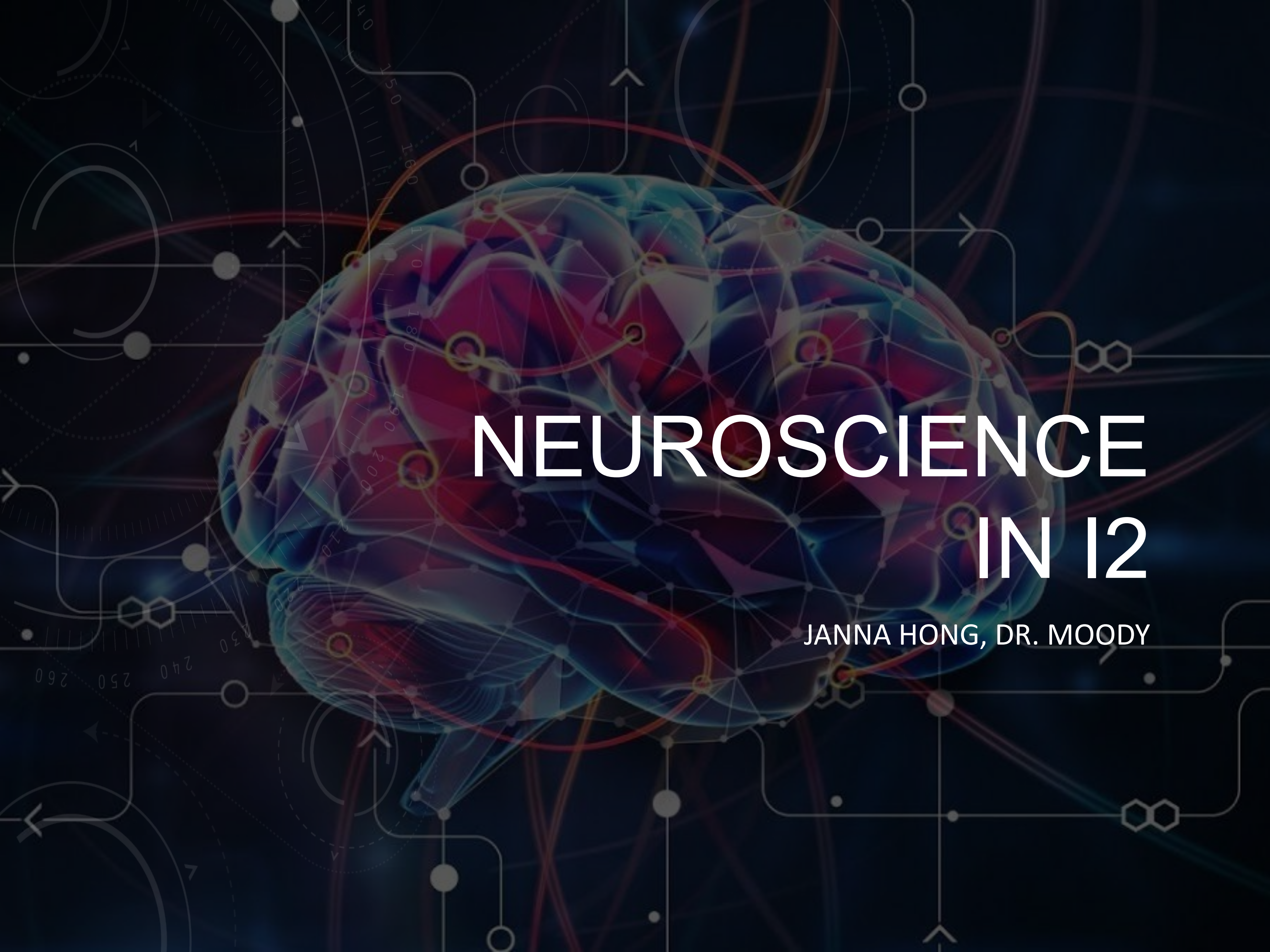
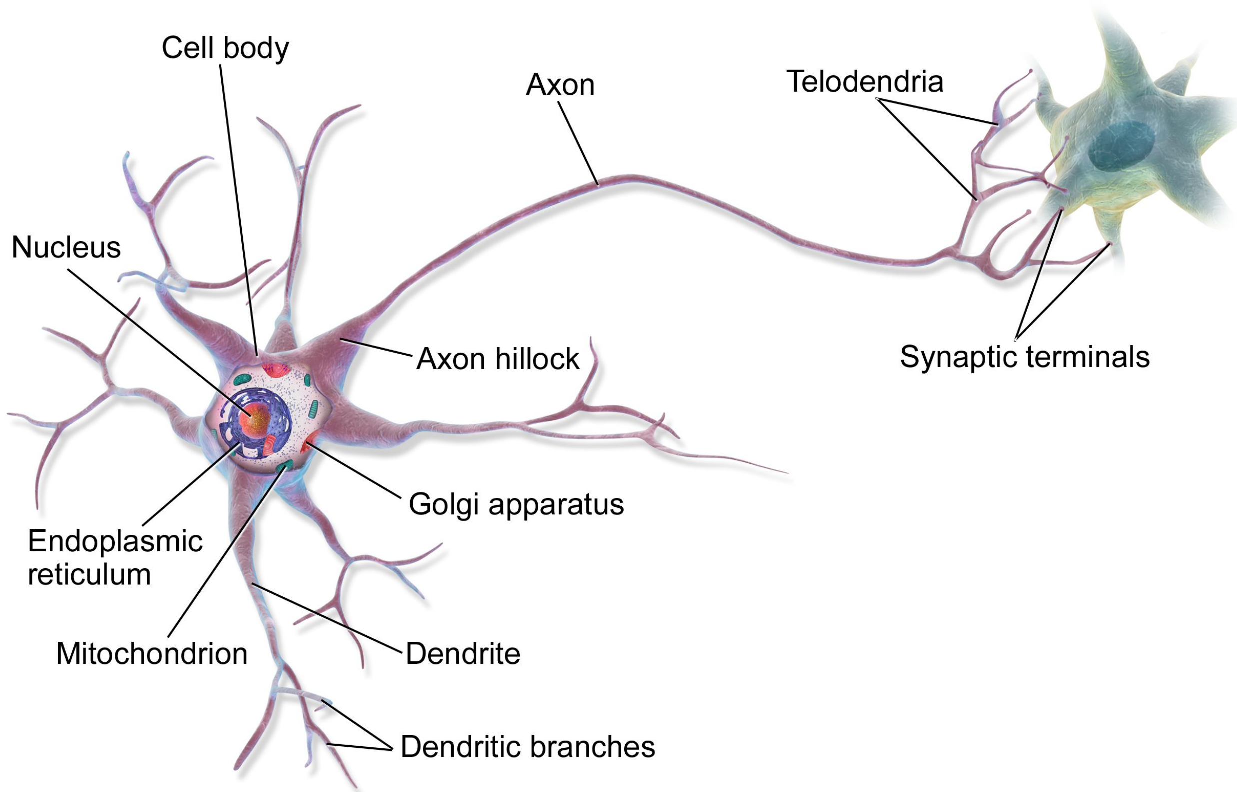


