

# **CERVEAU ET EMERGENCE**

Bertrand de LA CHAPELLE

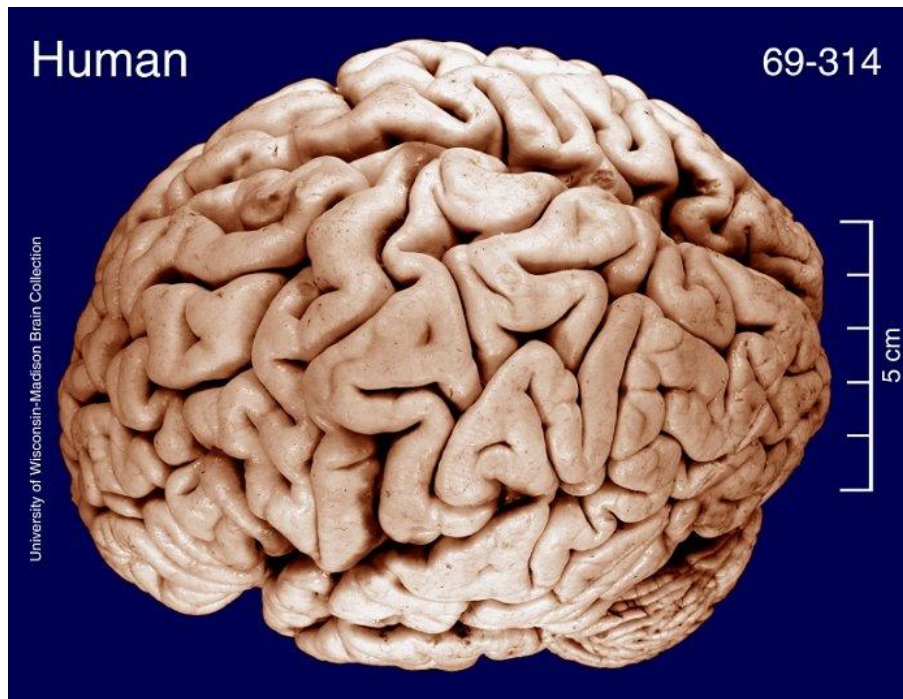
Réunion Groupe Emergence

08 / 09 / 2005

# **BRIEF ANATOMY NOTIONS**

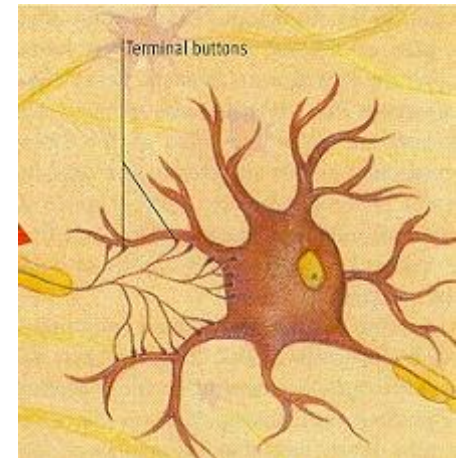
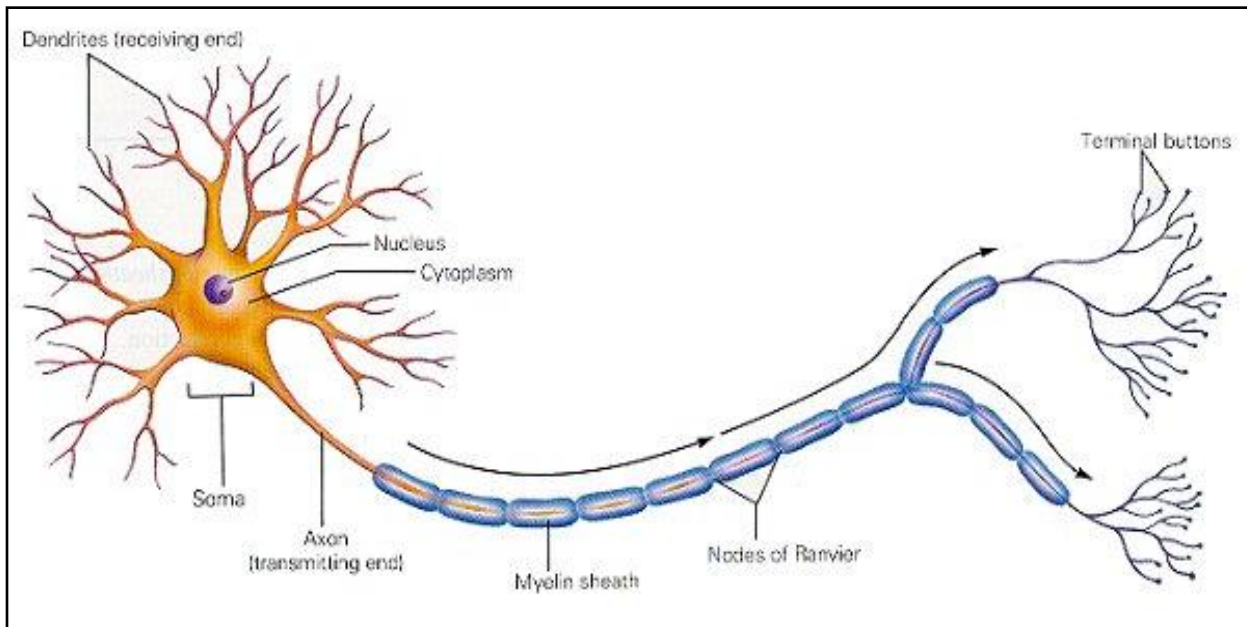
## Neurons and their functioning

