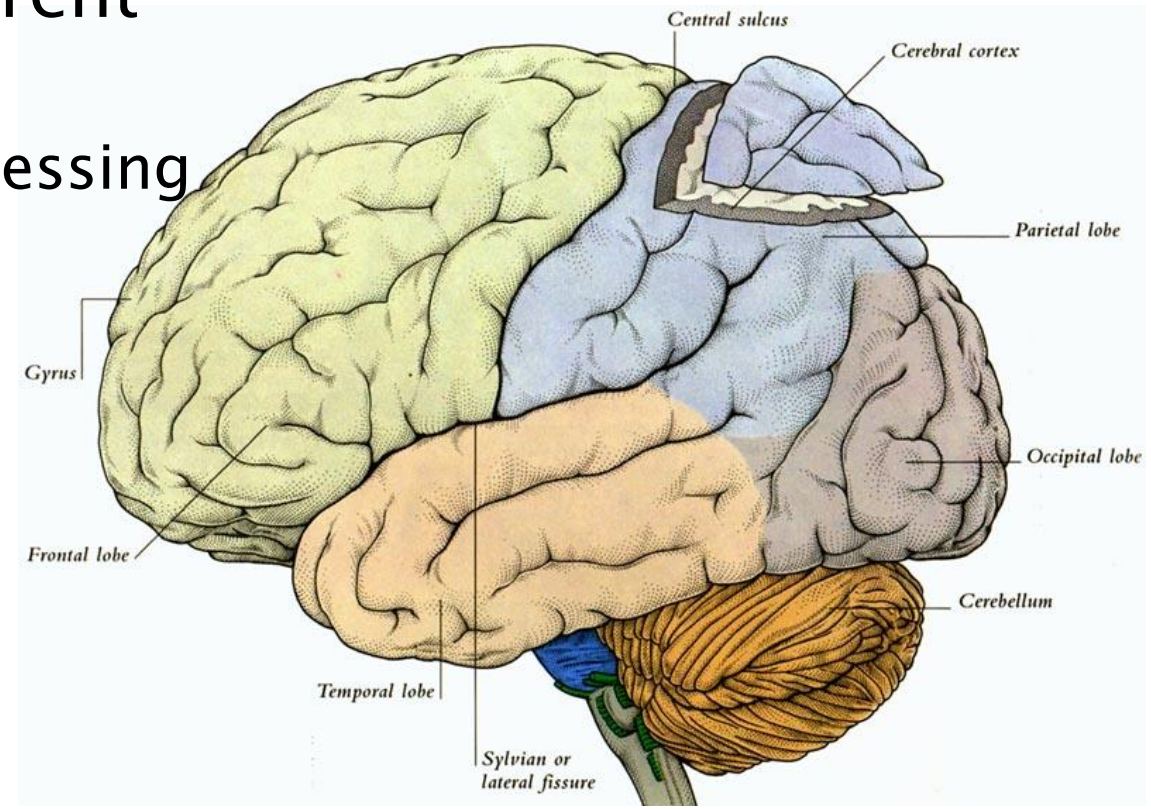
Self Organization in the Nervous System

- structure of brain extremely complex
  - number of genes not sufficient to completely specify neural connectivity
  - → self-organization of cells very likely
- requires external influences
  - from other regions of the NS
  - from sensory stimulation

Cerebral Cortex

- layer of cells on the brain surface
- lobes have different functions
  - information processing
  - thinking
  - perceiving

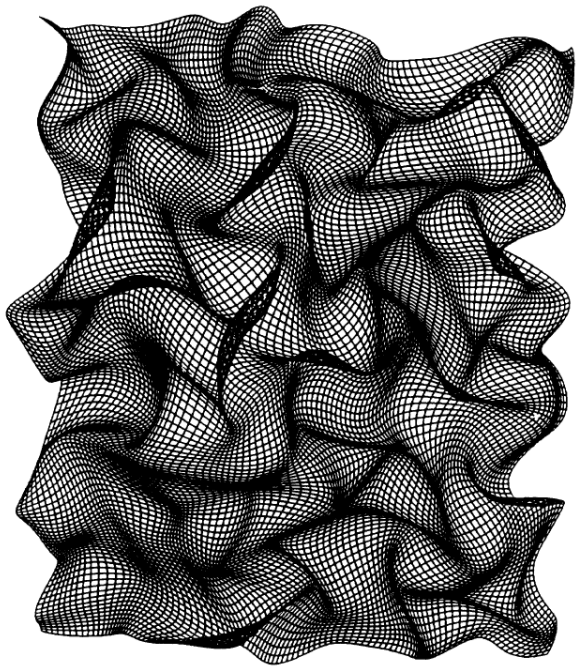
http://www.wiredtowinthemovie.com/images/hotspots/level04cerebralCortex.jpg



