

# 10. Introduction to neuronal networks:

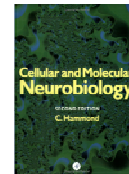
## *Architecture*

Molekylær biomedicin

## Cellular Neuroscience module

21/05/2007

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Chapter 22

Notes are available on [Absalon](#)

# overview

Network terminology and simple concepts

Network constituents (the neurons)

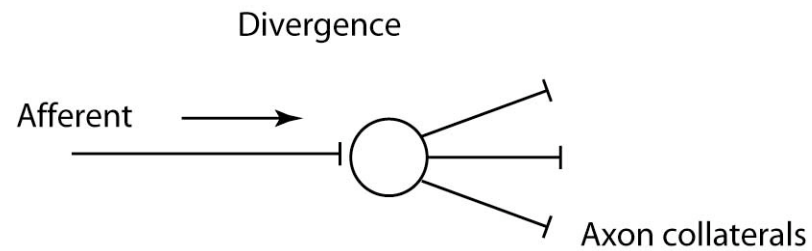
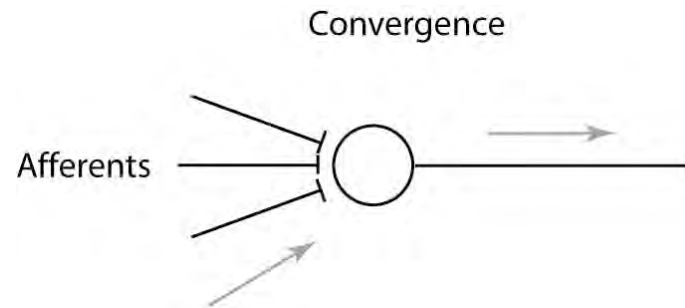
Architectural considerations