# Our Brain



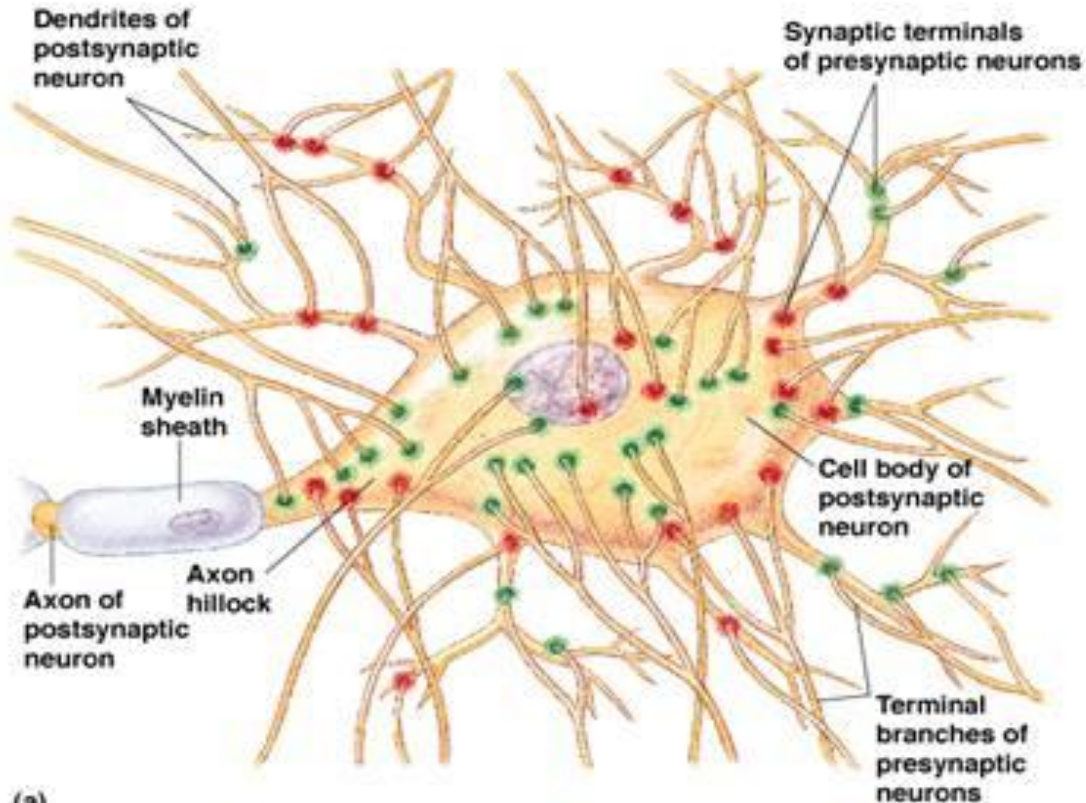
- **About 100 billion neurons**
- **Each with about 1000 connexions**

# Anatomy of a Neuron



- The brain bathes in Cerebrospinal fluid (different from extracellular fluid (ECF) in other cells of the body. CSF is stored in four ventricles in the brain and the brain itself is isolated by the « blood-brain barrier ».
- Myelination is key to speed of communication between remote parts of the brain (analogy Internet ?)

