Introduction to Cognitive Science
Neuroscience

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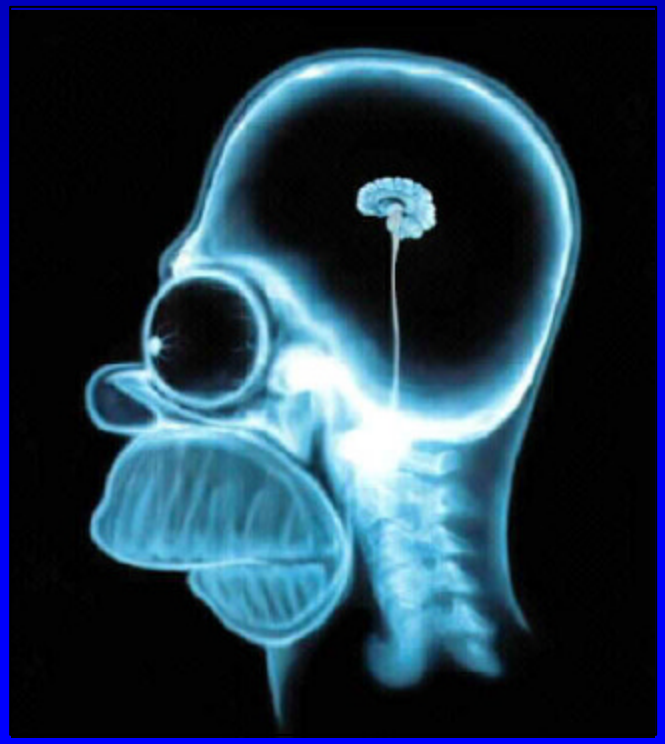
Lecture 1: Overview



Readings are now listed on the course website

- Some are downloadable as PDF files that can be read by Adobe Acrobat Reader
- Some are on reserve at Mullins Library

The written assignment and its due date will be posted on the website by this weekend.

My Goal

To provide you with a glimpse of what we know about the brain and how that knowledge can provide powerful insights into how the mind works

i.e., #3 sucks!

The Human Brain

What do we mean by MIND?

Philosophical Issues Involving the Brain

Mind / Body Problem (Actually the Mind / Brain Problem)

Two separate issues:

A. The mind seems too complex to be produced by a 2 1/2 pound object that fits inside the head.

B. It is difficult to imagine how the subjective experience of consciousness could be produced by a physical machine.

Does the brain do these things? If so, how?

Make up your own mind as we go along.

"Any sufficiently advanced technology is indistinguishable from magic"

Arthur C. Clarke

Paradox of the Brain Thinking about the Brain

If the brain were simple enough for us to understand, we would be too simple to understand it

Solution: work with simplified models that illustrate basic principles

Philosophical Issues Involving the Brain

Free Will

I can do whatever I want to; I'm not a machine!

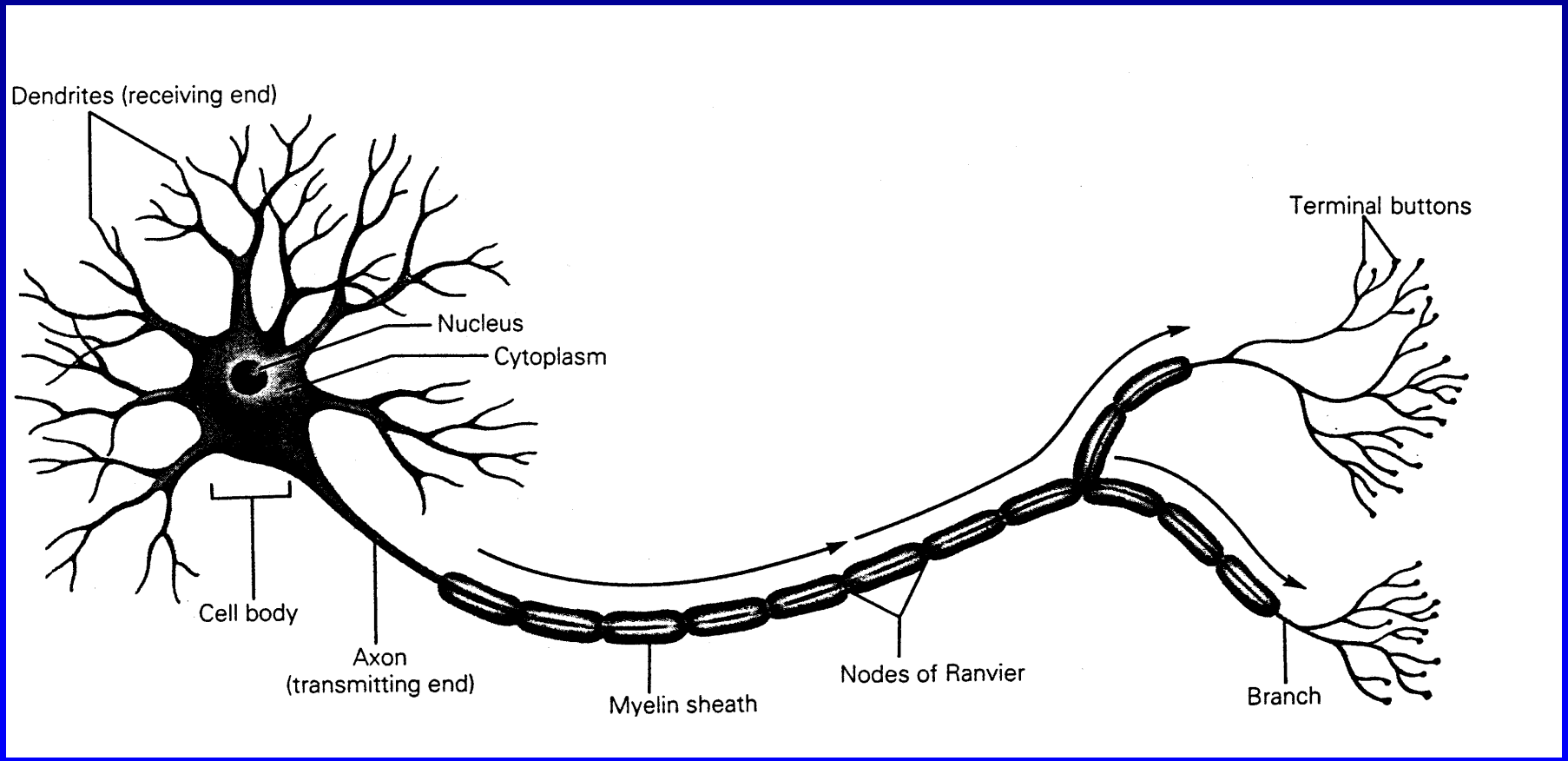
Issue of determinism (brain as machine)

