Fundamentals of Computational Neuroscience

Chapter 5: Cortical organizations and simple networks

Brain areas

Dorsal

Frontal lobe
Parietal lobe

3 1 2
4 5
8 6
7
9
Rostral
40
Occipital lobe
Caudal
46 44
19
10
41 42
18
45
22
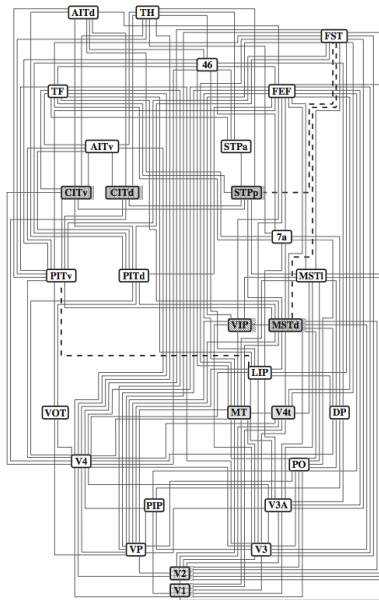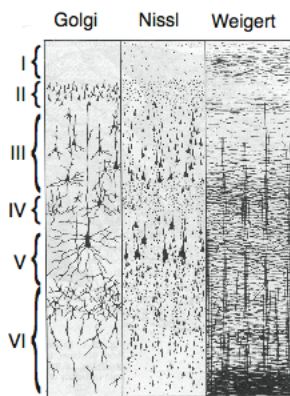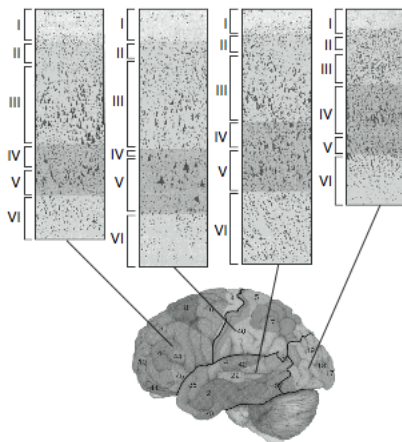17
11 38
21
20
Temporal lobe
Brainstem
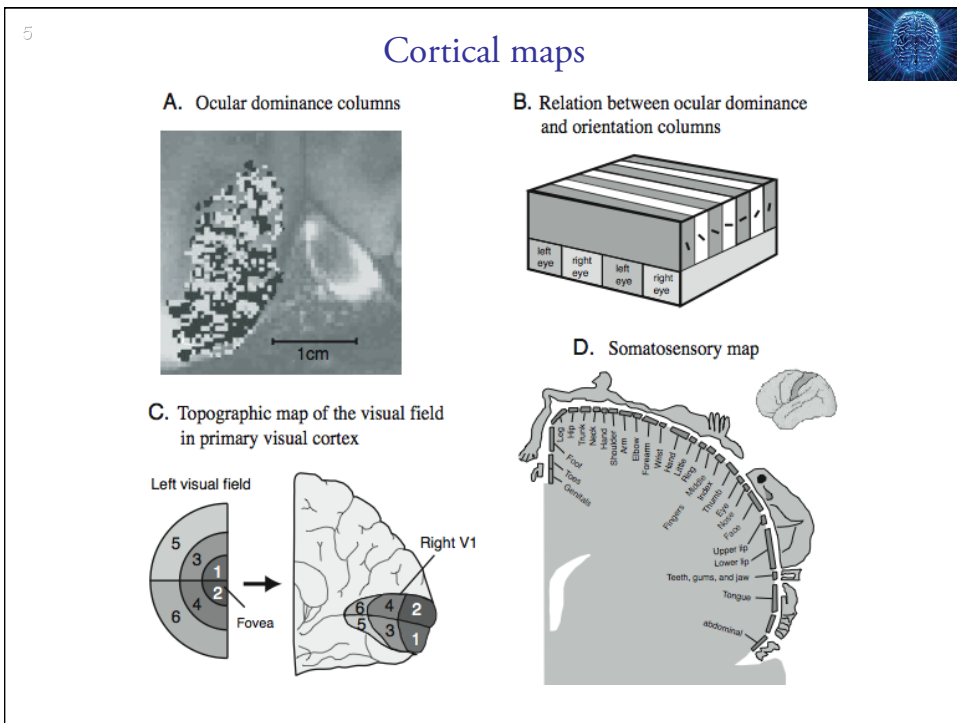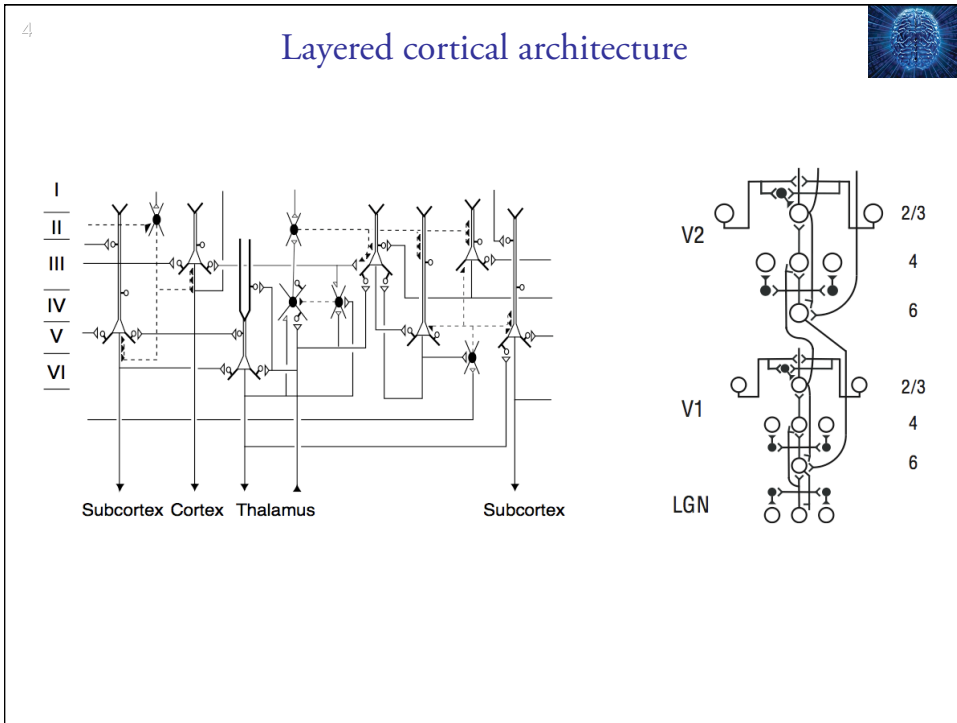Cerebellum

