Neurotech
UofT

Introduction to Neuroscience

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Neuroanatomy

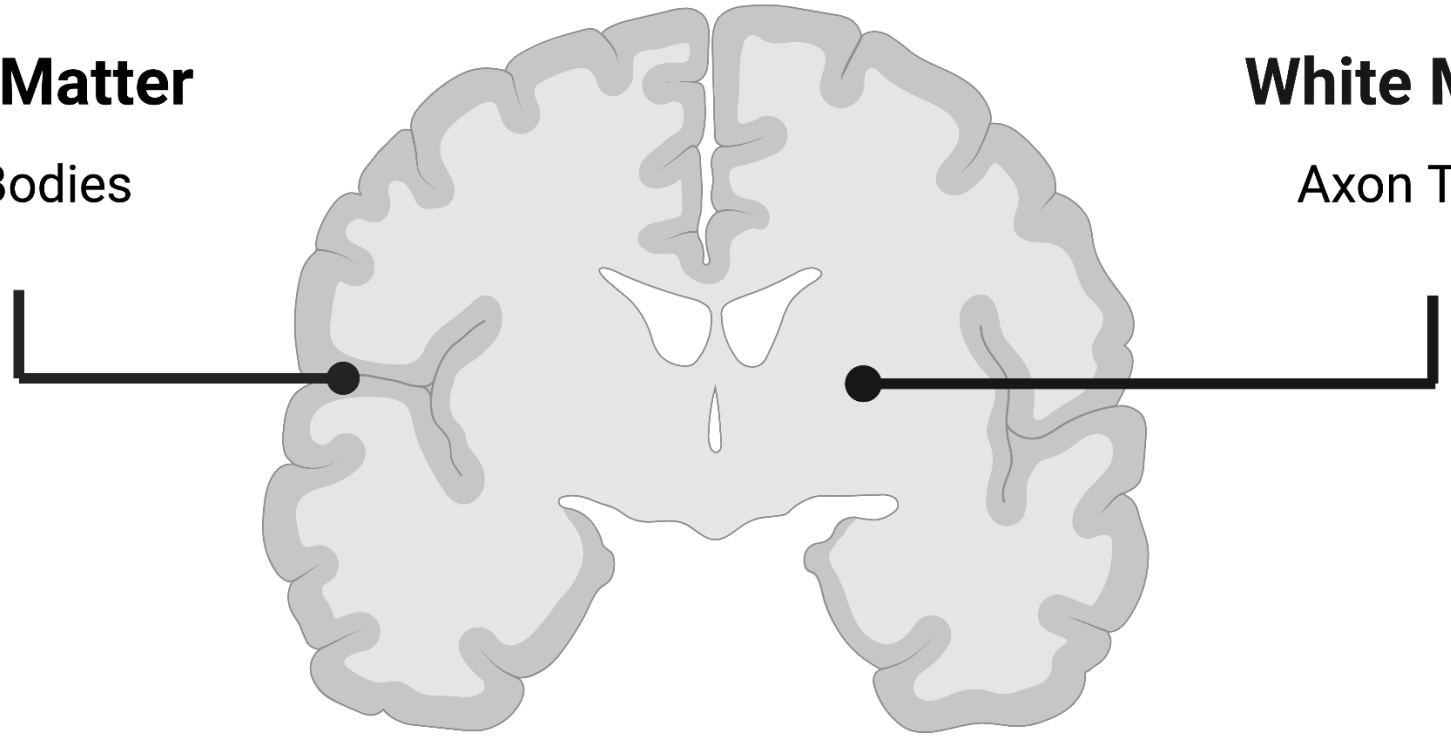
Grey and White Matter

Grey Matter

Cell Bodies

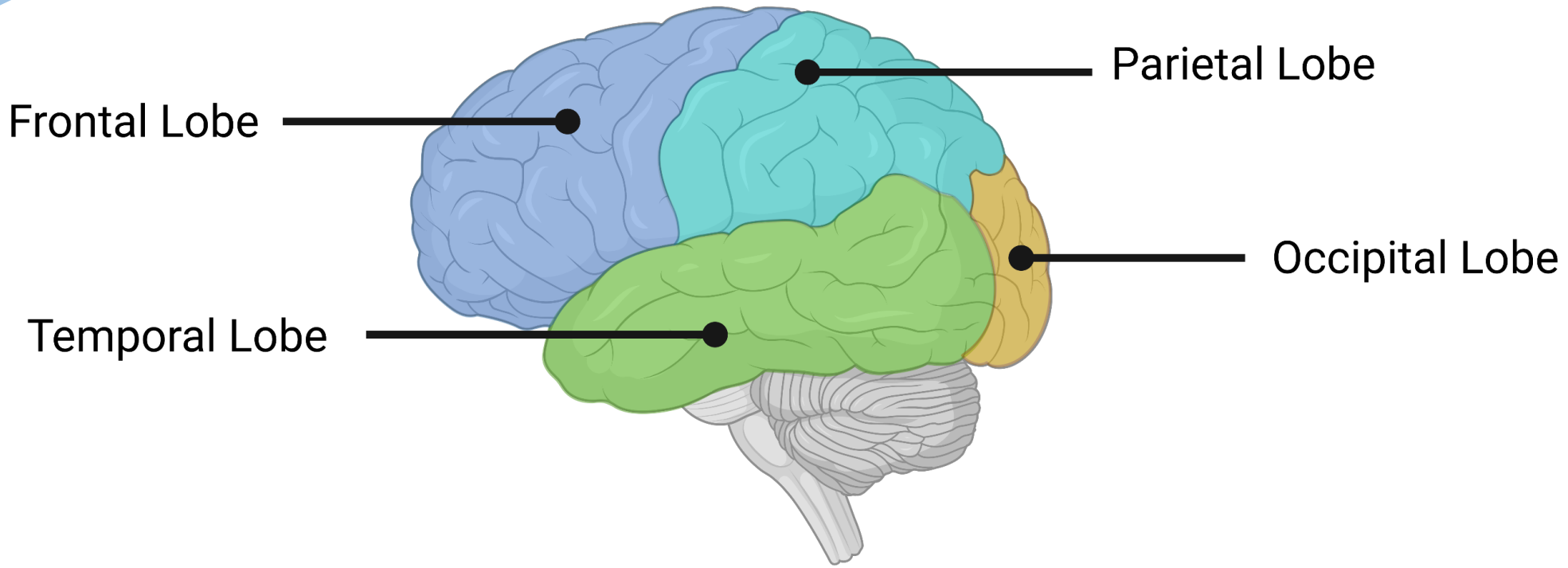
White Matter

Axon Tracts



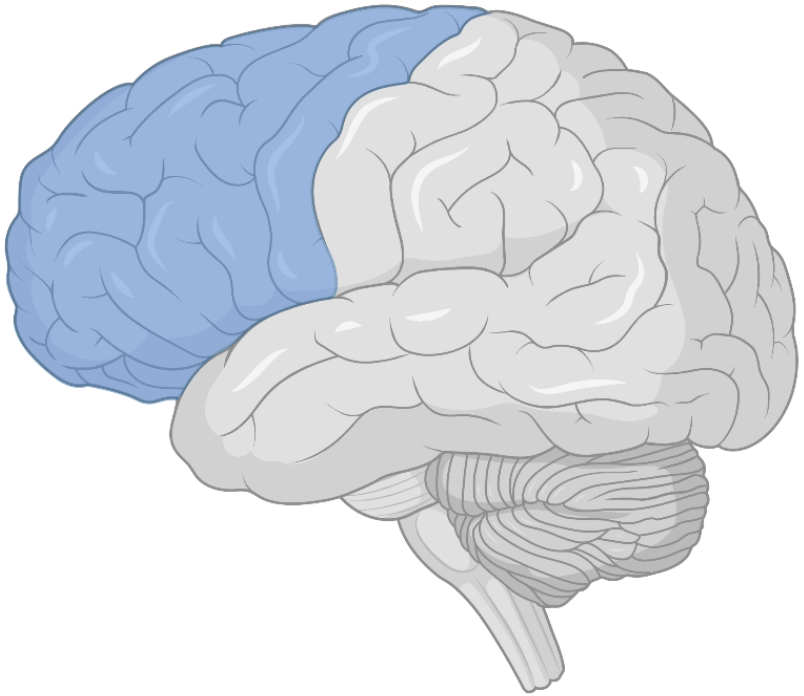
Neuroanatomy

Grey Matter: Cerebral Cortex



Neuroanatomy

Frontal Lobe



- Prefrontal cortex
  - Responsible for higher order cognitive function (decision making, attention, planning)
- Primary motor cortex
  - Responsible for the initiation and execution of voluntary movement
- Premotor and supplementary motor areas
  - Responsible for the integration of signals related to motor planning
- Broca's area
  - Responsible for the motor aspects of speech