Question: What determines what you want to do?

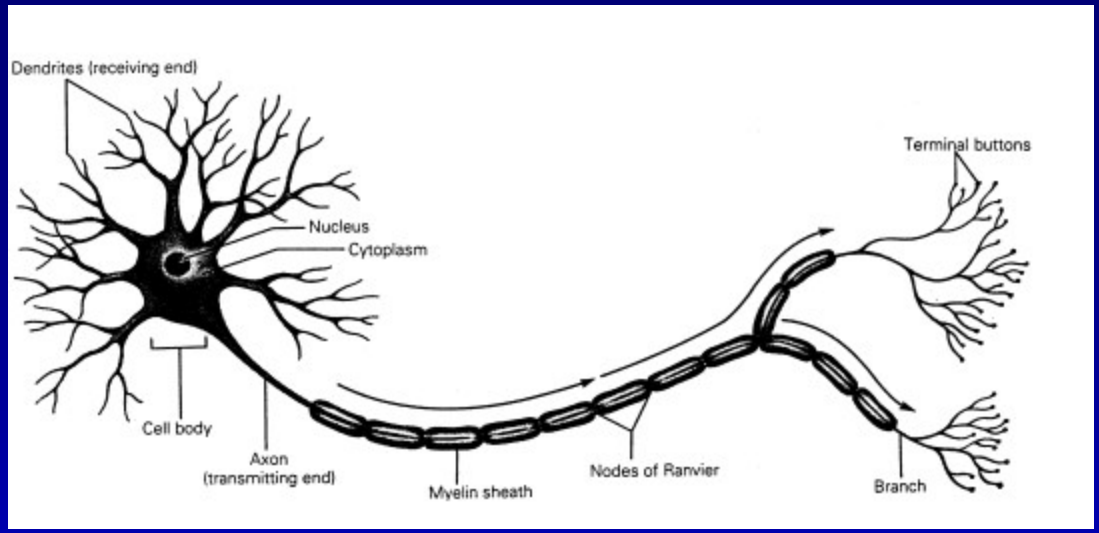
Behavior is not random

Issue of conscious vs. non-conscious processes

Motorneuron
(Triggers contraction of skeletal muscle)



Neuron Function



Dendrites - Receive information from other neurons in the form of electrical signals

Soma (cell body) - processes information by adding together all the signals (summation)