Basic types of networks

Real examples

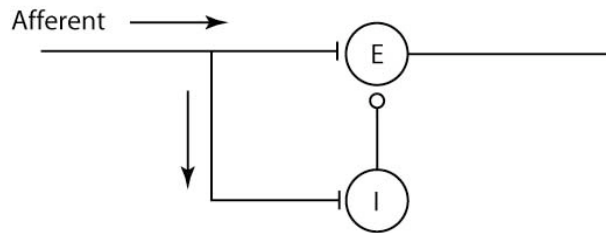
Next lecture - network dynamics

# Simple circuitry: convergence - divergence

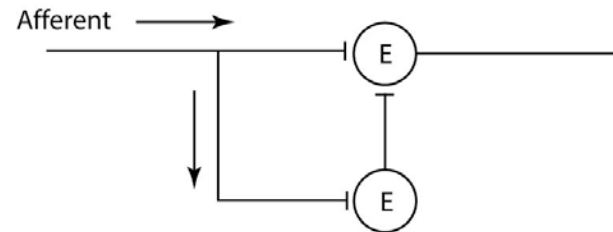


# Feed-forward and feedback loops:

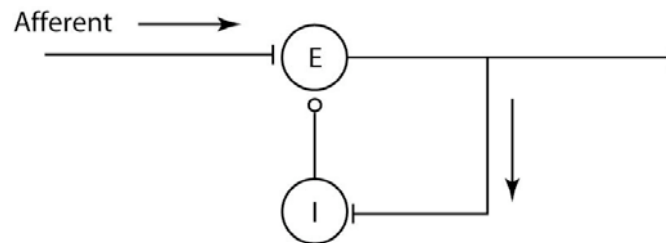
Feed-forward inhibition



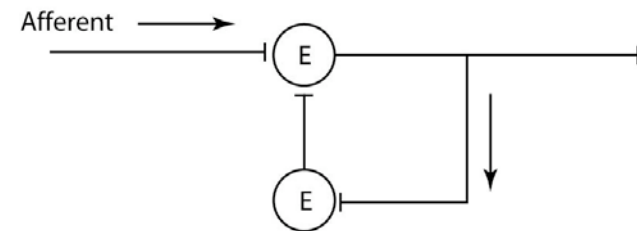
Feed-forward Excitation



Feedback Inhibition

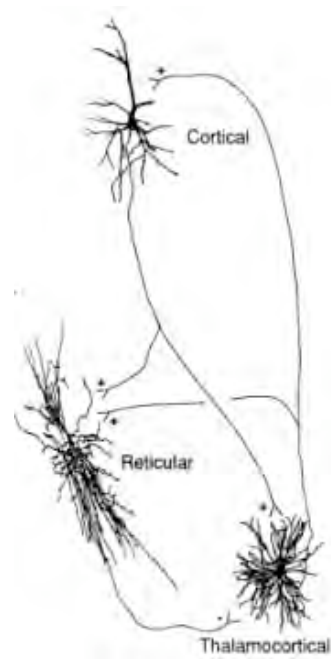
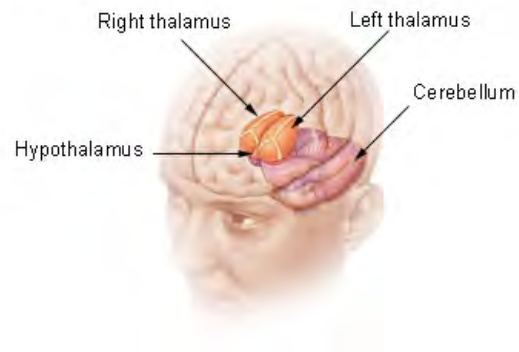


Feedback Excitation



# Example: Thalamo-cortical loops

## Diencephalon

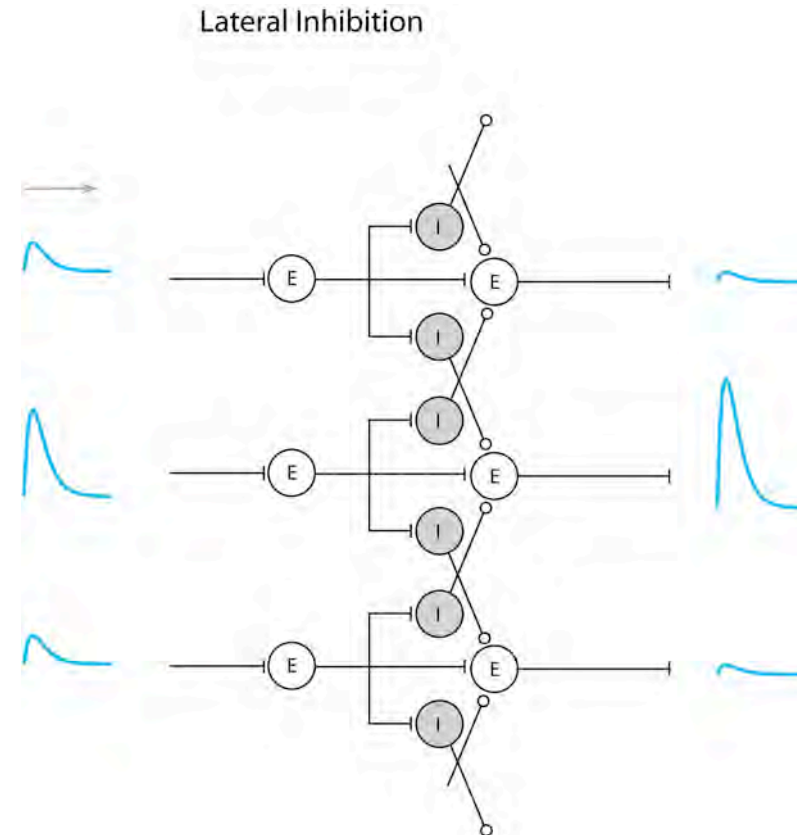


Feedback excitation

Feedback inhibition

Feedforward inhibition

# Lateral inhibition



# Basic network constituents: 2 types of neurons

Principal neurons and Interneurons

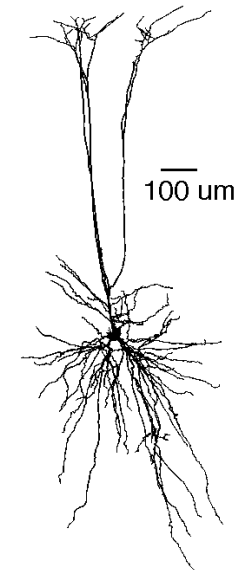
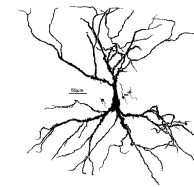
# Principal neurons