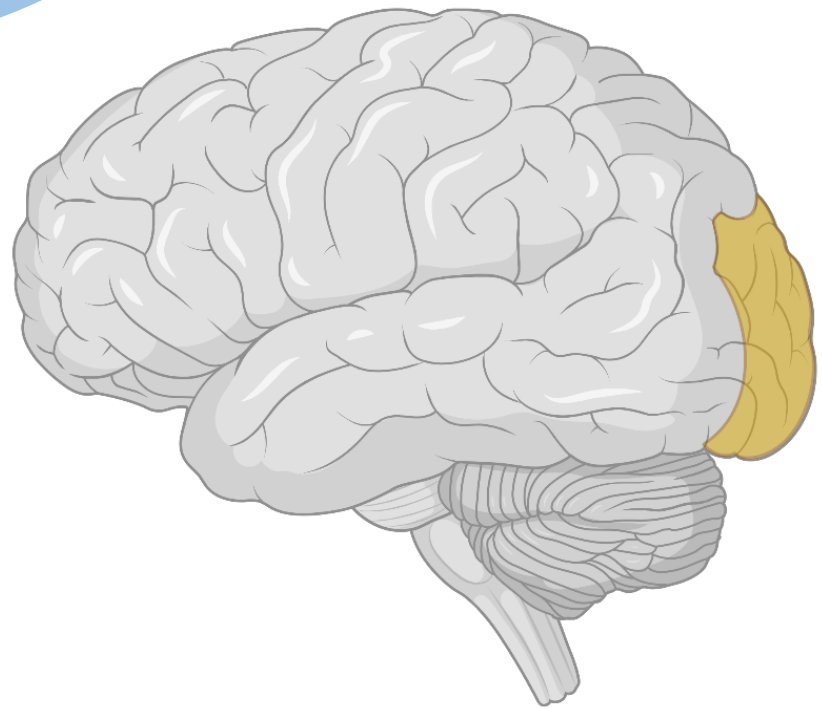
Neuroanatomy

Parietal Lobe

- Primary somatosensory cortex
  - Responsible for the integration and conscious awareness of sensory signals related to pain, proprioception, temperature, tactile
- Somatosensory association cortex
  - Responsible for the analysis and processing of somatic stimuli
- Posterior association area
  - Responsible for the processing of visual and auditory stimuli

Neuroanatomy

Occipital Lobe



- Primary visual cortex
  - Responsible for visual perception
- Visual association area
  - Responsible for the recognition and interpretation of the visual images that we are seeing