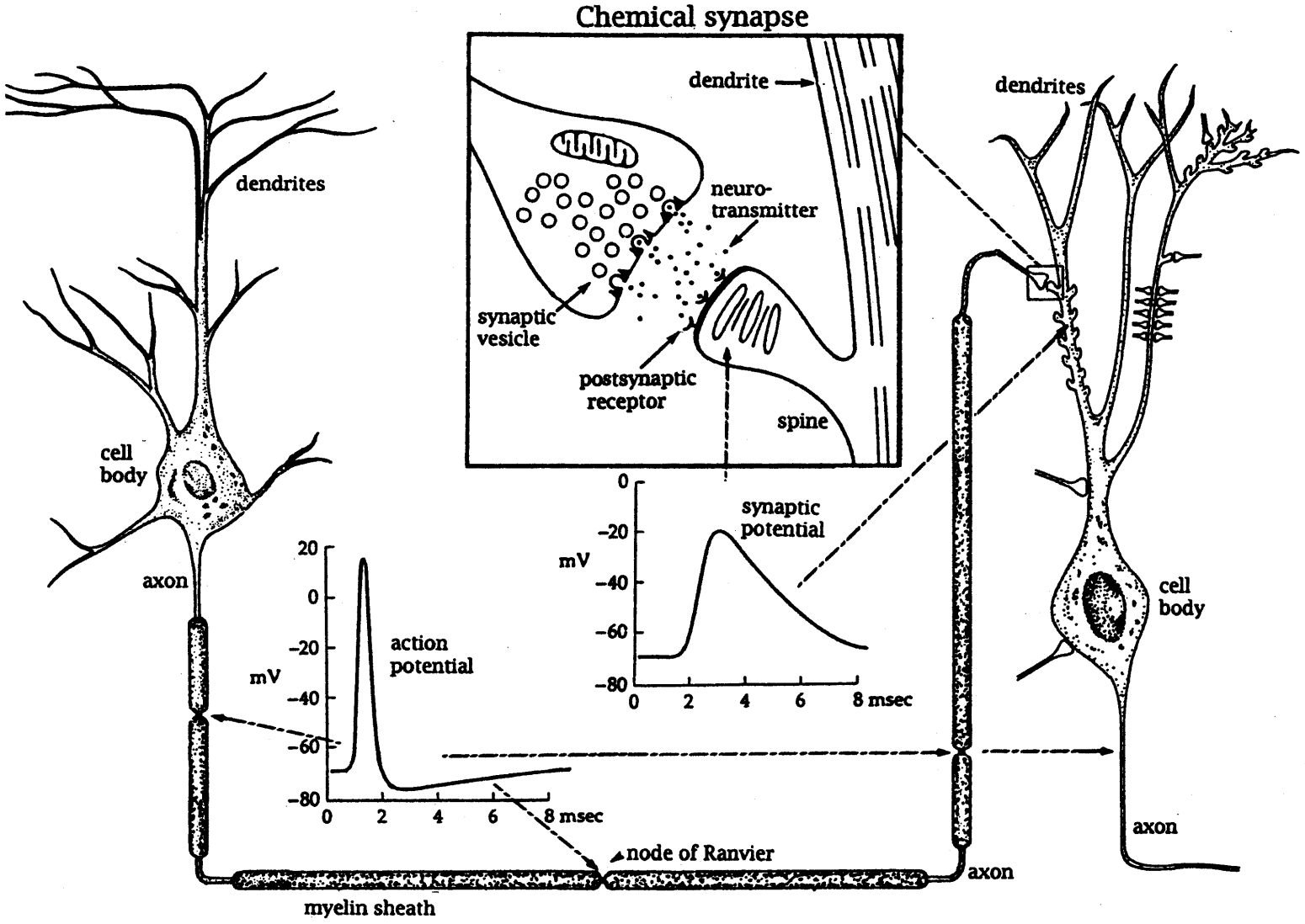
Axon - sends output to other neurons

Action Potential travels from soma to axon terminals

Synapse - transmits information to next neuron

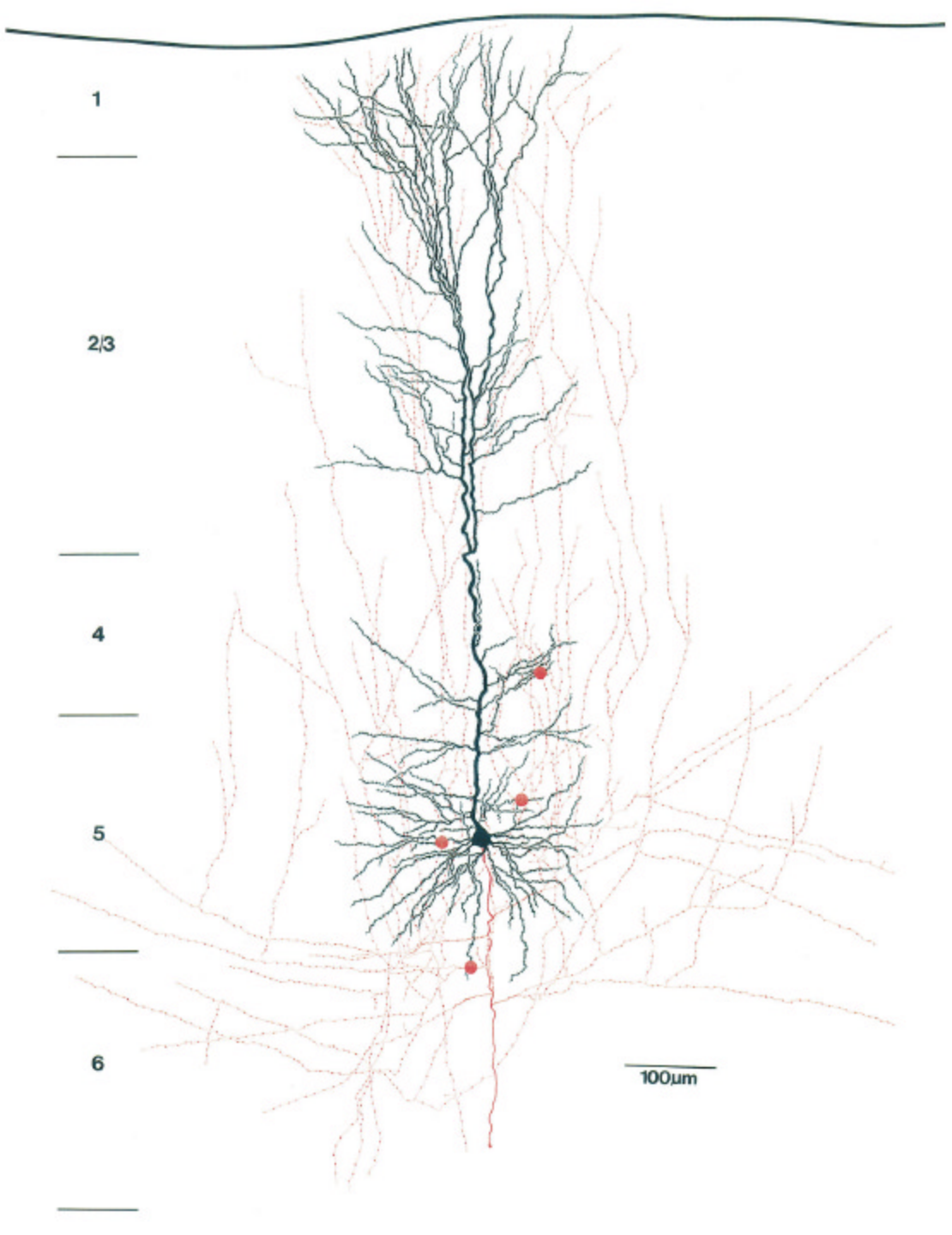
Axon terminals release a chemical (Neurotransmitter) onto dendrites of another neuron that either excites or inhibits that neuron