NEUROSCIENCE IN I2

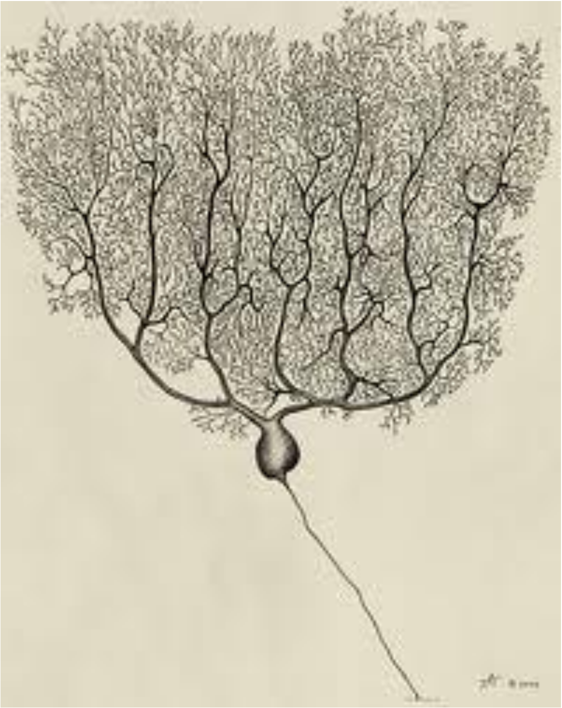
JANNA HONG, DR. MOODY

Neurons support electrochemical transmission!



Pyramidal cell of cerebral cortex

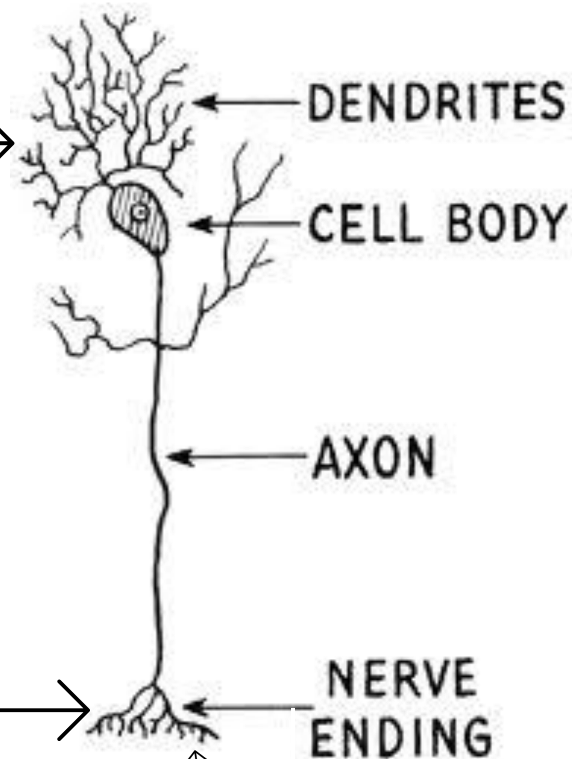
Olfactory bulb neuron



Purkinje neuron of cerebellum

Simplified anatomy of a neuron

Axon terminals of another neuron would make synapses on these dendrites



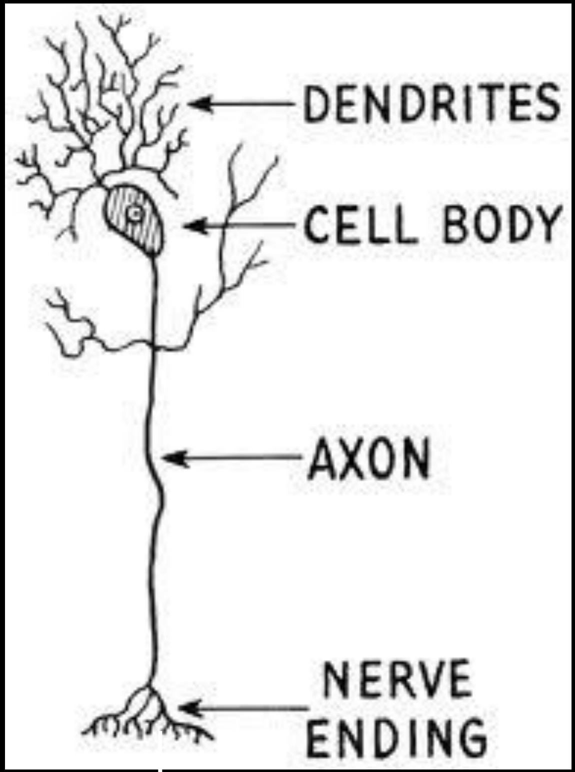
These axon terminals would make synapses on the dendrites of another neuron