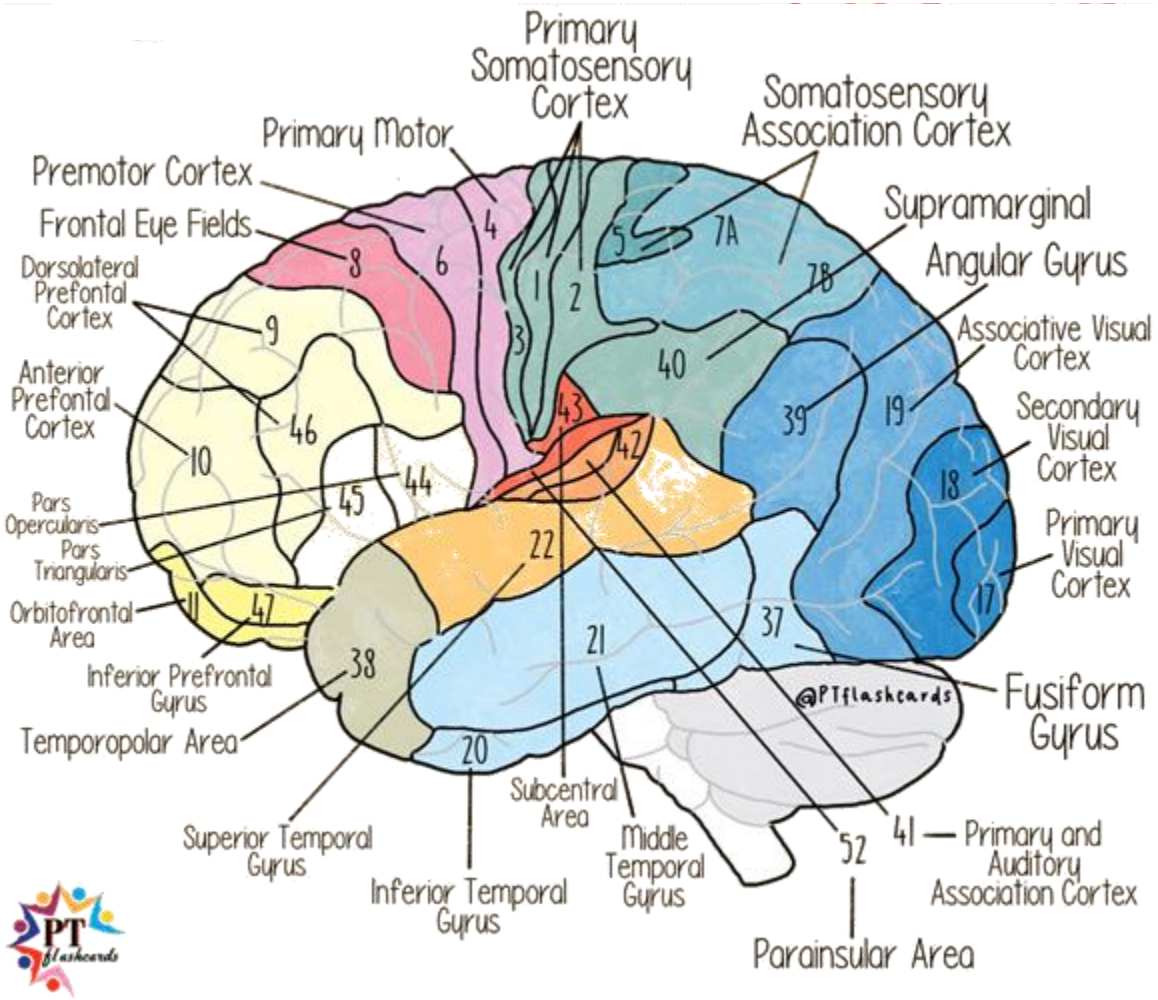
Neuroanatomy

Temporal Lobe

- Primary auditory cortex
  - Responsible for the reception and conscious awareness of auditory information
- Auditory association cortex
  - Responsible for the analysis and processing of auditory stimuli
- Wernicke's area
  - Responsible for the understanding and comprehension of language
- Primary olfactory cortex
  - Responsible for the conscious awareness of smell

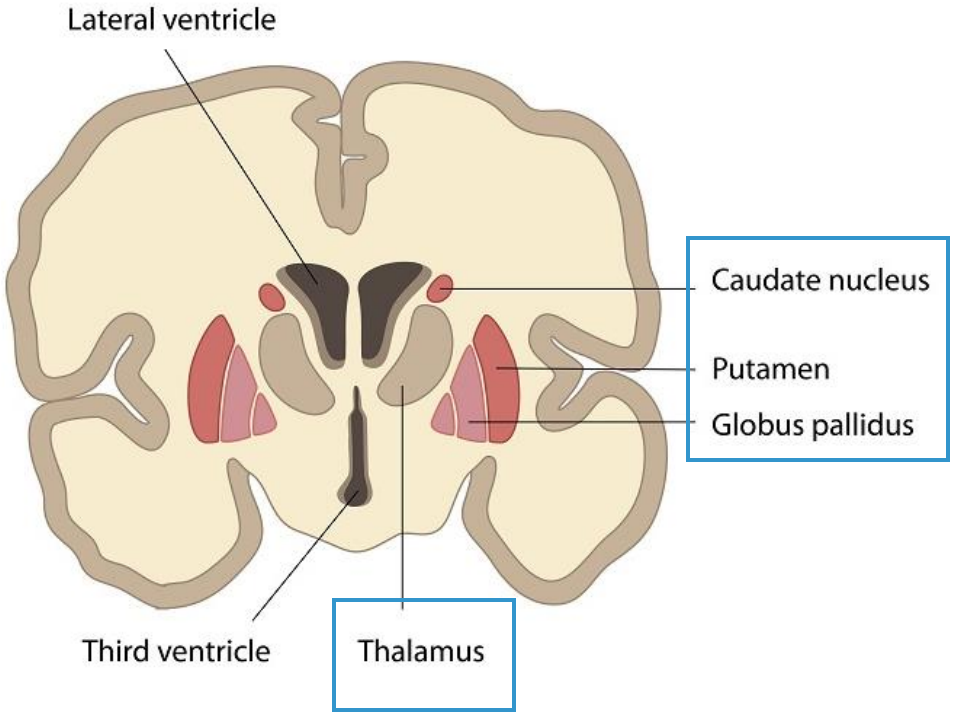
Neuroanatomy

Brodmann Areas



Neuroanatomy

Deep Grey Nuclei



- Thalamus
  - Relay center for all body senses except smell
- Basal ganglia
  - Responsible for motor control and learning
  - Includes structures such as the caudate nucleus, putamen and globus pallidus