Neuron function in a nutshell

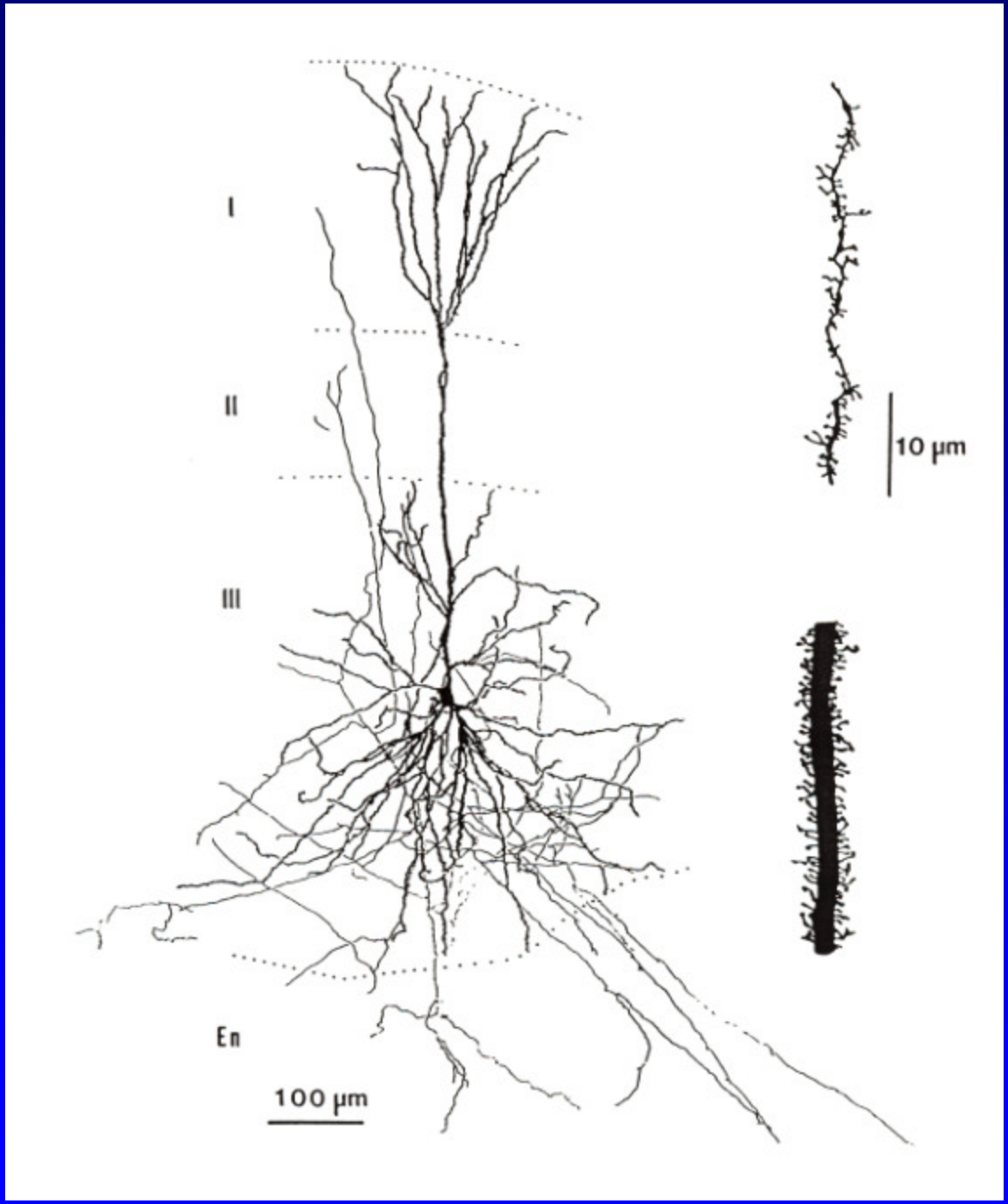


Cortical Pyramidal Cell

(Lubke, Markram, Frotscher, & Sakmann, 1996)



Pyramidal cell
(rat olfactory cortex)