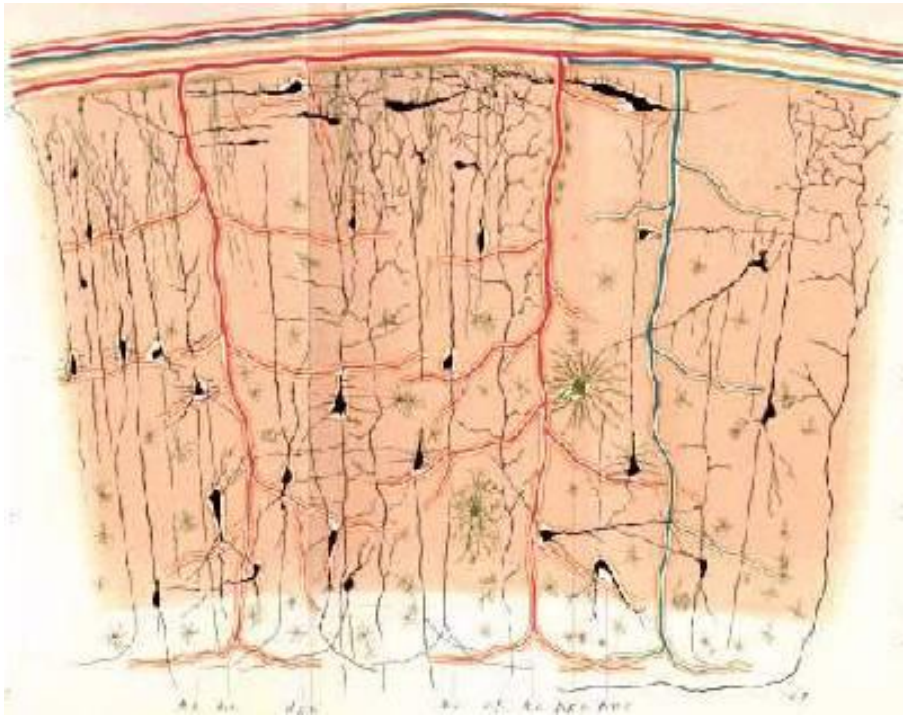
http://www.coheadquarters.com/coOuterBrain1.htm

Cortical Organization

- layers are planar
- columnar structure



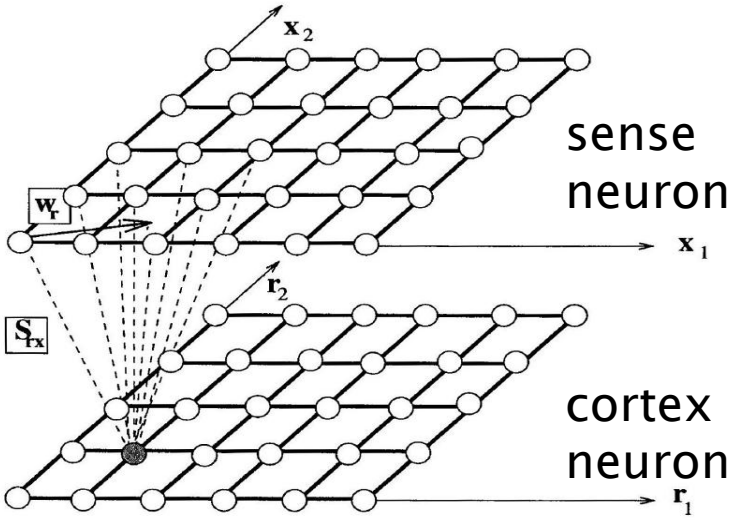
Obermayer (bibliography)