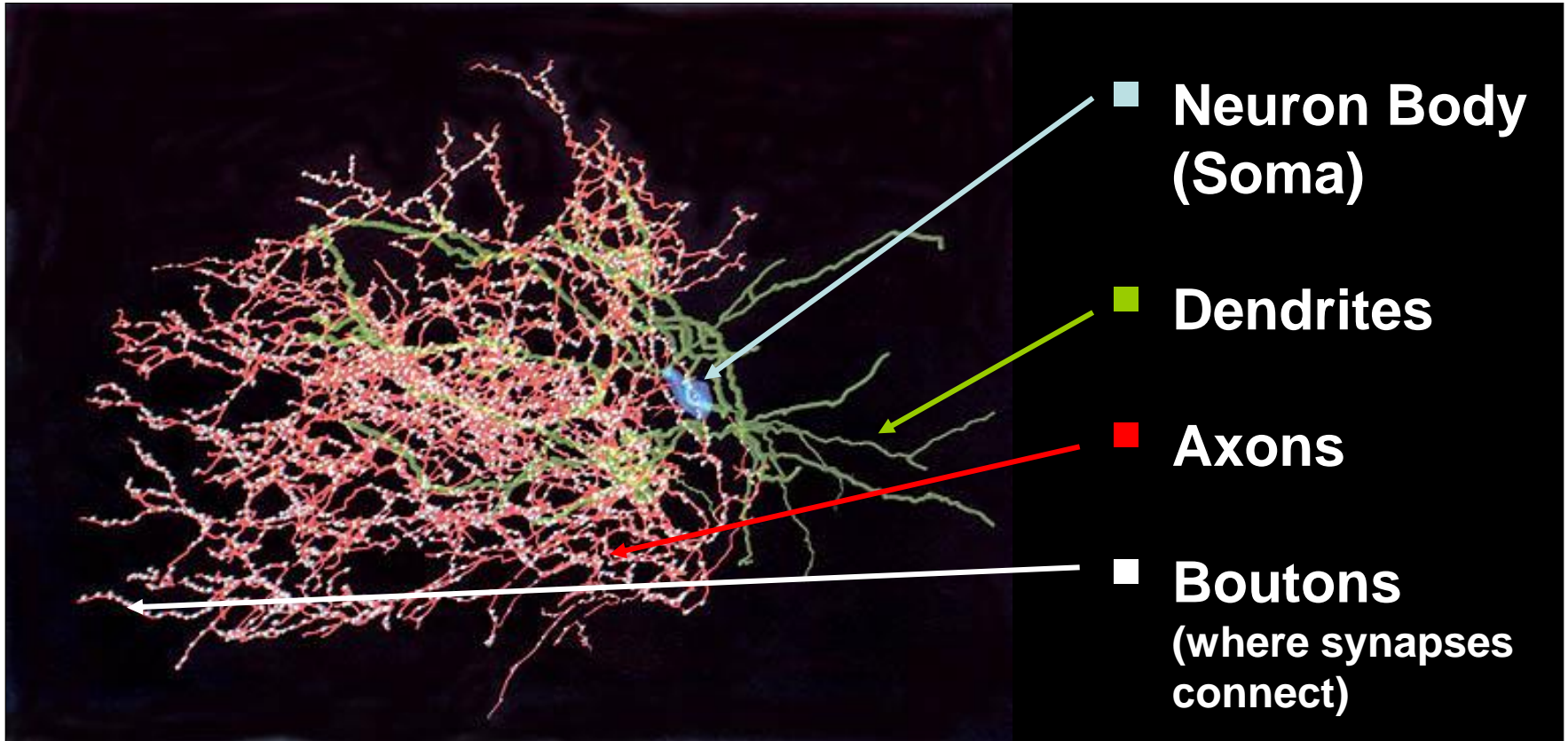
# Synapses



■ **Excitatory synapses**

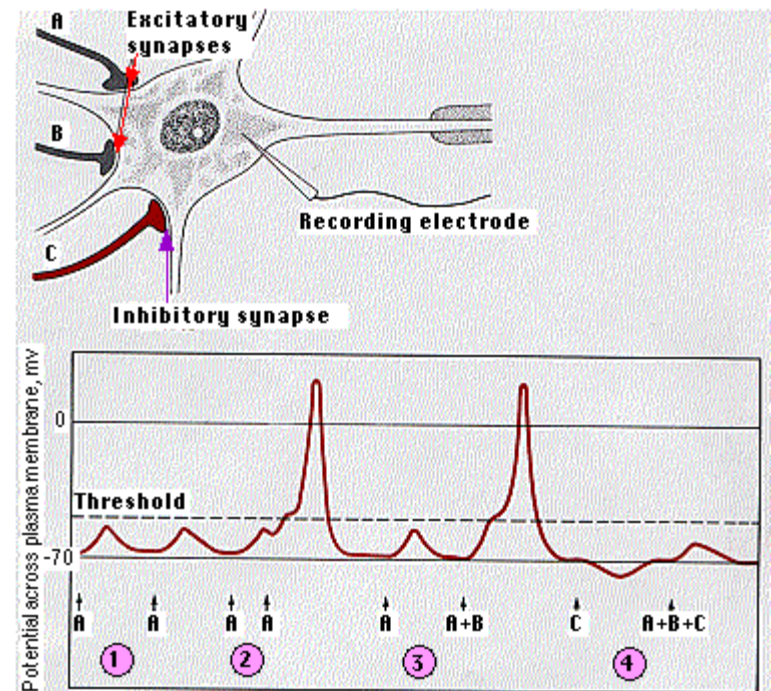
■ **Inhibitory synapses**

# Complete Neuron « bush »



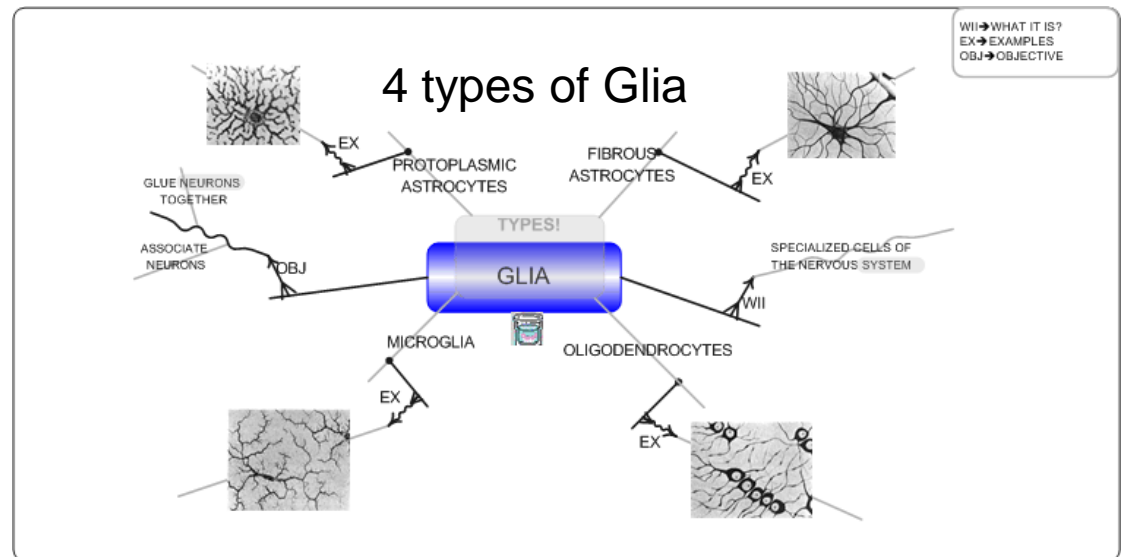
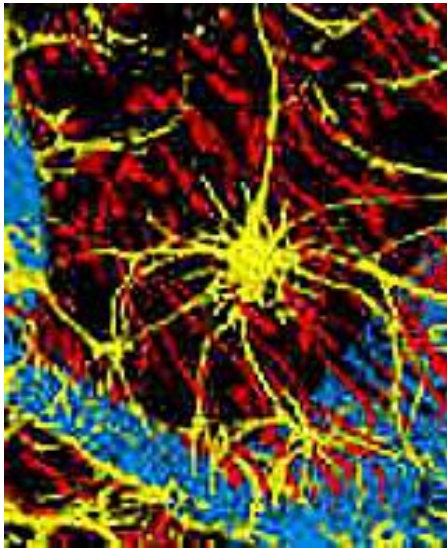
# « Summation » of potentials

1. The EPSP created by a single excitatory synapse is insufficient to reach the threshold of the neuron.
2. EPSPs created in quick succession, however, add together ("**summation**"). If they reach threshold, an action potential is generated.
3. The EPSPs created by **separate** excitatory synapses (**A + B**) can also be added together to reach threshold.
4. Activation of inhibitory synapses (**C**) makes the **resting potential** of the neuron more negative. The resulting IPSP may also prevent what would otherwise have been effective EPSPs from triggering an action potential.