Axon (or presynaptic) terminals

Direction of information flow

Dr. Moody's Slide

Information processing in different regions of a neuron



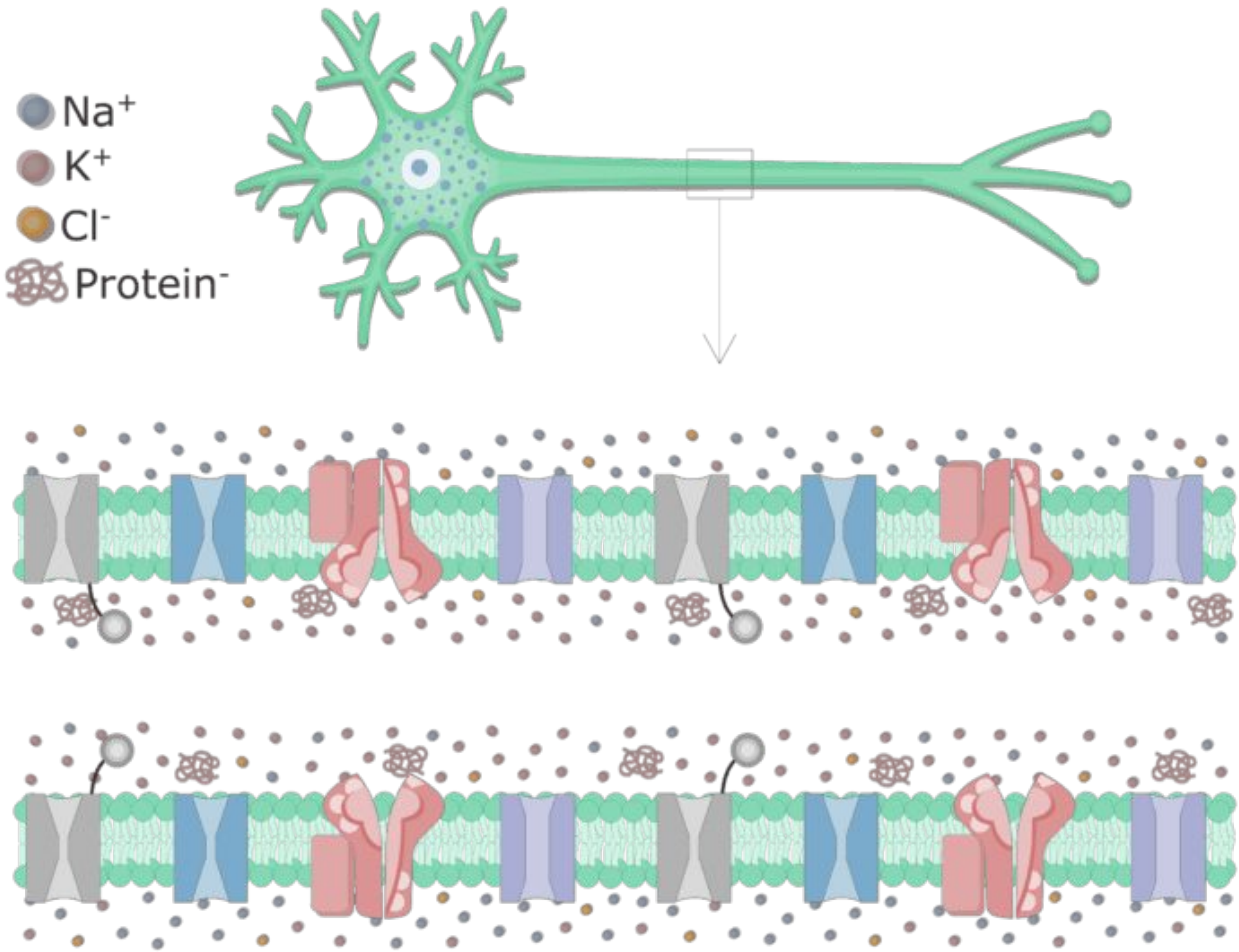
Axon (or presynaptic) terminals

Receive up to 50,000 synaptic inputs and integrate them.
Excitatory and inhibitory synaptic potentials.
Add and subtract, but cannot propagate over distance.
Information coded by amplitude.

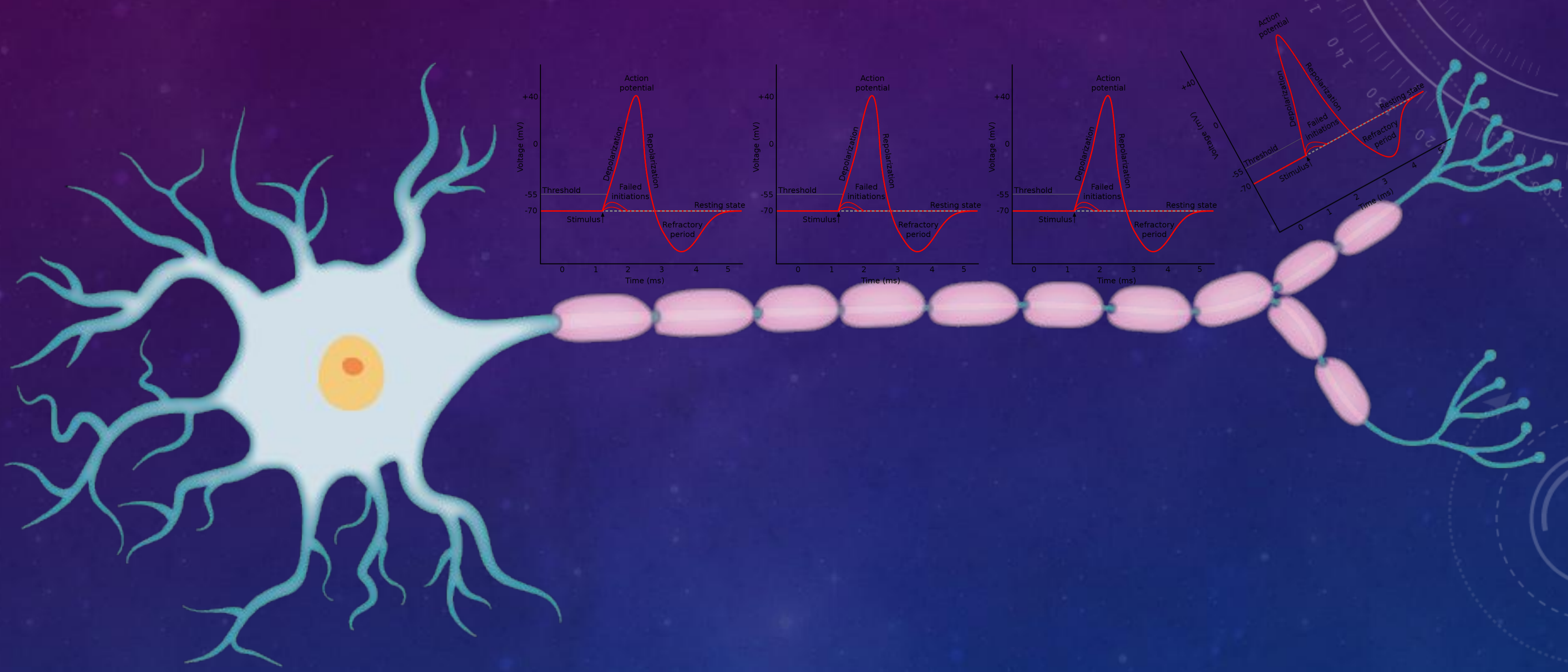
Create output based on sum of synaptic potentials.
Action potential created by voltage-gated Na and K channels.
Action potentials cannot add or subtract.
They propagate over distance without decrement.
Information coded by frequency.