Principal neurons (80% in cortex):

Cortex/hippocampus: Pyramidal shape/Stellate  
Dentate gyrus: Granular cells

- Large
- Excitatory
- Some have long projections and local collaterals
- Receive both afferent and local input.
- Homogenous

Hippocampus CA3 pyramidal



Cortical Layer V pyramidal

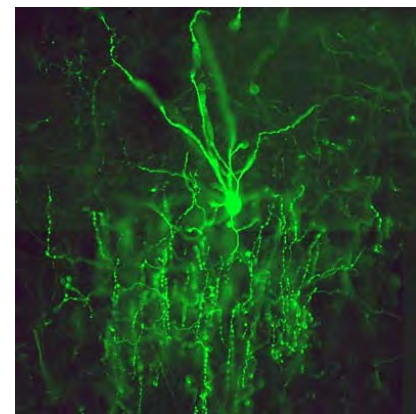


# Interneurons

Interneurons are typically:

- Small
- Inhibitory
- Most have local connections
- Very diverse in morphology/physiology  
(Often more than a dozen classes depending on brain area)

The degree of interneuron diversity is presumably linked to the functional Complexity of brain region/animal



Chandelier interneuron in mouse neocortex (GFP)

# Architecture - considerations

Constructing a network is a balance between:

Complexity:

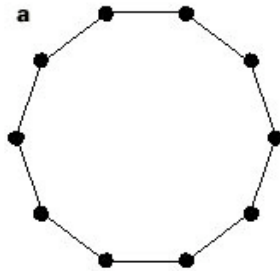
Computational power  
Speed

Simplicity:

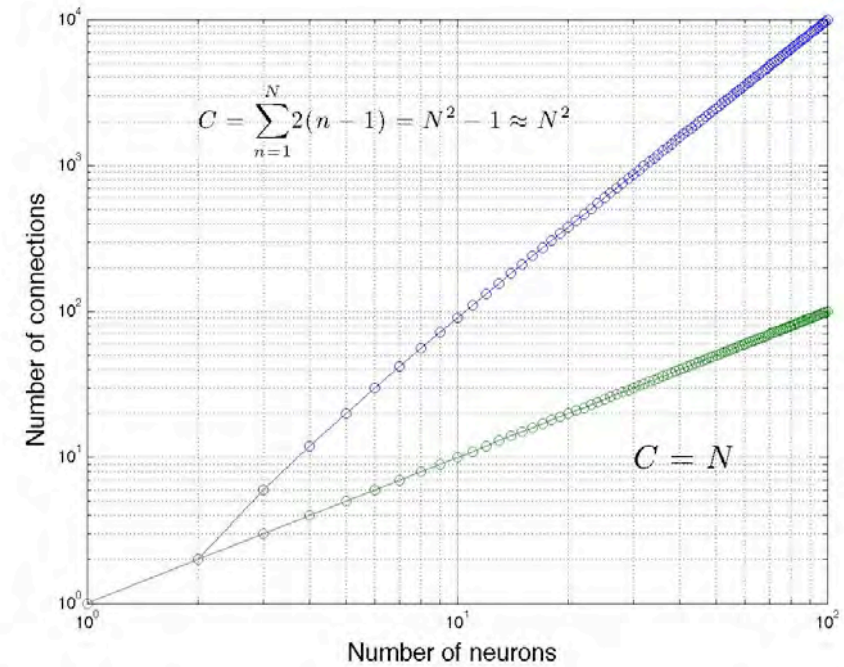
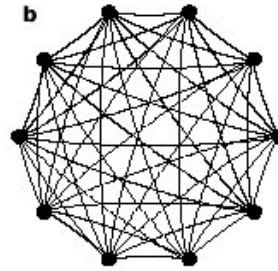
Economy  
Space constraints