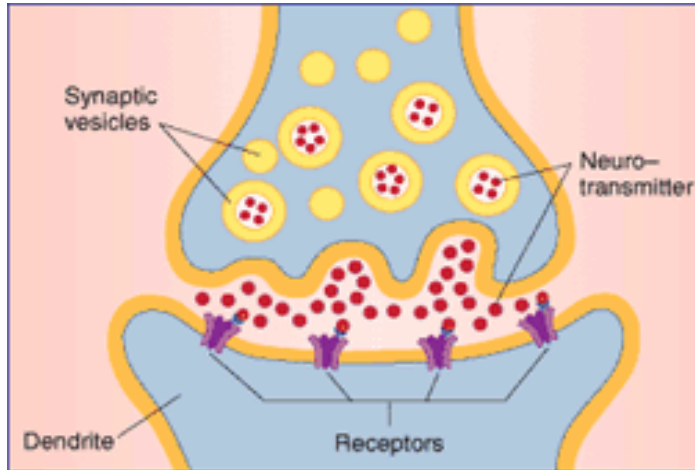
# Glial Cells

1. Glia Cells outnumber neurons in a proportion of 50 to one
2. For long, they have been considered as only providing physical support to neurons and nutrition
3. We discover they also help clean dead neurons after « pruning », help establish synapses and may have a strong role in the general shaping of the brain, particularly during its early development

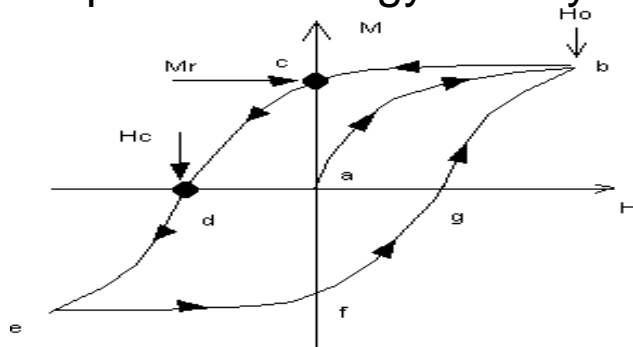




# Synapses / Neurotransmitters



Silent period : analogy with hysteresis



## Anecdote

Plains and mountain rats : genetic definition of hormone receptors sensitivity for vasopressin influence mating behavior in two closely related species.

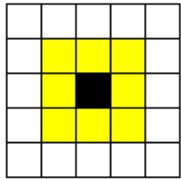
## Synapse strengthening and memory

(Douglas Fields (NICHD))  
Synapse reinforcement : Gene expression in neuron cell is triggered by time pattern of incoming stimulations

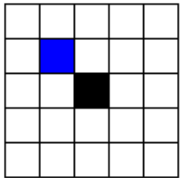
# CELLULAR AUTOMATA

A modelization tool ?

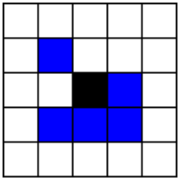
# Conway's Game of Life



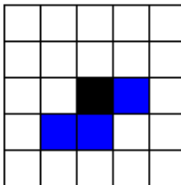
Each cell has 8 neighbors



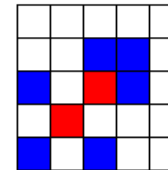
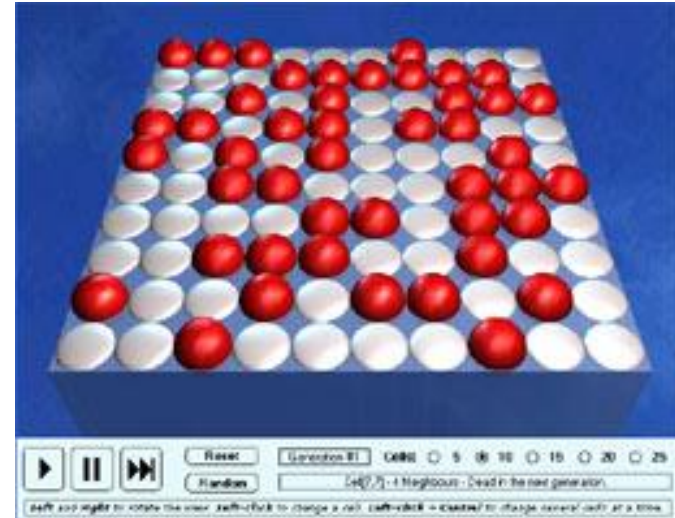
if an occupied cell has 0 or 1 neighbors, it dies (loneliness)



if an occupied cell has 4 to 8 neighbors, it dies (overcrowding)