Release of neurotransmitter by exocytosis.
Action potential to trigger transmitter release.
Passes information on to next neuron in circuit.

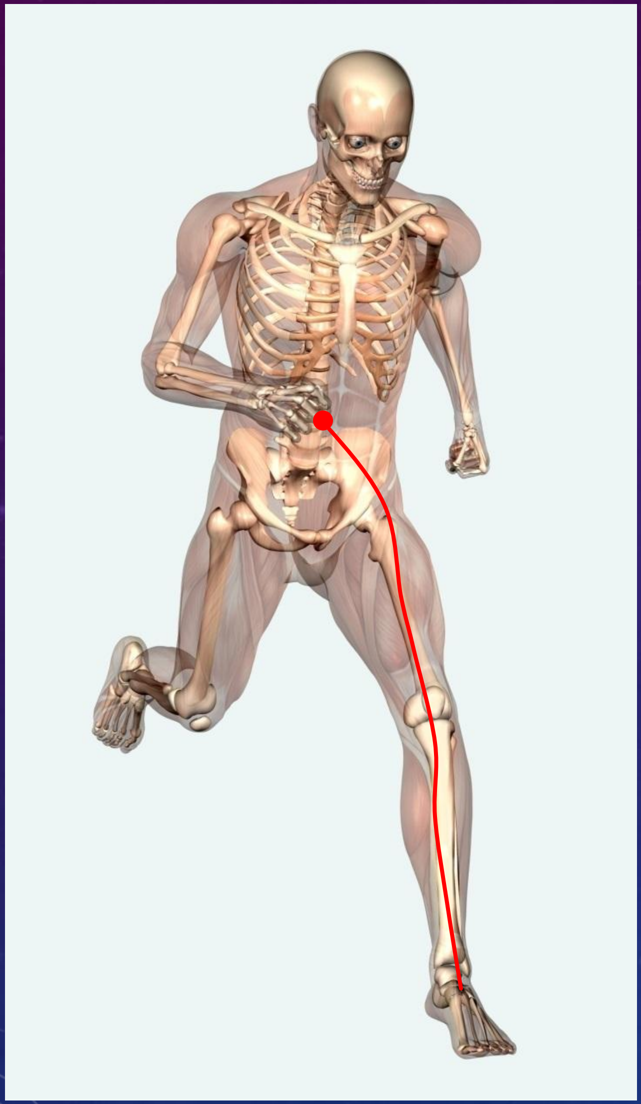
Dr. Moody's Slide


Na+
K+
Cl-
Protein-

ACTION POTENTIALS PROPAGATE DOWN THE AXON



Dr. Moody's Slide



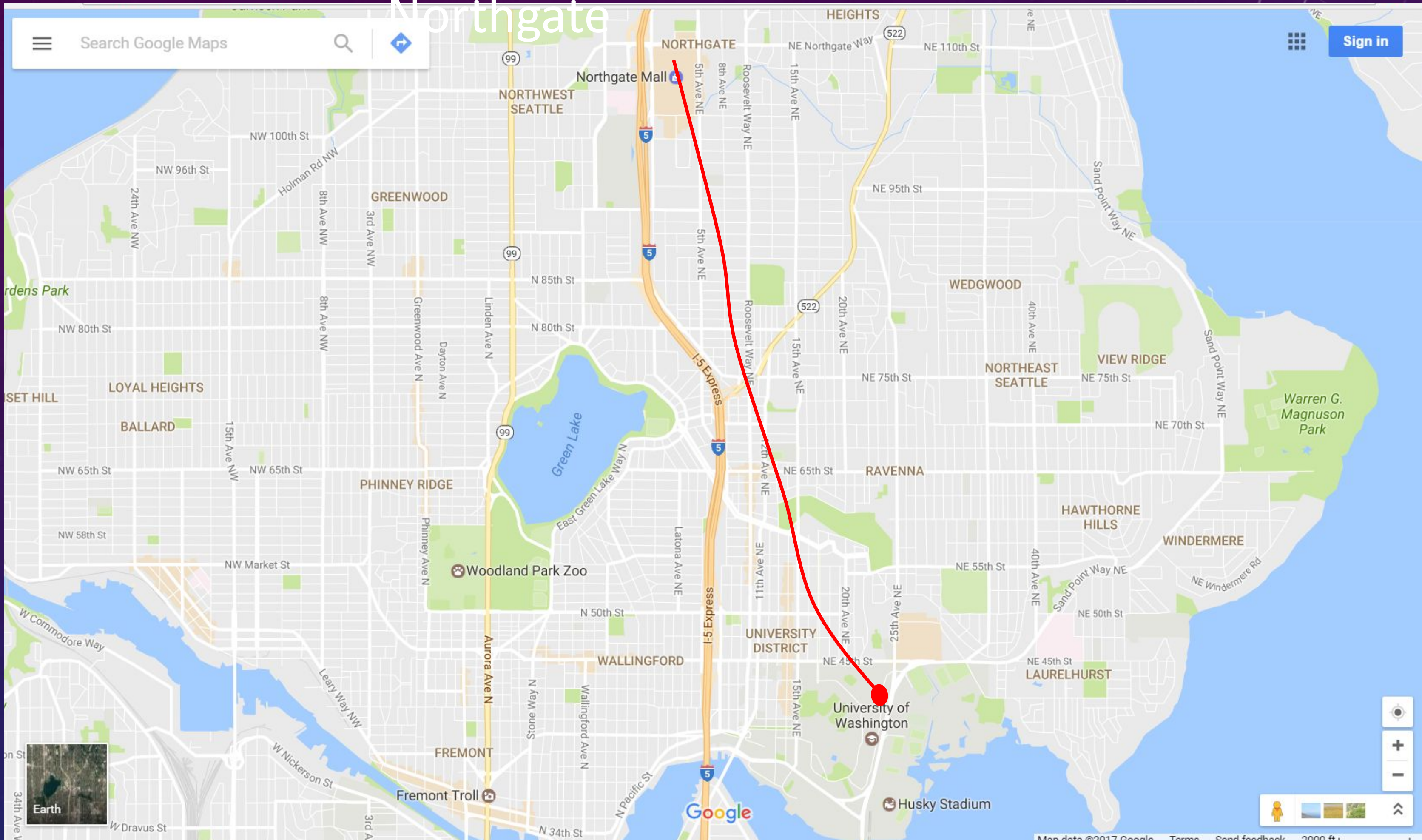
Axons Are Very Long

A neuron that controls muscles in your foot has its cell body in the spinal cord and an axon that runs for about 1 meter to your foot.