http://www.cerebromente.org.br/n05/opiniao/cortex4p.jpg

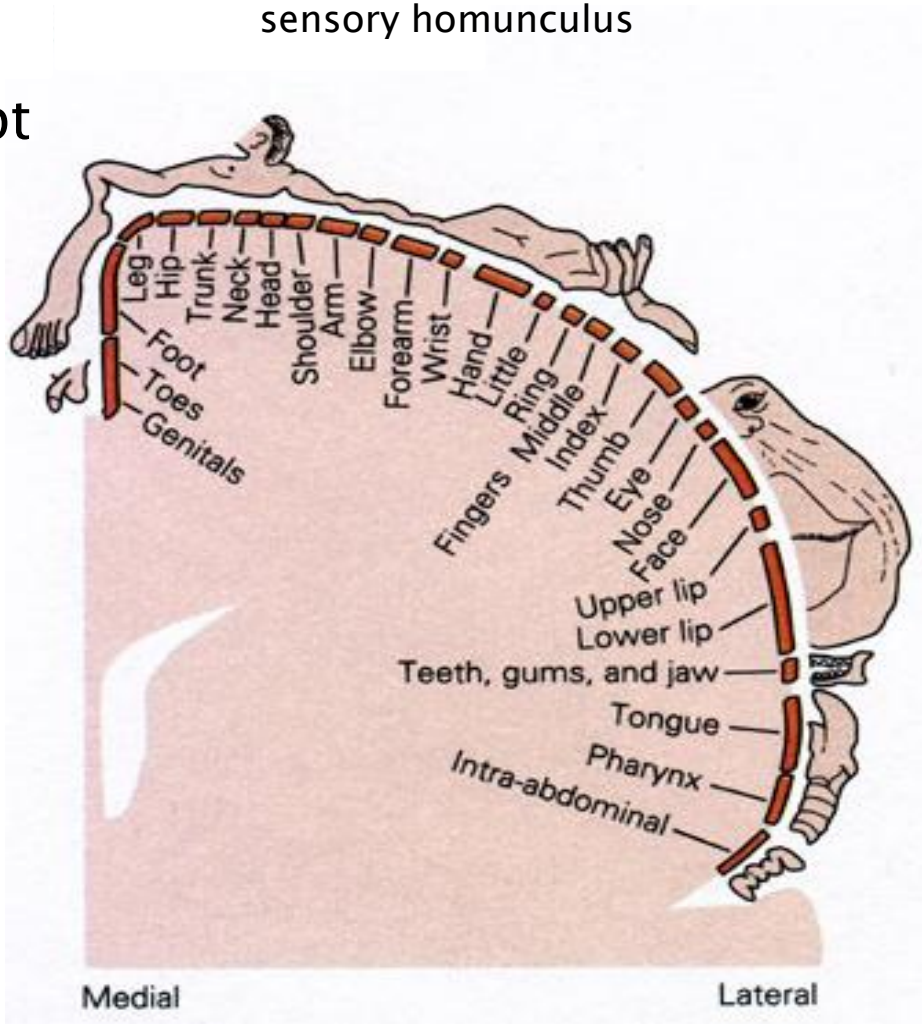
cortical map

- topographic map
  - local neighborhoods are kept
  - divergent projection
  - →better differentiation of nearby stimuli



http://www.bmo.physik.uni-muenchen.de/lehre/SS05/HaSeTheoBiopNeuro Netze/talks/kortex_karten.pdf