if an occupied cell has 2 or 3 neighbors, it survives to the next generation

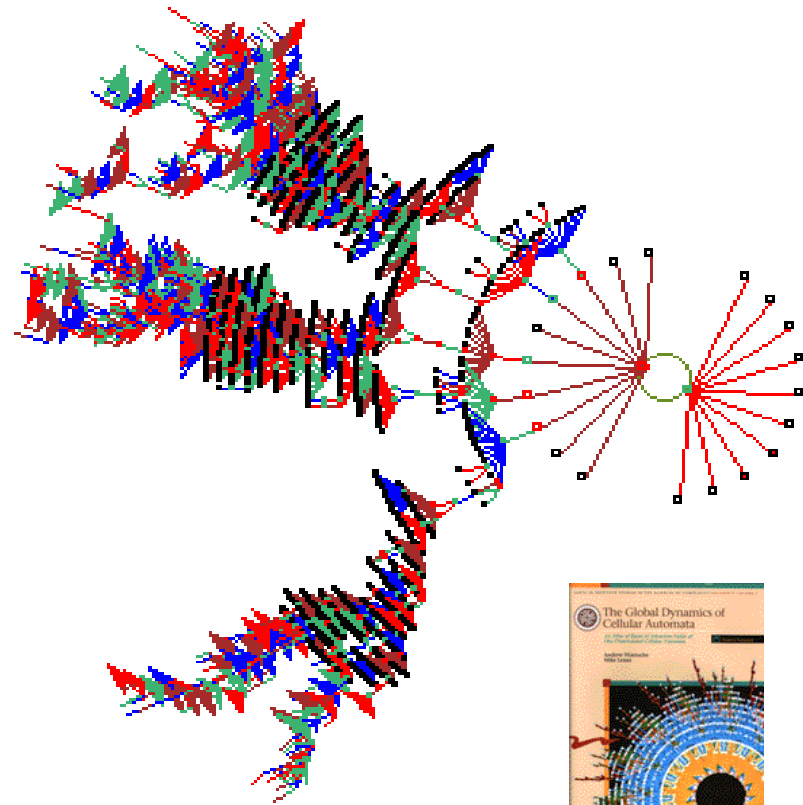


if an unoccupied cell has 3 occupied neighbors, it becomes occupied (birth)

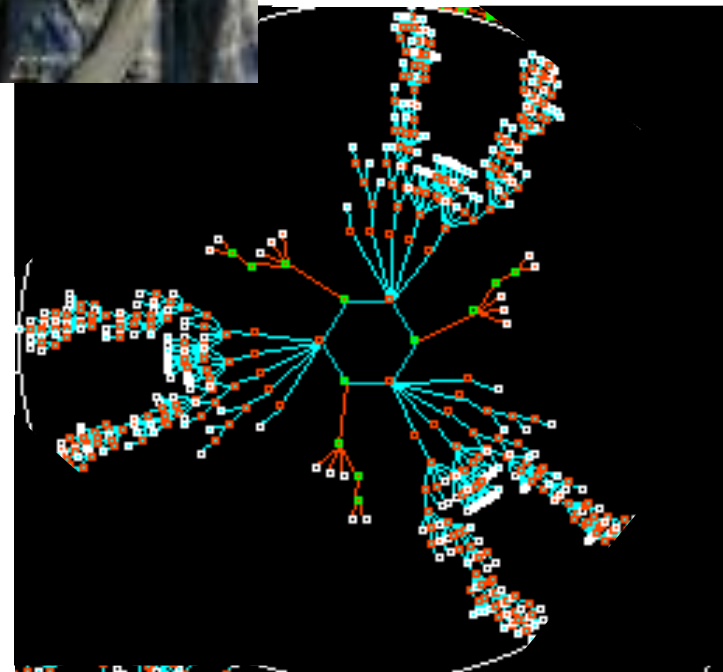
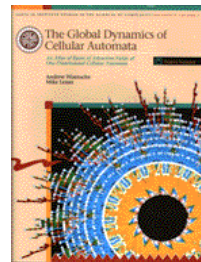
# Notions

- Initial State
- Neighbors
- Rule tables
- Trajectories and envelopes (space-time patterns)
- Patterns and Attractors (fixed, cycles)
- Attractor basins
- Gardens of Eden (not attainable by any other state)
- Phase transitions