The axon diameter is about 1/1000 mm.

So, if I made the axon the right length in relation to the diameter you see on this screen, it would…..

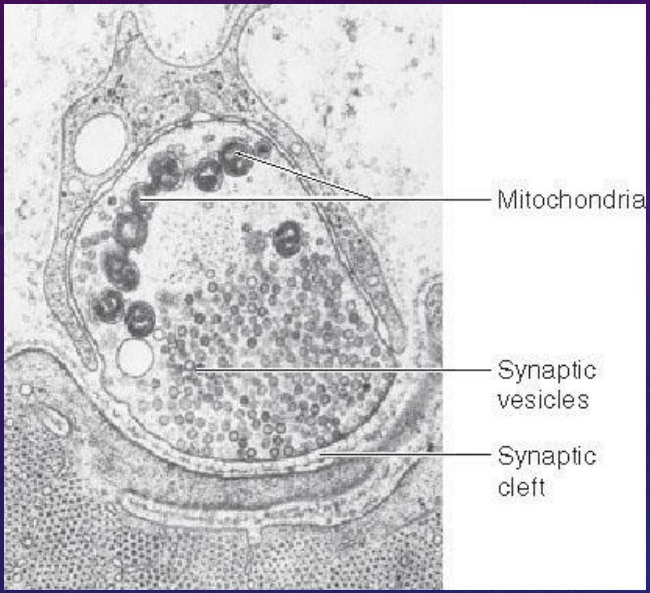
… reach from here to Northgate

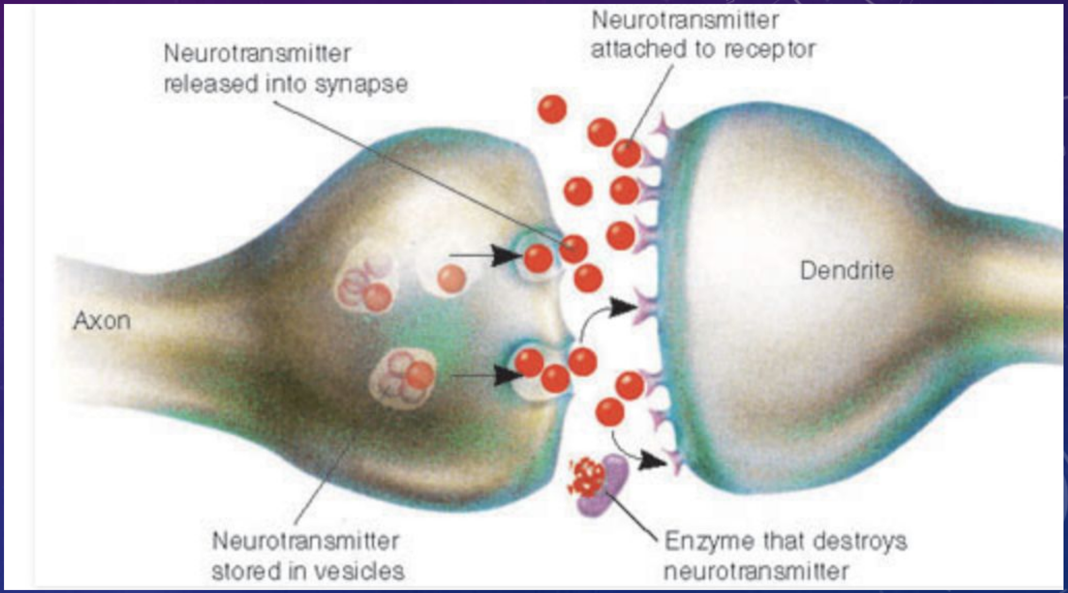


Note: This picture does not convey the reality. Drawn to scale, the axon would look just like it does on this slide, but the slide would have to be 5 miles tall.