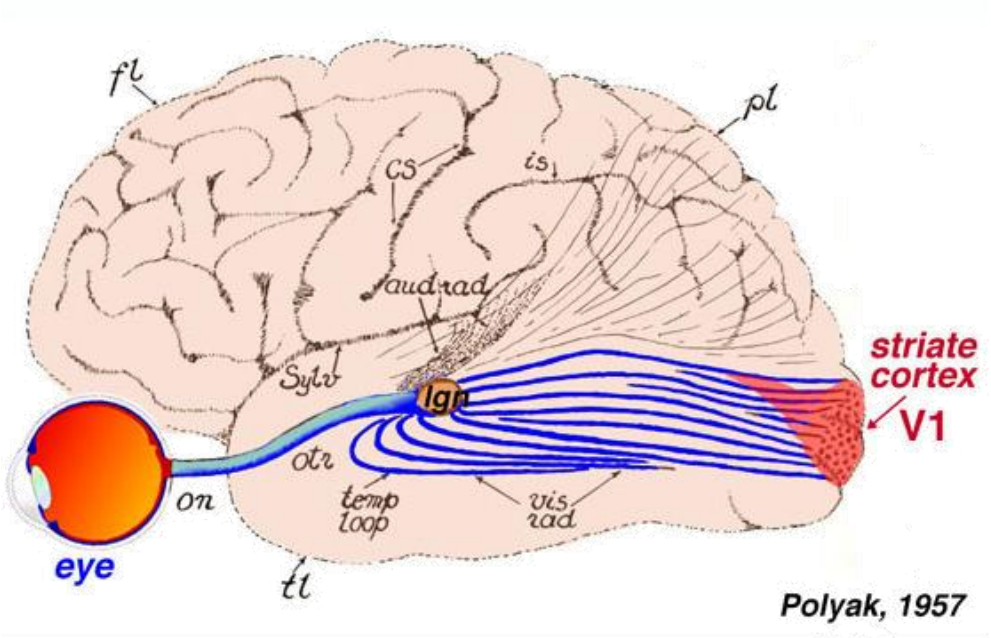
sensory homunculus



http://pharyngula.org/~pzmyers/neuro/chap9/

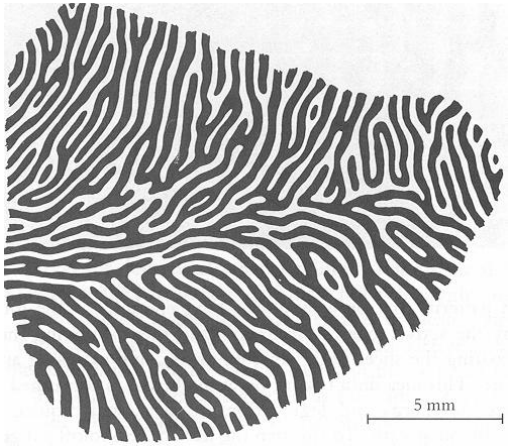
visual path

- retina cells project to the primary visual cortex
- nearby locations in the retina → neighboring locations in the cortex
- cortical maps
  - process all possible elements in natural scenes e.g.:
    - contours
    - texture
    - color