# Atlas of CA Attractors



Andrew  
Wuensche



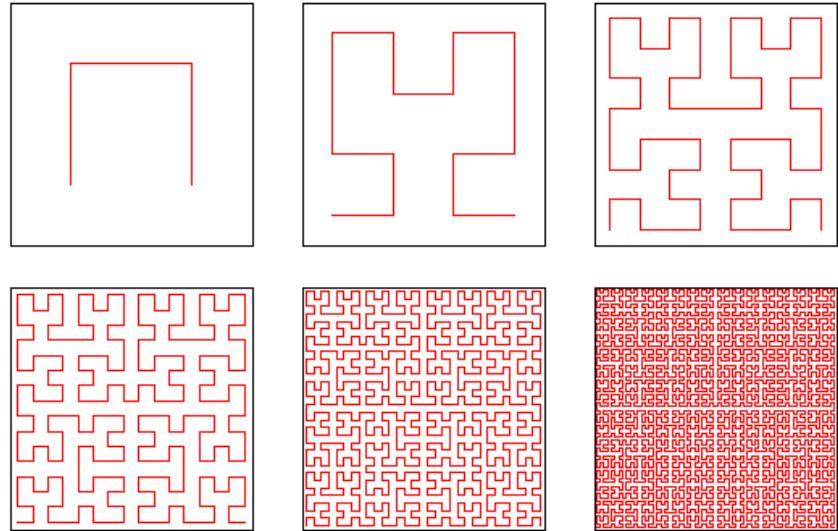
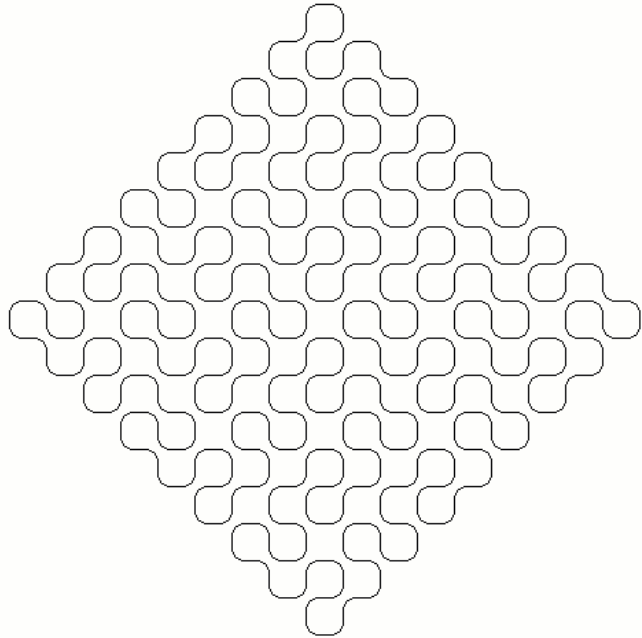
# Questions

- Do neuron networks in the brain behave as cellular automata (boolean networks) ?
- Attractors 5+envelopes) for neuro-vegetative functions ? Also for behaviors ?
- Hormones and neurotransmitters altering the rules table ?
- Glia cells as incorporating rules tables ?
- Interaction between activity/state and rules tables (self-configuring Cellular automata) ?
- Discrete time steps ? (quanta ?)
- Connexions as wiring diagram for neighbors ?

# **FRACTALS**

The brain works in 4D space

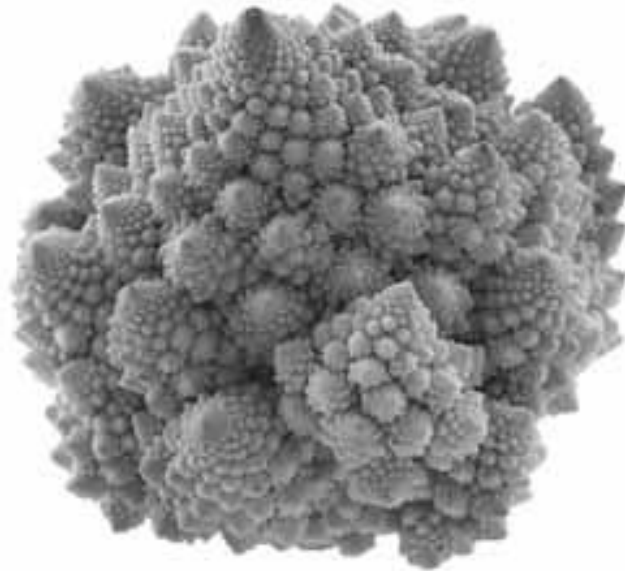
# Fractal lines in 2D plane



Peano curves : a line covering the plane, with fractal dimension  $>1$  and going to 2



# Fractal surfaces in 3D



Surfaces in 3D space can have a fractal dimension superior to 2 and inching towards 3