# Connectivity: Extreme cases

Nabo-only

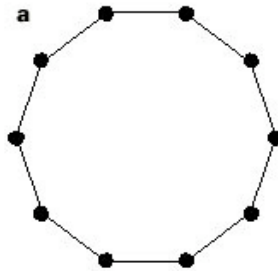


All to all

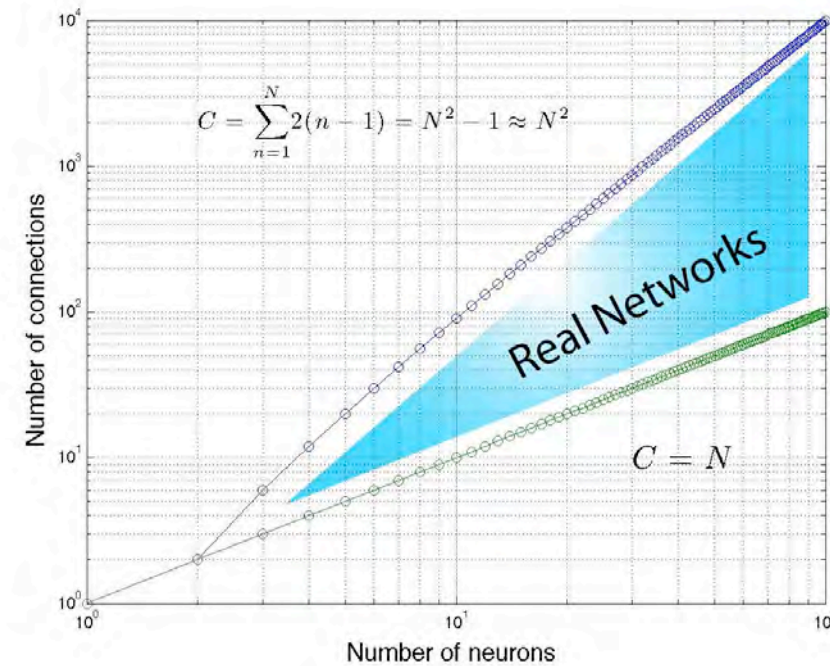
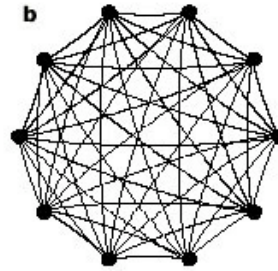