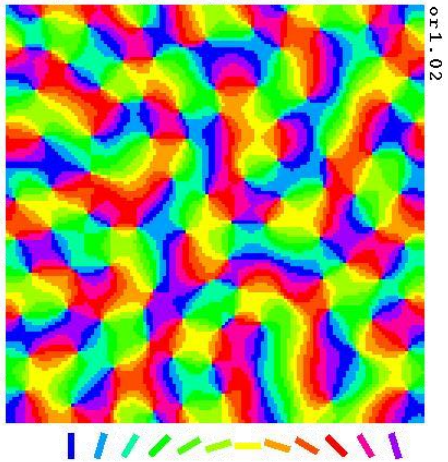


http://webvision.med.utah.edu/imageswv/capas-cortex.jpg

primary visual cortex

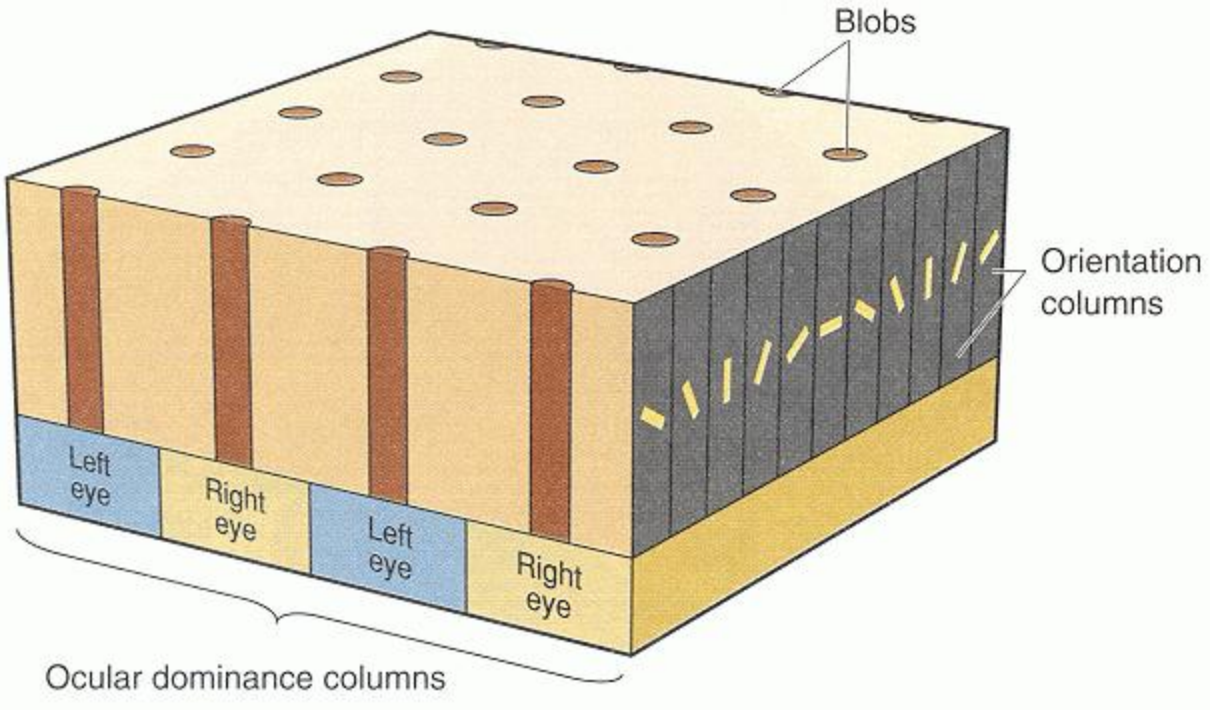


http://hubel.med.harvard.edu



http://www.vnc.brain.riken.jp/simulator/sample/C

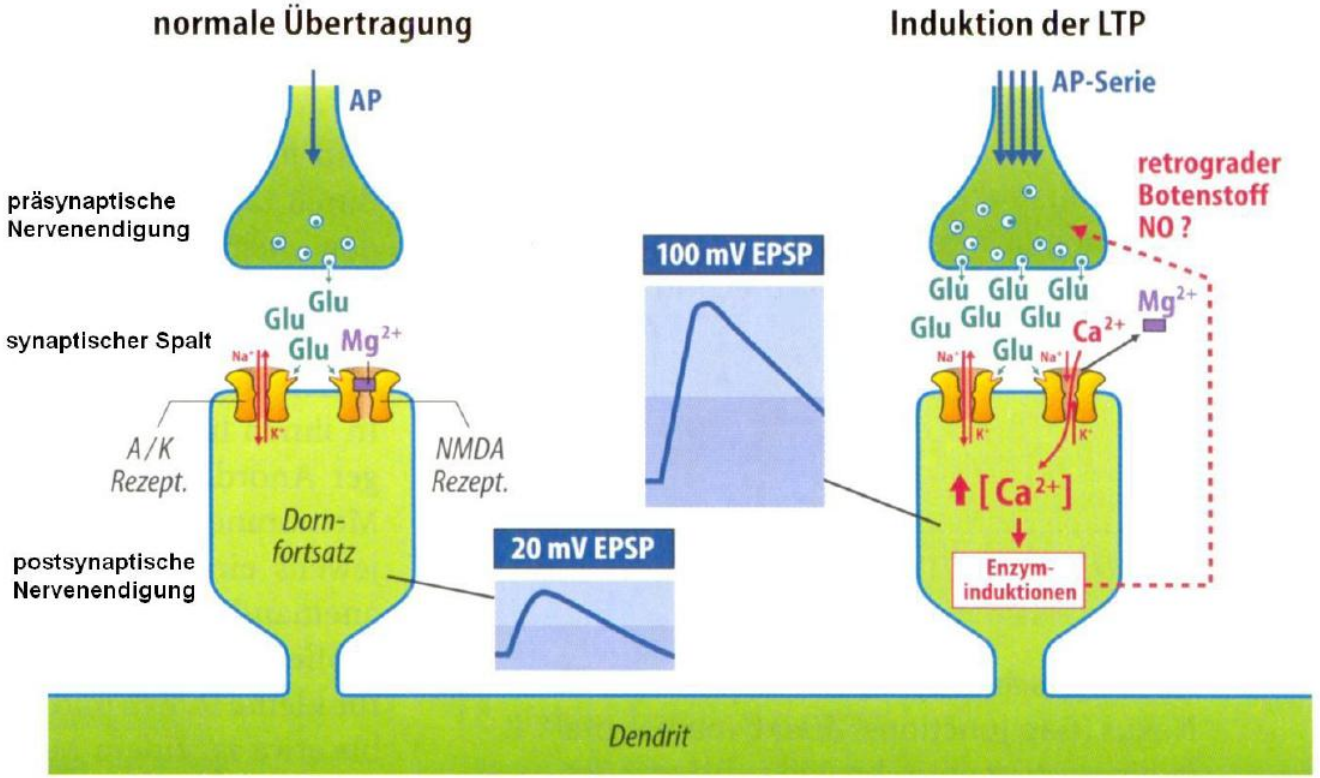
- ocular dominance
  - response depends on the eye that gave the input
- orientation selectivity
  - response depends on orientation of the input pattern