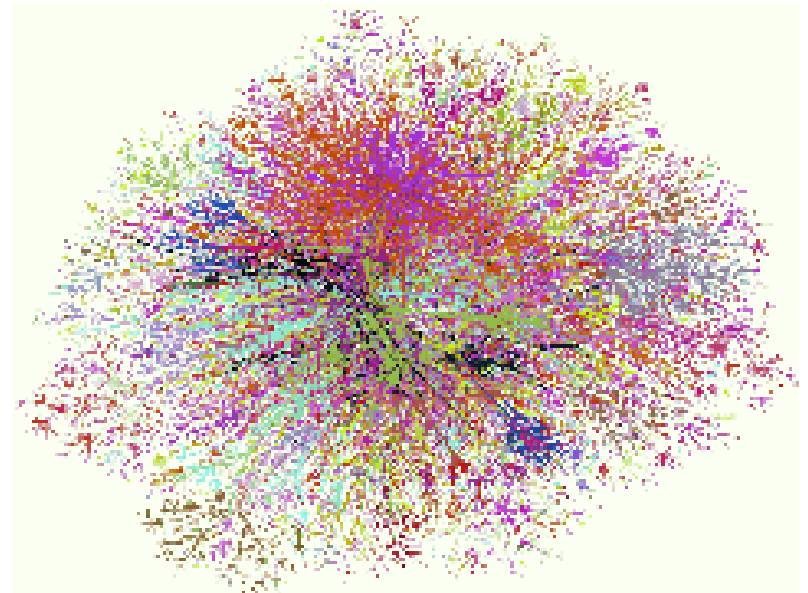
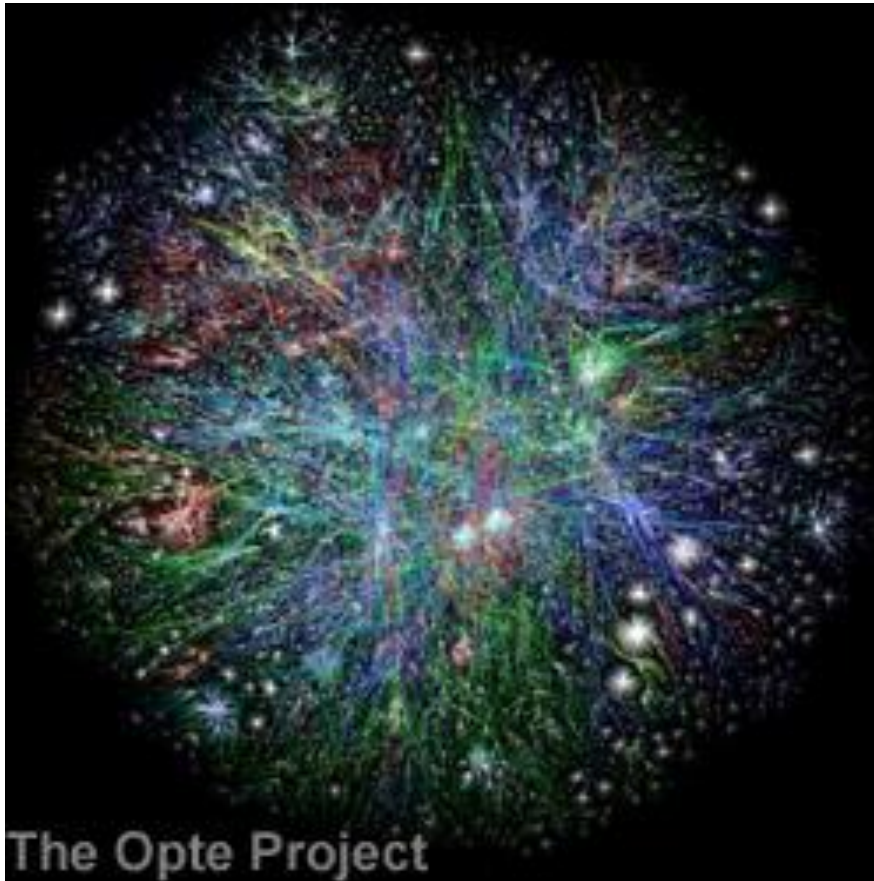
# Question on consciousness

- What is a fractal in 4D space ?
- Could a dense enough and interconnected network of neurons firing with time-space patterns exhibit a pattern of fractal dimension superior to 3 ?
- And could this be connected to consciousness, if (when ?) a density-interconnectedness threshold has been crossed in the forebrain ?

# THE INTERNET

A large Brain – Extended Brains  
– multi-human entities ?

# The Internet



# Questions

- The Internet as myelin ?
- The Web as memory ?
- Web applications as reflex /learned behaviors
- Social networking applications ?
- Collective / collaborative intelligence : Amazon's recommendations, Furl, Del.icio.us, rating systems : a model for the high-level Brain functions ?
- Are companies and social groups multi-human entities as there are multi-cellular animals ?