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Nabo-only



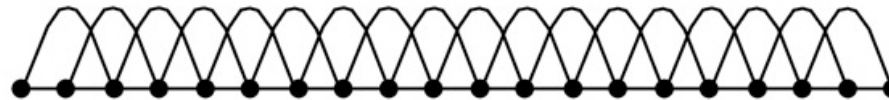
All to all



# 3 basic types of networks

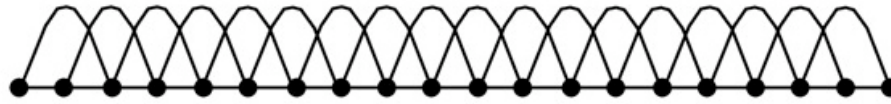
# 3 basic types of networks

Regular: High L, High C



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Regular: High L, High C

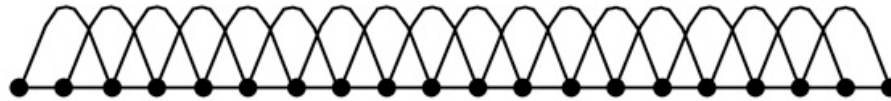


Random: Low L, Low C



# 3 basic types of networks

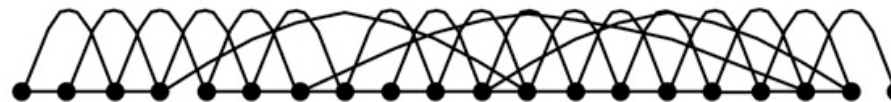
Regular: High L, High C



Random: Low L, Low C

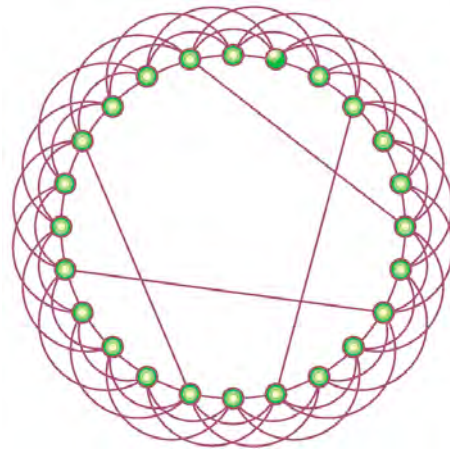


Small World: Low L, High C

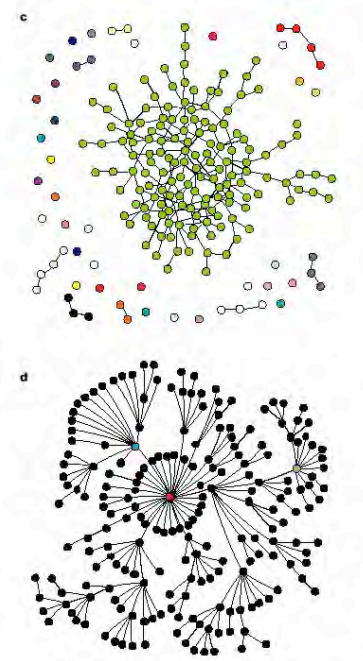




# Small-world networks



Many local,  
few “short-cuts”/long-range

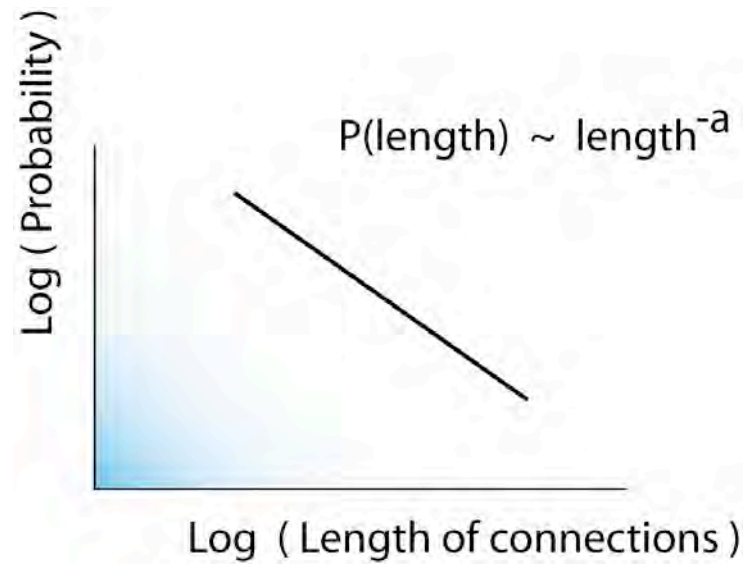


Clusters or “cliques”  
Many small, few large

Nodes:  
Many with small, few  
with large numbers  
of connections



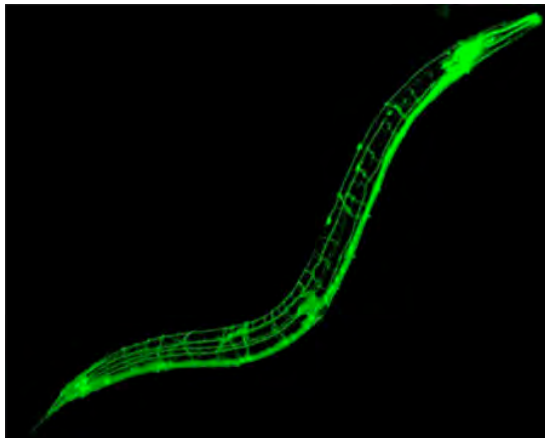
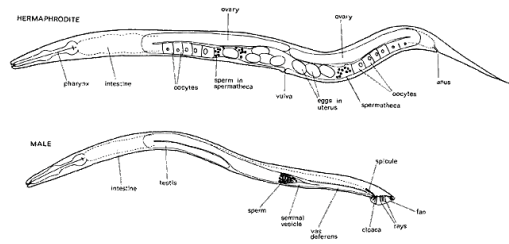
# Small-world networks