Ventral

2

Hierarchical connectivity

3

Layered cortex

A. Different staining techniques

Golgi   Nissl   Weigert

B. Variation in cortex
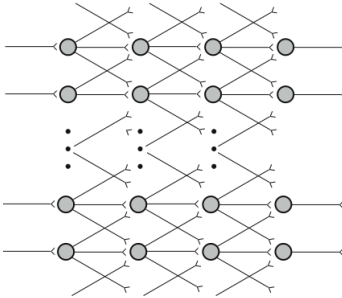
Layered cortical architecture

Cortical maps
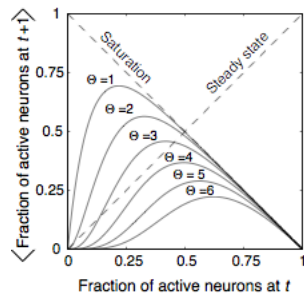
Neuronal chains

A. Linear chain

B. Diverging~converging chain

Netlets

A. Without inhibitory neurons

B. With inhibitory neurons

Random networks with axional delay

A. Spike trains in random network

C. Spike activation with axonal delay

B. Power spectrum in random network
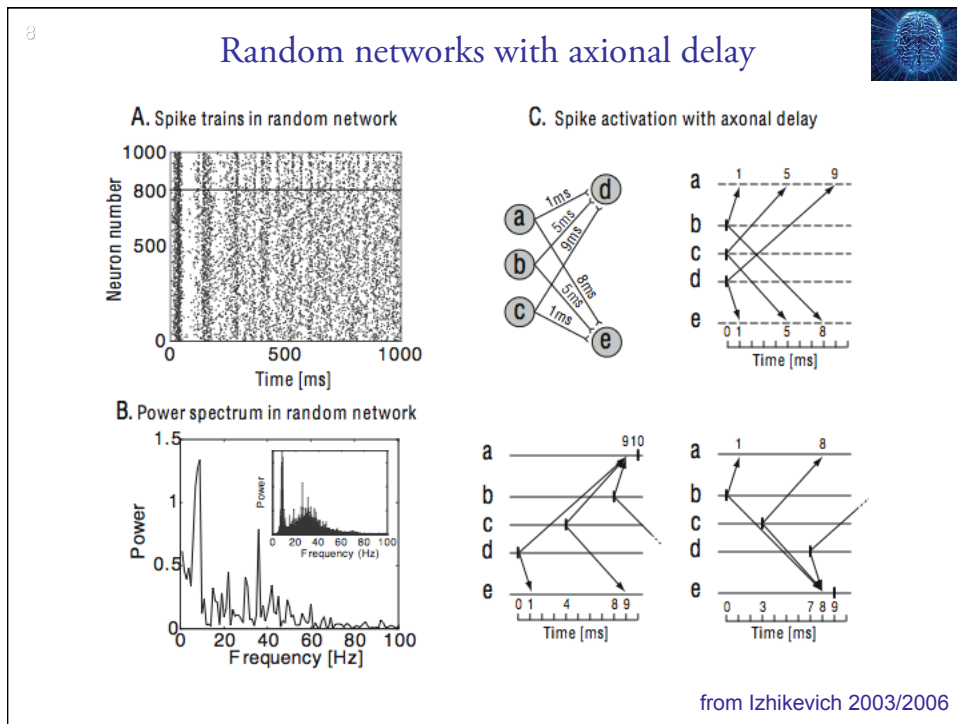
from Izhikevich 2003/2006
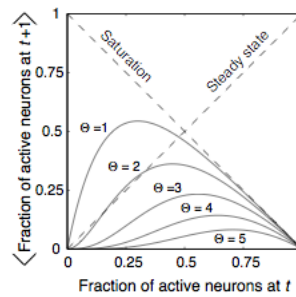
Matlab program

```
1    % Created by Eugene M. Izhikevich, February 25, 2003
2    % Excitatory neurons    Inhibitory neurons
3    Ne=800;               Ni=200;
4    re=rand(Ne,1);        ri=rand(Ni,1);
5    a=[0.02*ones(Ne,1);   0.02+0.08*ri];
6    b=[0.2*ones(Ne,1);    0.25-0.05*ri];
7    c=[-65+15*re.^2;      -65*ones(Ni,1)];
8    d=[8-6*re.^2;         2*ones(Ni,1)];
9    S=[0.5*rand(Ne+Ni,Ne),-rand(Ne+Ni,Ni)];
10
11   v=-65*ones(Ne+Ni,1);  % Initial values of v
12   u=b.*v;               % Initial values of u
13   firings=[];           % spike timings
14
15   for t=1:1000          % simulation of 1000 ms
16       I=[5*randn(Ne,1);2*randn(Ni,1)]; % thalamic input
17       fired=find(v>=30); % indices of spikes
18       if ~isempty(fired)
19           firings=[firings; t+0*fired, fired];
20           v(fired)=c(fired);
21           u(fired)=u(fired)+d(fired);
22           I=I+sum(S(:,fired),2);
23       end;
24       v=v+0.5*(0.04*v.^2+5*v+140-u+I);
25       v=v+0.5*(0.04*v.^2+5*v+140-u+I);
26       u=u+a.*(b.*v-u);
27   end;
28   plot(firings(:,1),firings(:,2),'.');
```

Further readings

Edward L. White (1989) **Cortical circuits**, Birkhäuser

Moshe Abeles (1991) **Corticonics: Neural circuits of the cerebral cortex**, Cambridge University Press