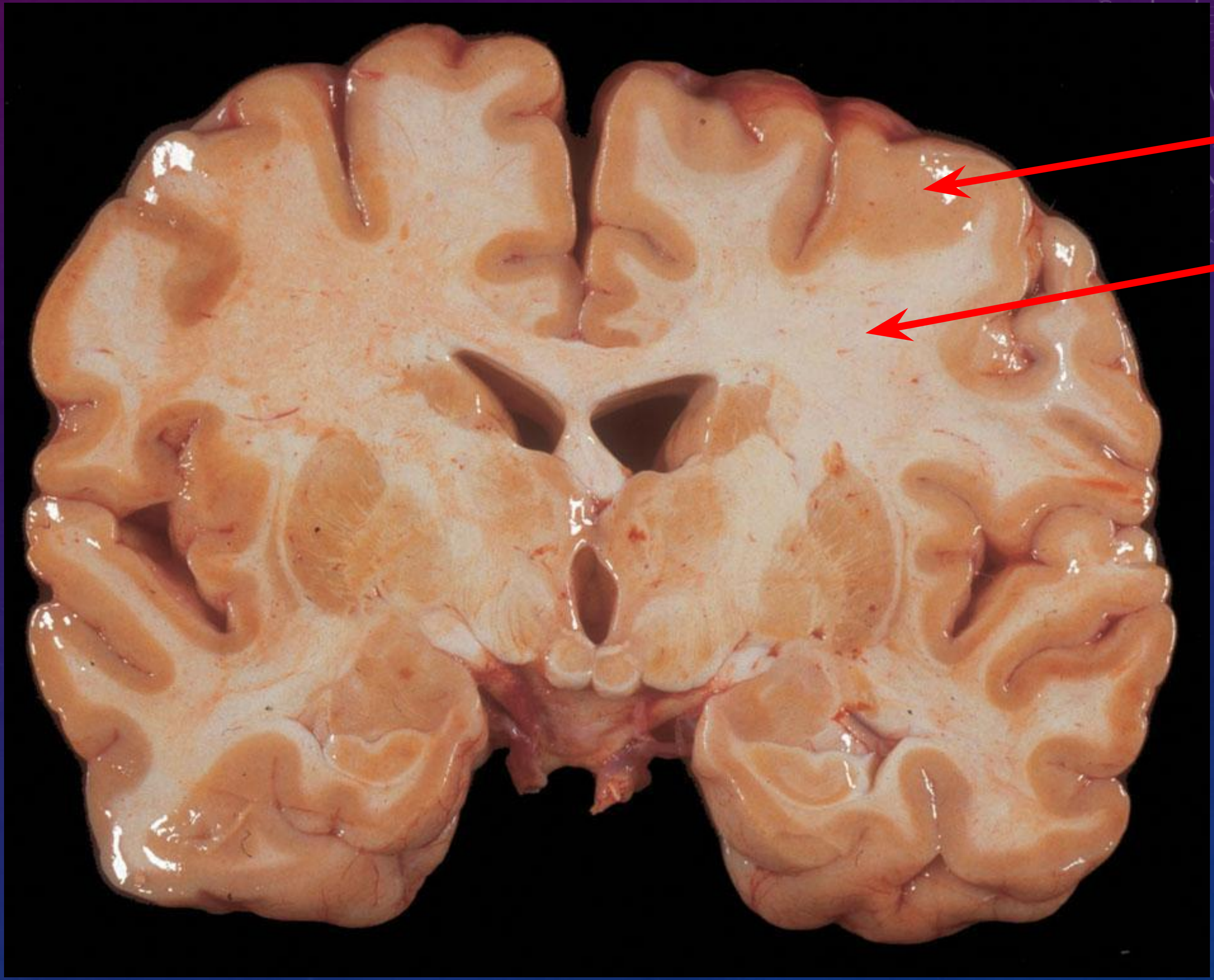
Or I could shrink the diameter of the axon by a factor of 6000.

THE SYNAPSE


Mitochondria
Synaptic vesicles
Synaptic cleft


Neurotransmitter released into synapse
Neurotransmitter attached to receptor
Axon
Dendrite
Neurotransmitter stored in vesicles
Enzyme that destroys neurotransmitter