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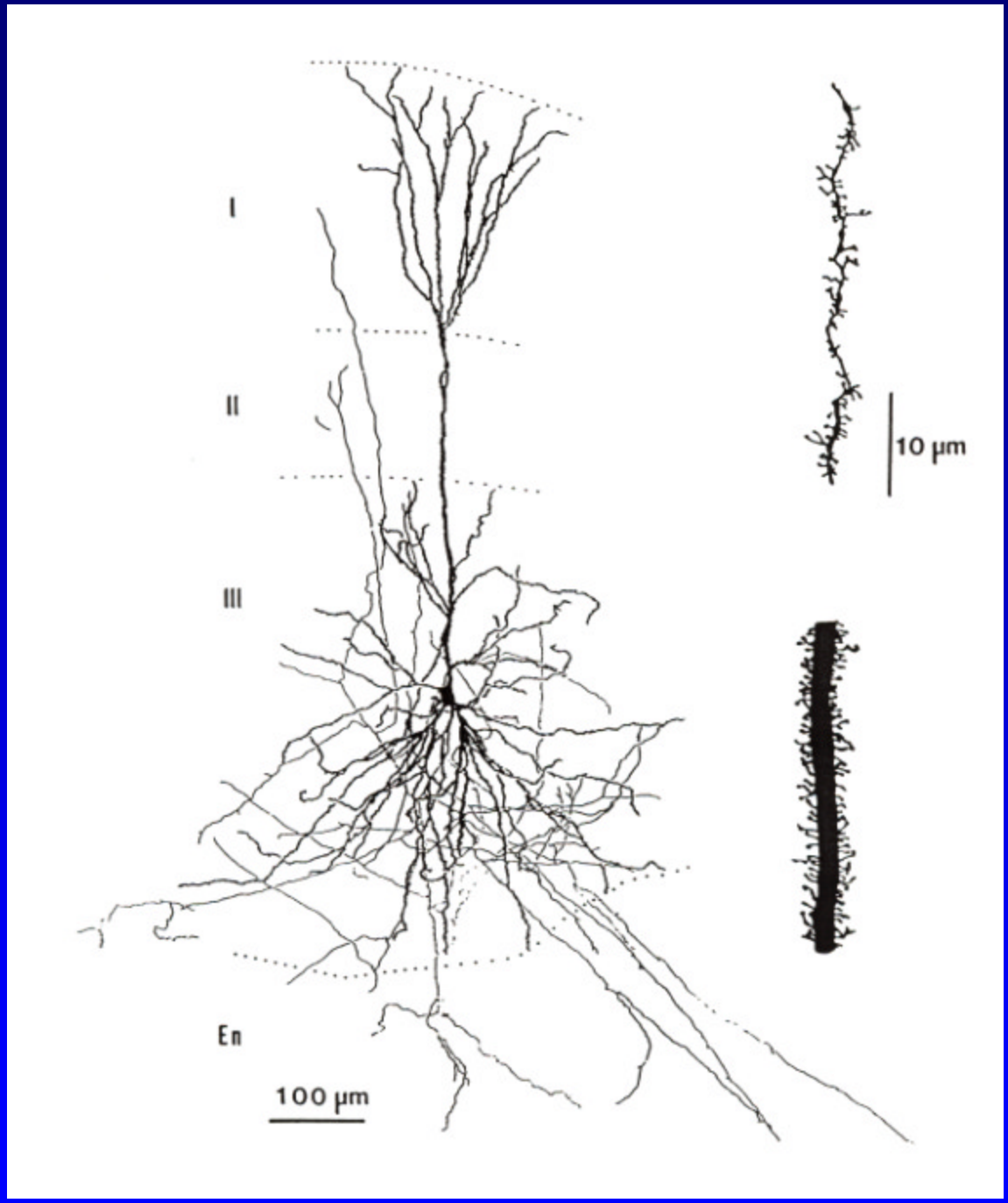


Complexity of Brain

Number of neurons

Number of connections between neurons

Complexity: Number of Neurons

1. Caenorhabditis elegans (C. elegans)
   flatworm (2 mm long)
   Has 959 cells; 302 of them are neurons
   Smallest nervous system studied in detail

Complexity: Number of Neurons

2. Ant

   10,000 - 100,0000 neurons (varies with species)

   More complex walking patterns than best robot

   Sophisticated social behavior

Complexity: Number of Neurons

3. Rat

   100 - 200 million neurons (1/1000 of human brain)