http://fourier.eng.hmc.edu/e180/handouts/figures/

Hebbian learning

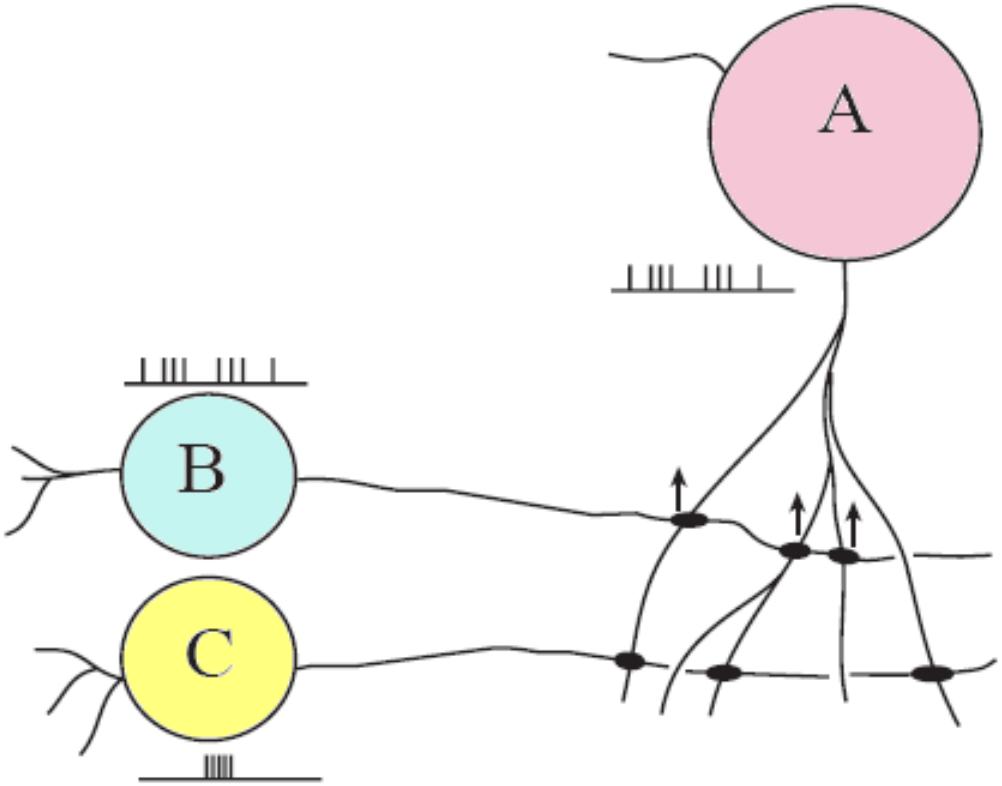
- basis for the network's ability to learn



http://www.bmo.physik.uni-muenchen.de/lehre/SS05/HaSeTheoBiopNeuroNetze/talks/kortex_karten.pdf