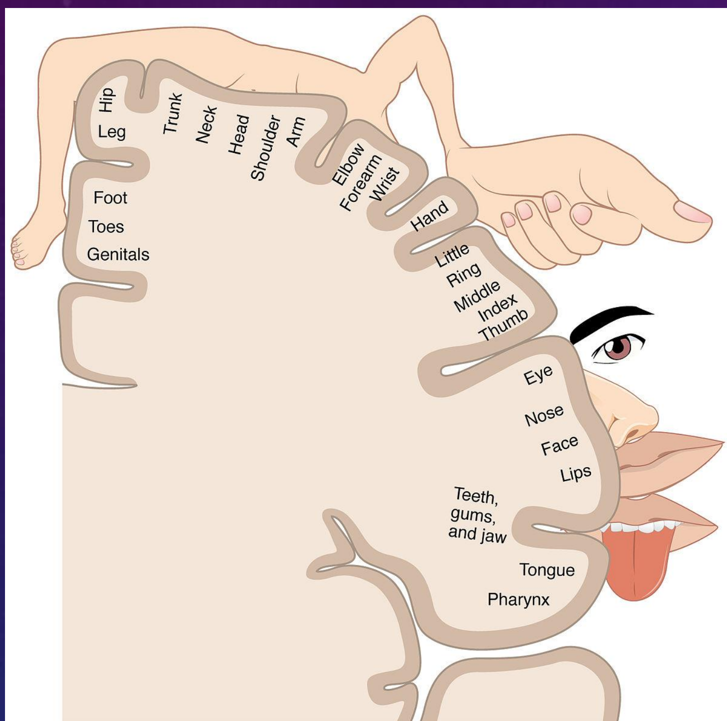
Cross Section of Human Brain

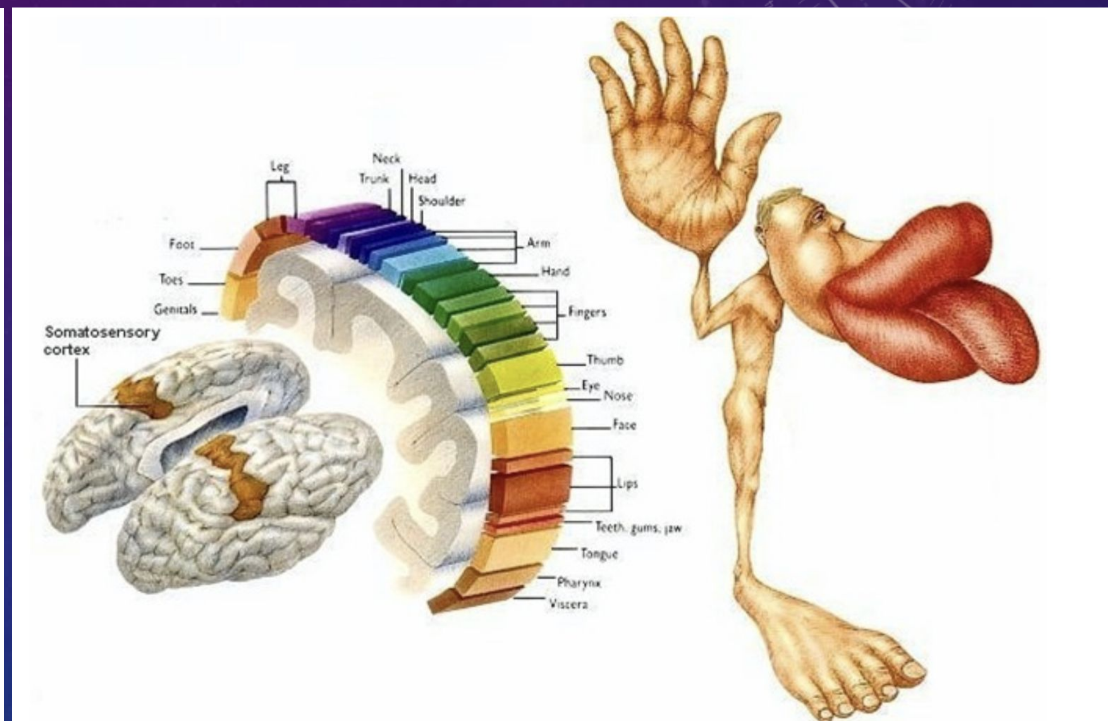


Gray Matter

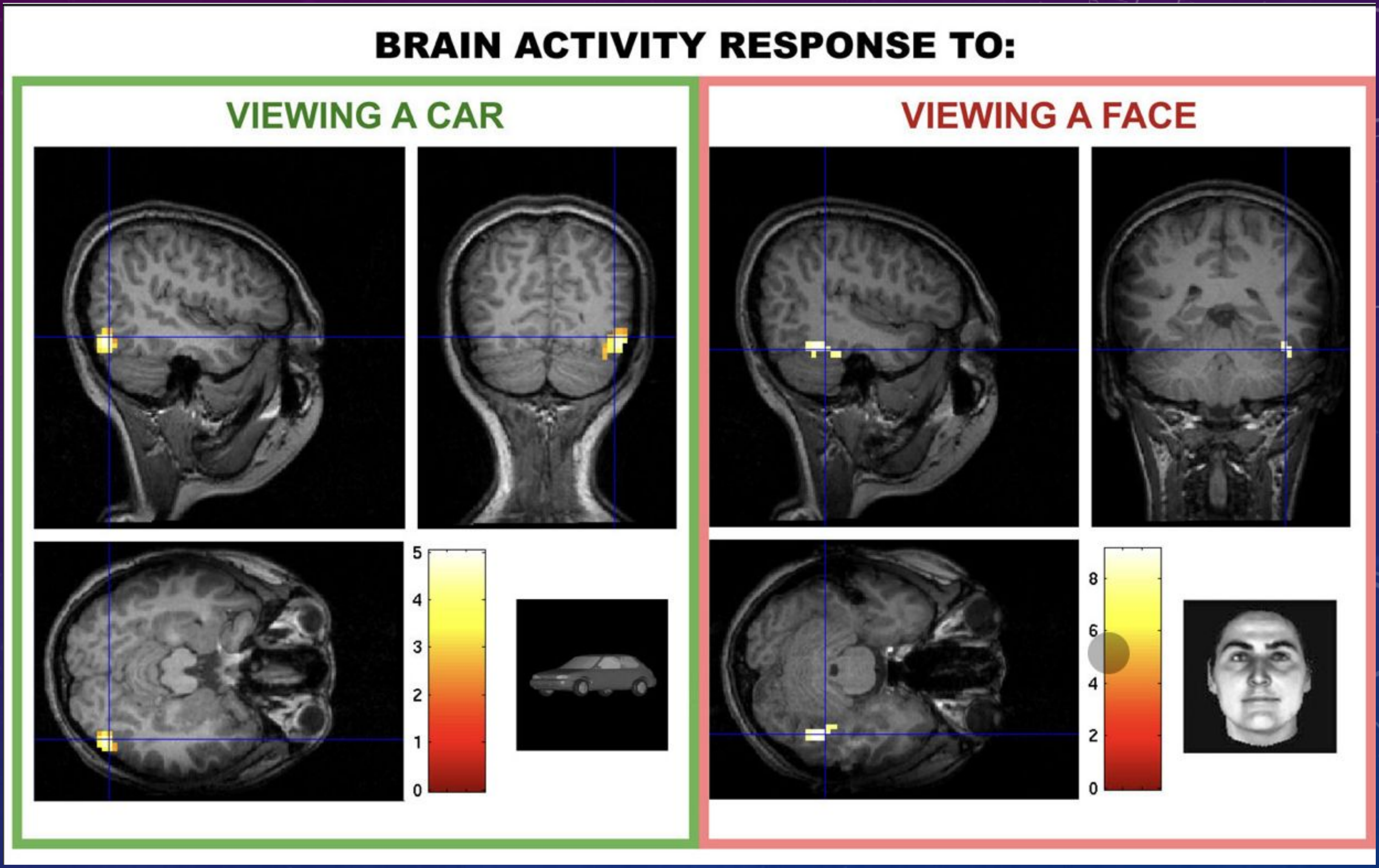
White Matter

SOMATOSENSORY CORTEX





THE SENSORY HOMUNCULUS
(HOW YOUR BODY LOOKS TO YOUR BRAIN)