   Sophisticated learning capabilities

   Probably best understood mammalian brain on earth

Complexity: Number of Neurons

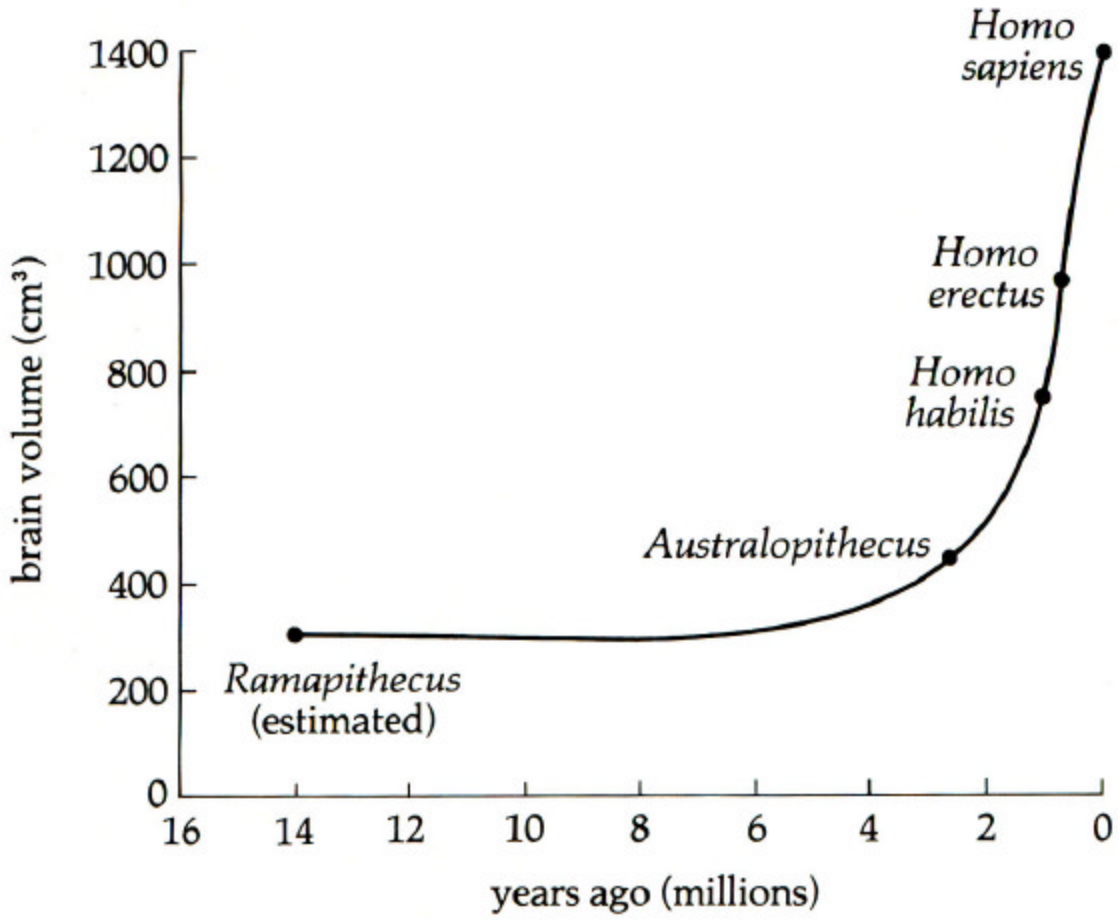
4. Human

   100 - 200 billion neurons

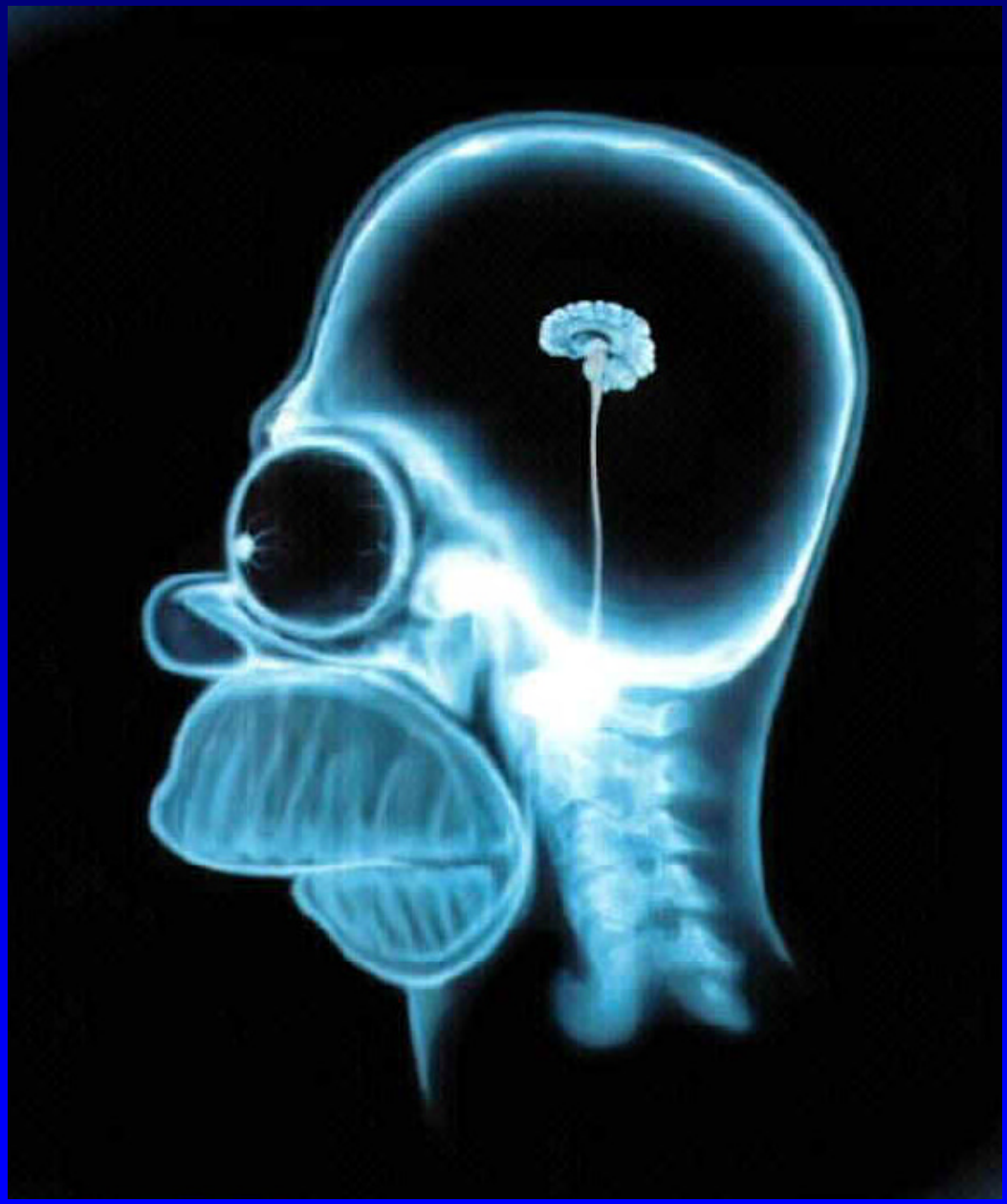
   Cerebral cortex