Hebbian learning

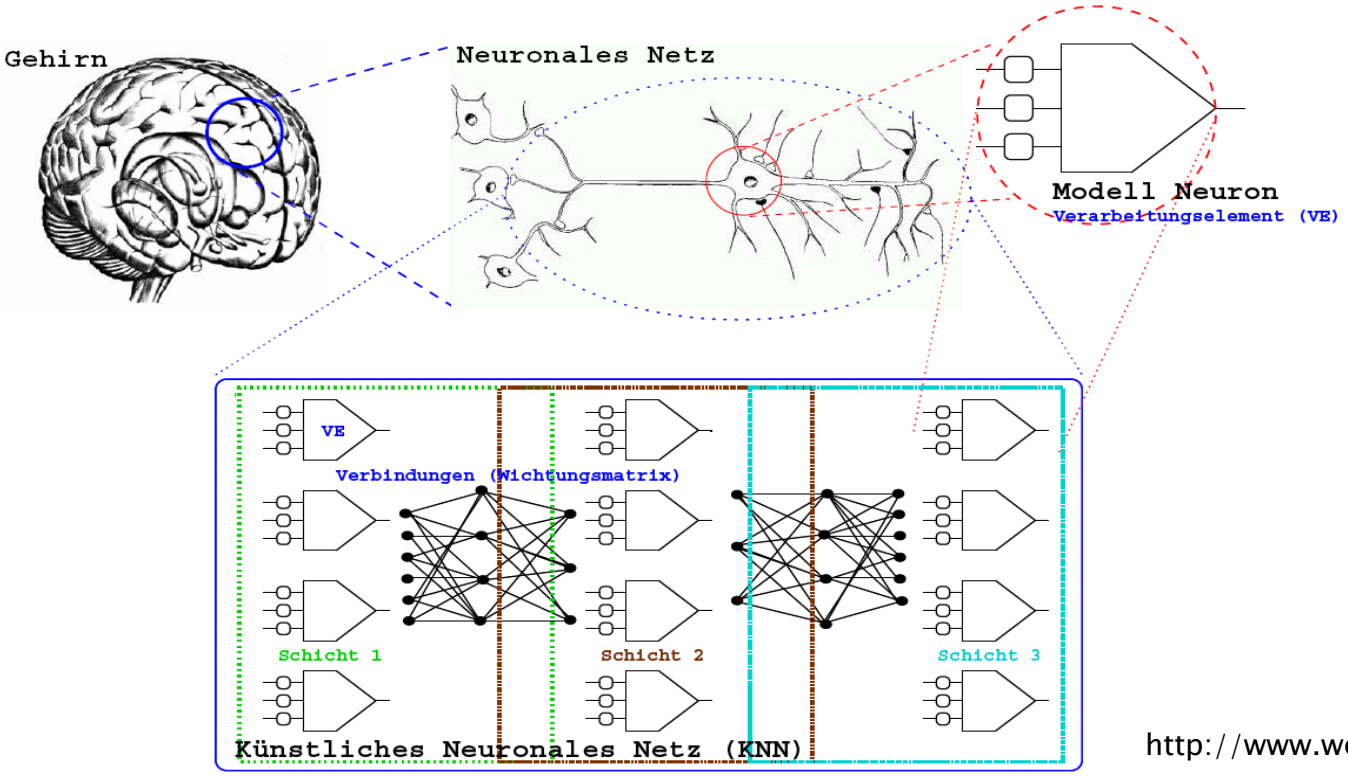
- cells that fire together, wire together



http://openwetware.org/images/thumb/e/ed/Hebbian.bmp/

neural networks

- natural neural networks
  - lead to abstract models
  - → uncover basics in neural information processing
  - transfer knowledge to technical appliances



http://www.weiprecht.de/ANN/knn.pdf

structure of cortical maps

- Pattern Formation by unsupervised learning
  - competitive learning networks
  - cells strongly coupled, coupling is essential for their specific properties

- Kohonen
  - algorithm for self organizing feature maps
  - explains development of cortical maps
  - creates dimension reducing maps

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  - Molecular_self-assembly
- Neural Nets by Kevin Gurney (http://www.shef.ac.uk/psychology/gurney/notes/)