BRAIN ACTIVITY RESPONSE TO:
VIEWING A CAR
VIEWING A FACE
5
4
3
2
1
0
8
6
4
2
0

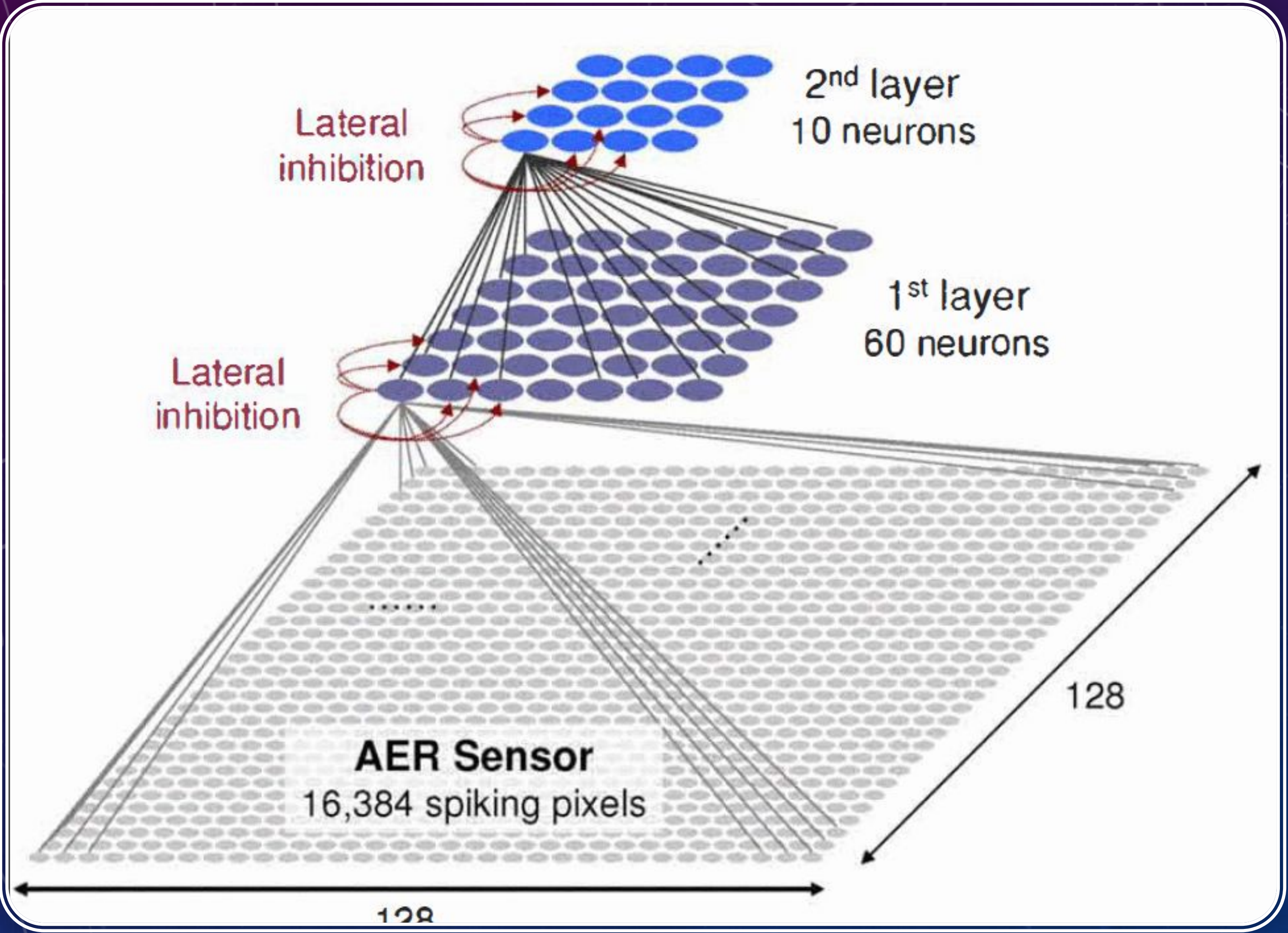
COMPUTATIONAL METHODS IN NEUROSCIENCE

Three general strategies of computational methods:

- Predict how a collection of connected neurons ('circuit') behaves based on experimentally measured properties of the individual neurons.
- Make a model neural circuit based on known parameters and see what it can learn in either an unsupervised or supervised setting.
- Reduce the dimensionality of data sets from recordings of large numbers of neurons.

Dr. Moody's Slide

NEURAL NETWORK



Brain-Computer Interfaces: Thought-driven Devices

Signal processing to extract relevant information*

Record brain activity

Effector device:

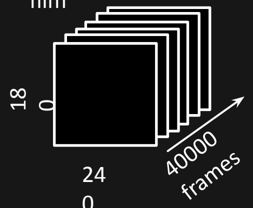
Robotic limb
Wheelchair
Screen cursor
Actual limb (bypassing spinal injury, for example

* Training required. Signal processing might extract, for example, the EEG signal corresponding to visualization of a limb movement.

Dr. Moody's Slide

Seeking patterns of activity in sleep and wake with Non-Negative Matrix Factorization

Original imaging film

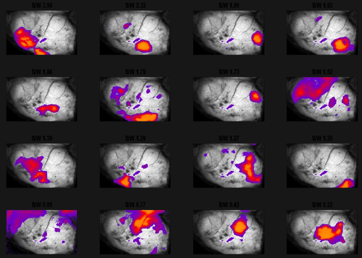


Reshape

43200 x
40000

=

16 spatial modes, 180 x
240



UnReshape

43200 x
16
'Features'

X

16 x 40000

'Coefficients'

16 40K time vectors
(1 for each spatial
component)

For each time vector:
Mean sleep value /mean wake value (S/W Ratio) measures distribution of each spatial component into sleep vs wake

spatial modes chosen by us based on
residual error plots

Dr. Moody's Slide