   Consciousness and higher information processing

   20-50 billion neurons

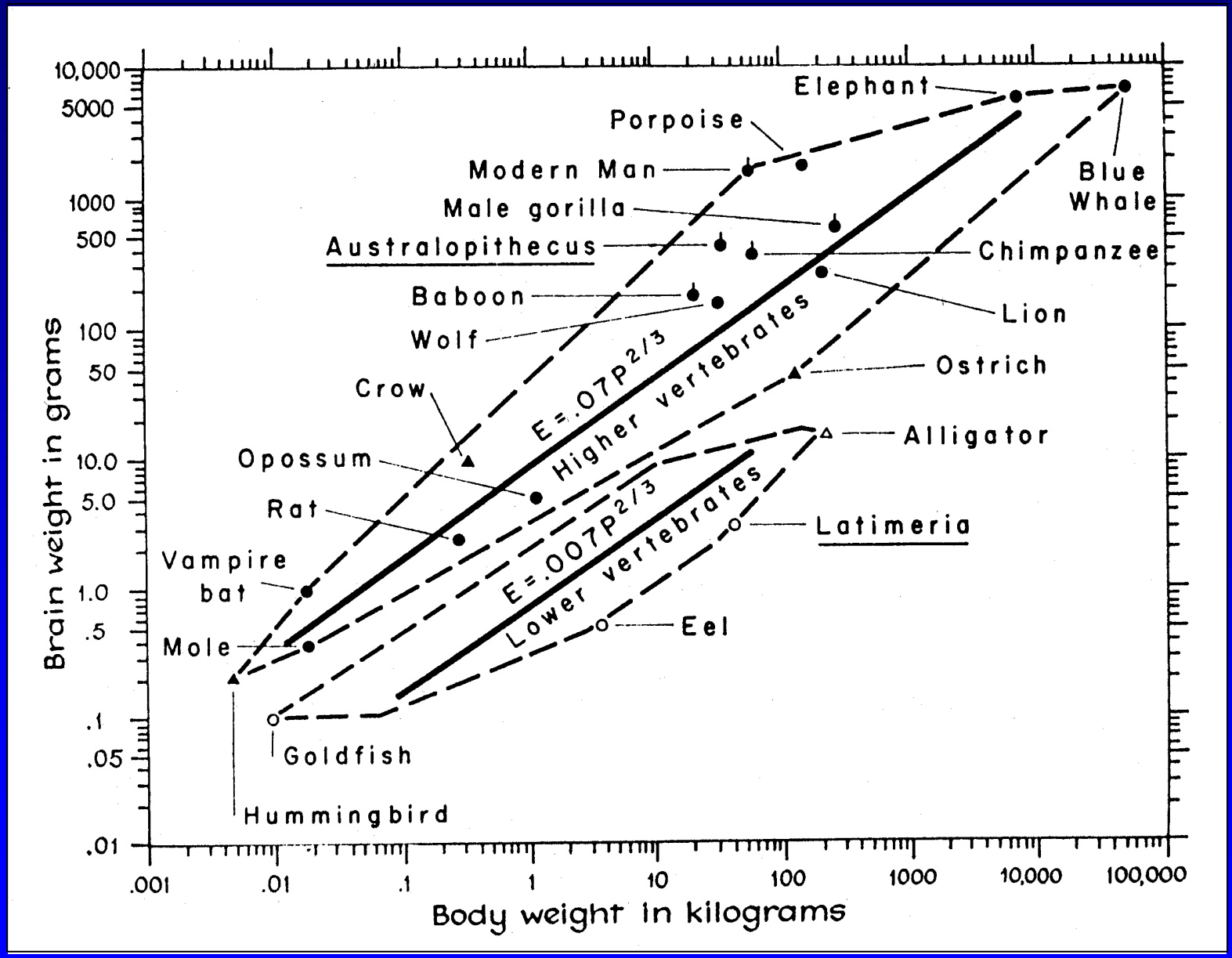

Homo sapiens
Homo erectus
Homo habilis
Australopithecus
Ramapithecus (estimated)
brain volume (cm³)
1400
1200
1000
800
600
400
200
0
16
14
12
10
8
6
4
2
0
years ago (millions)