$a \sim 1$  in Hippocampus

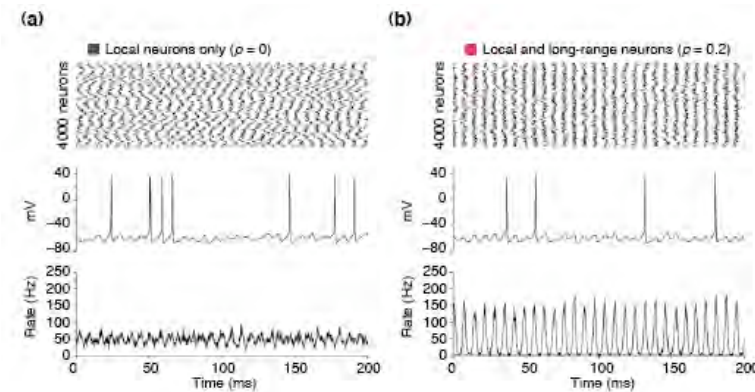
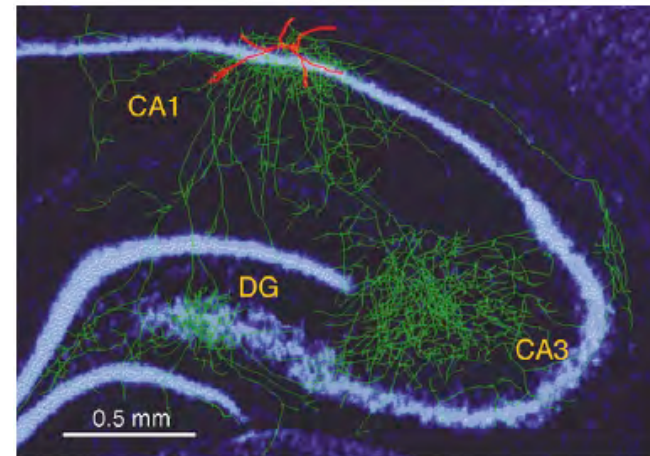
# Small-world network: Examples