5. Homer Simpson



Relationship between brain size and body size

Relationship between brain size and body size



Complexity:
Number of connections between neurons

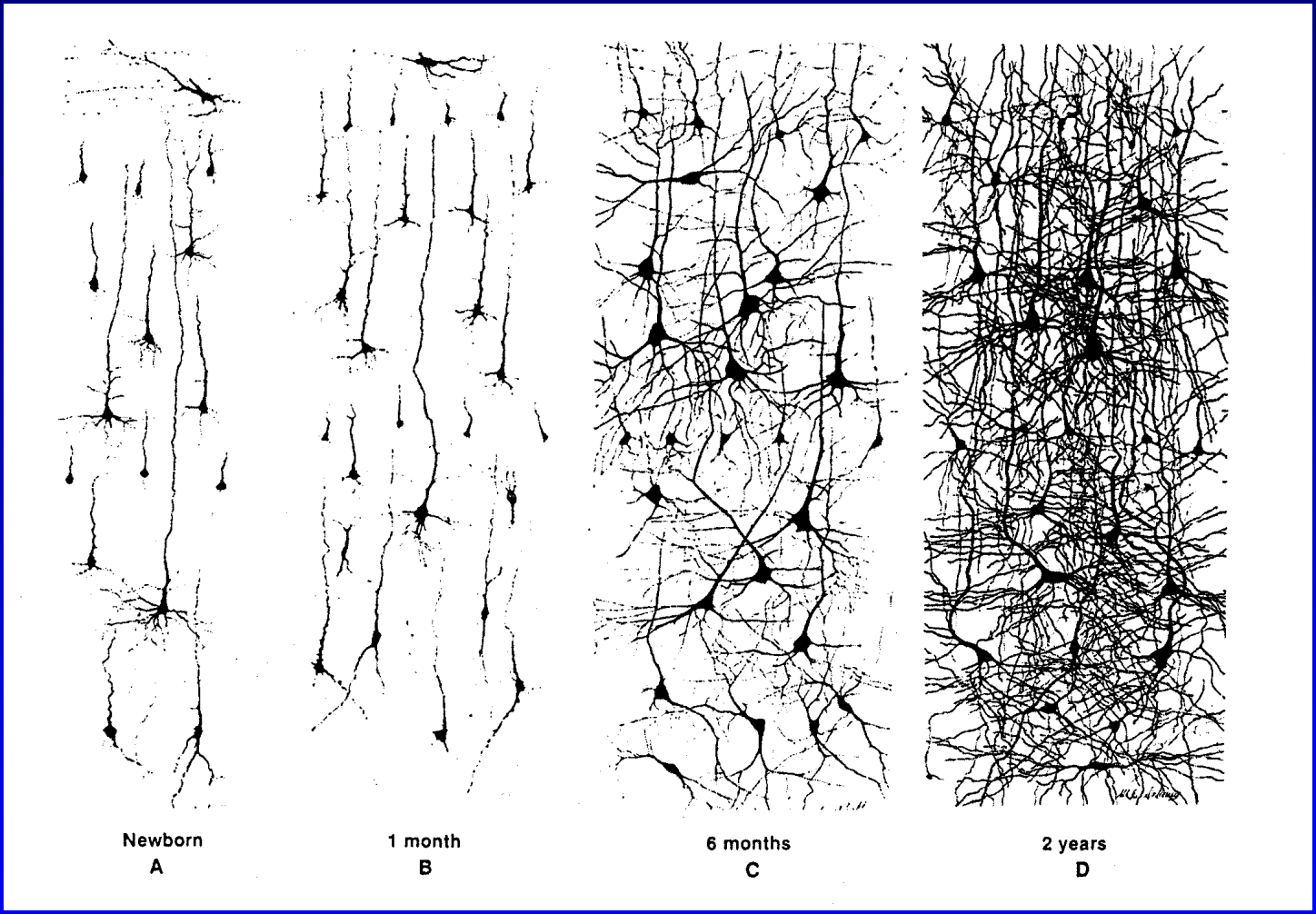
A cortical pyramidal cell has approximately 20-30,000 synapses on it, and makes as many synapses on other neurons.

If neurons are the hardware in the brain, synaptic connections are the software.

This software is written not only by our genes but also by our experiences.

- Early experience powerfully shapes synapse formation.
- Memories are stored by changing the strength of existing synaptic connections (synaptic weights).
- The record of all our experiences and memories is stored in our synapses.

Development of Human Neocortex



The number of neurons doesn't increase, but the number of synapses on each neuron does.

Neurons are the only cells in the body that don't reproduce freely

- We are born with as many neurons as we will ever have.
- Some neurons in our brain die every day.
  - There is some new neuron formation, but it is infrequent.
  - The total cell count diminishes with age.
- Mental deterioration in old age is due to:
  - Accelerated neuron death (especially in Alzheimer's Disease).
  - Reduction in number of synapses on surviving neurons (early development in reverse).
    - Dendritic tree shrivels.
    - We gradually lose our software in old age.

Question:

Why don't we just replace neurons as they are lost?

Answer:

Because new neurons wouldn't be able to function properly

Their sophistication is in their connections, which contain the record of a lifetime of experience.

New neurons would be "naïve" (no software).

Although in theory the software of the brain could be deciphered by measuring all of the synaptic connections in the brain and their strength (synaptic weight), this isn't going to happen in the foreseeable future

As a result, neuroscience isn't going to put Jim Lampinen out of business anytime soon

The brain evolved to perform specific types of information processing. By studying how it represents and processes information, we can gain powerful insights into how the brain (and the mind) work.