## C. Elegans (302 neurons)



## Hippocampus

Long range interneuron

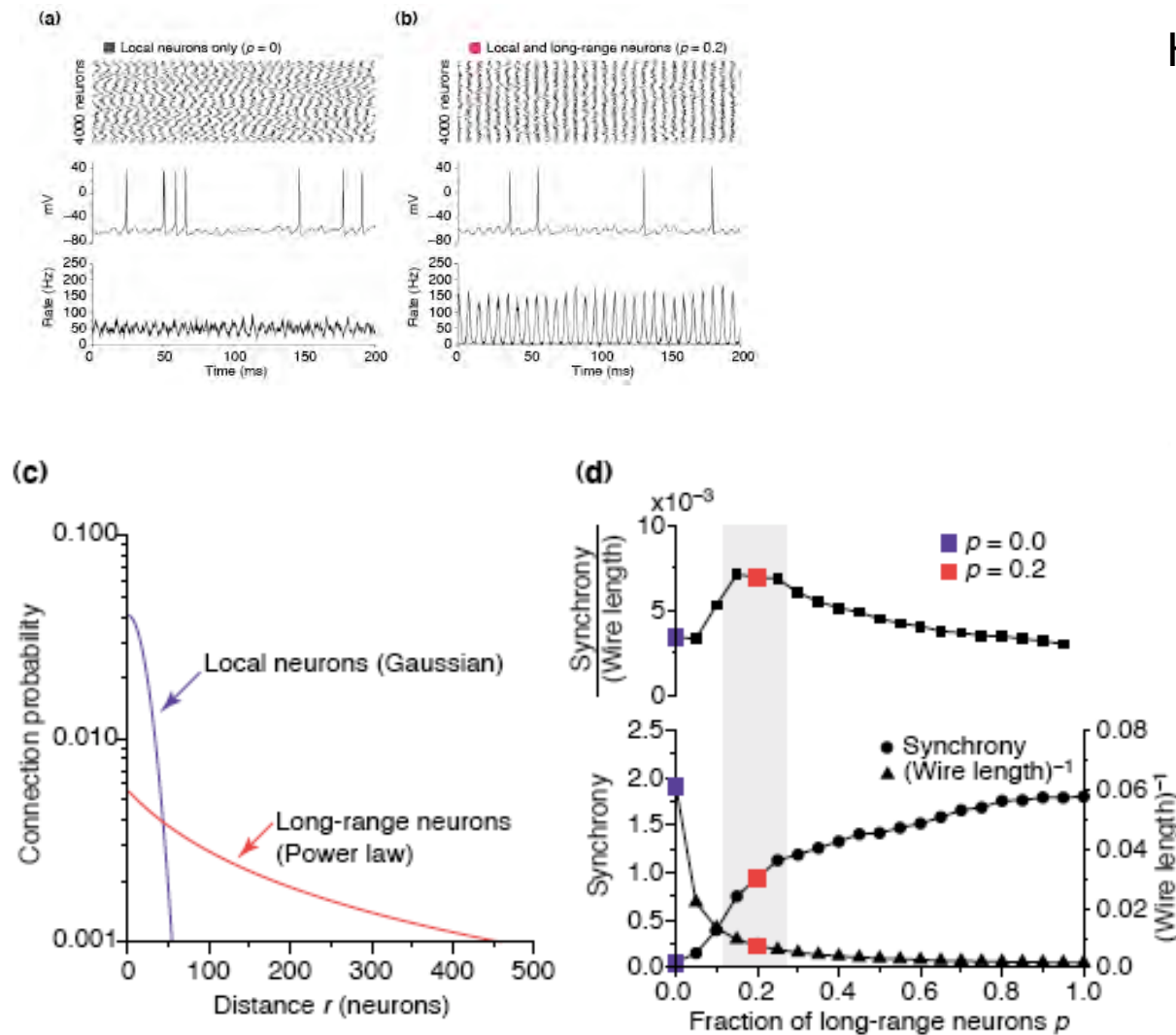


Neocortex

Buzsaki et al. 2004

# Small-world network: Examples

Hippocampus



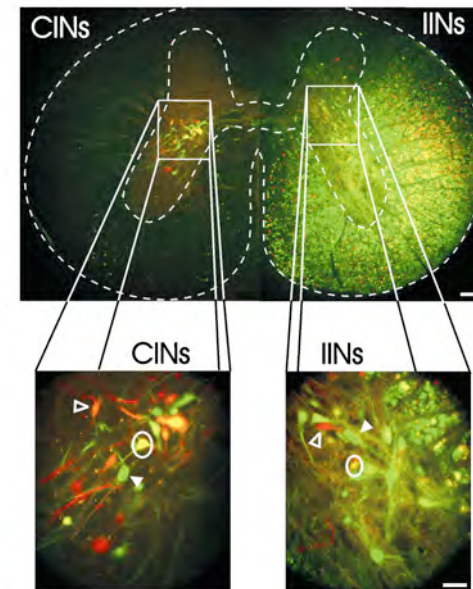
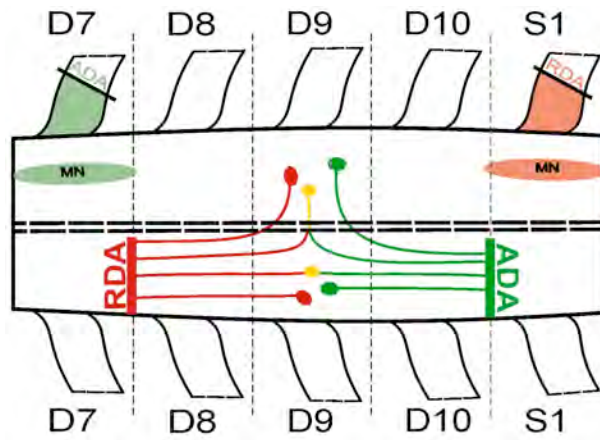
# Non-SW networks

Isolated modules  
No long range connections

Cerebellum

Basal ganglia

# Spinal cord?



# Further reading:

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**Steriade M, McCormick DA, Sejnowski TJ (1993)** "Thalamocortical oscillations in the sleeping and aroused brain" *Science* vol. 262, 679-685.

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