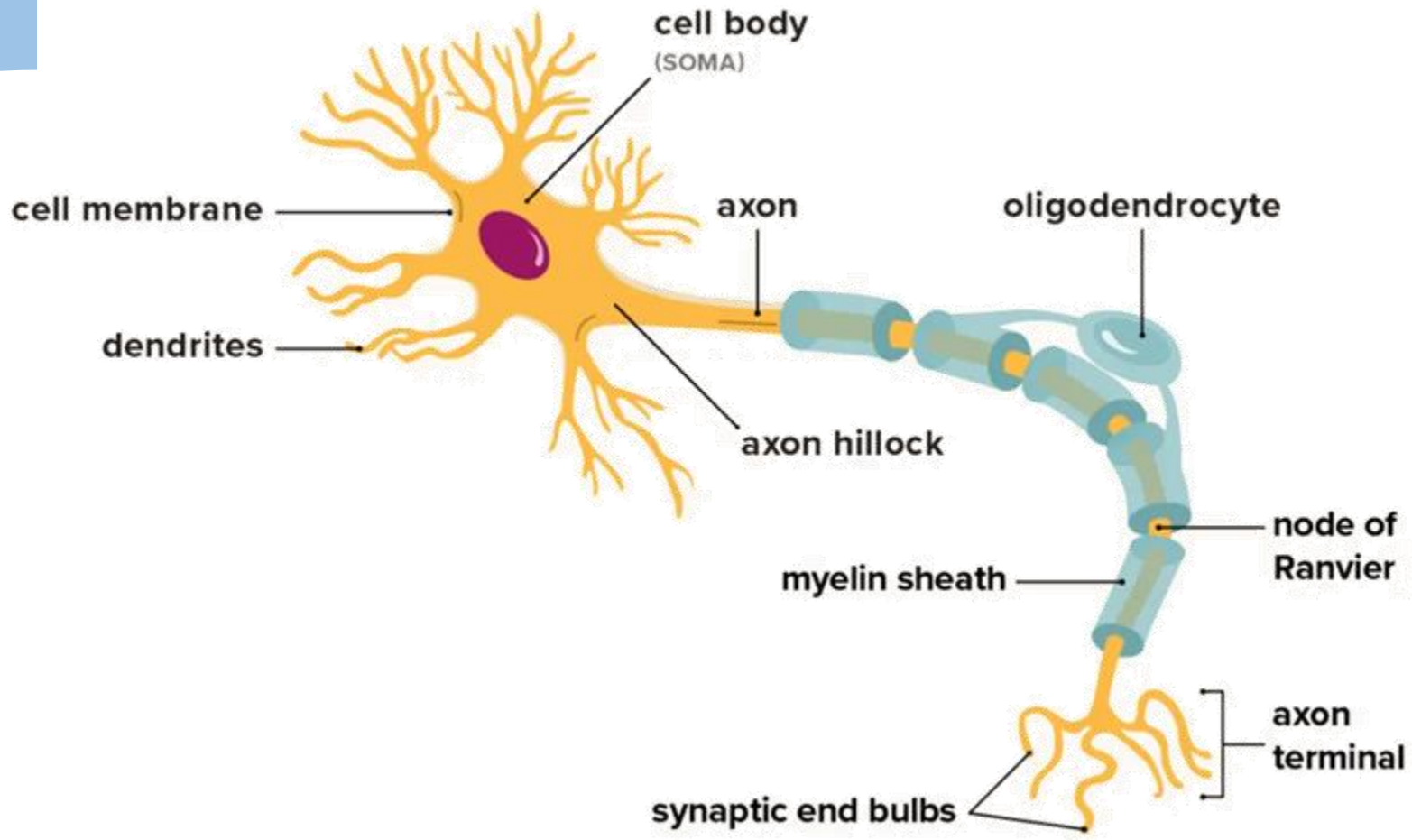
Neuroanatomy

White Matter: Fiber Types

1. **Commissural fibers** – connect hemispheres
2. **Projection fibers** – connect the cerebral cortex to other structures in the brain
3. **Association fibers** – connect structures within the same hemisphere

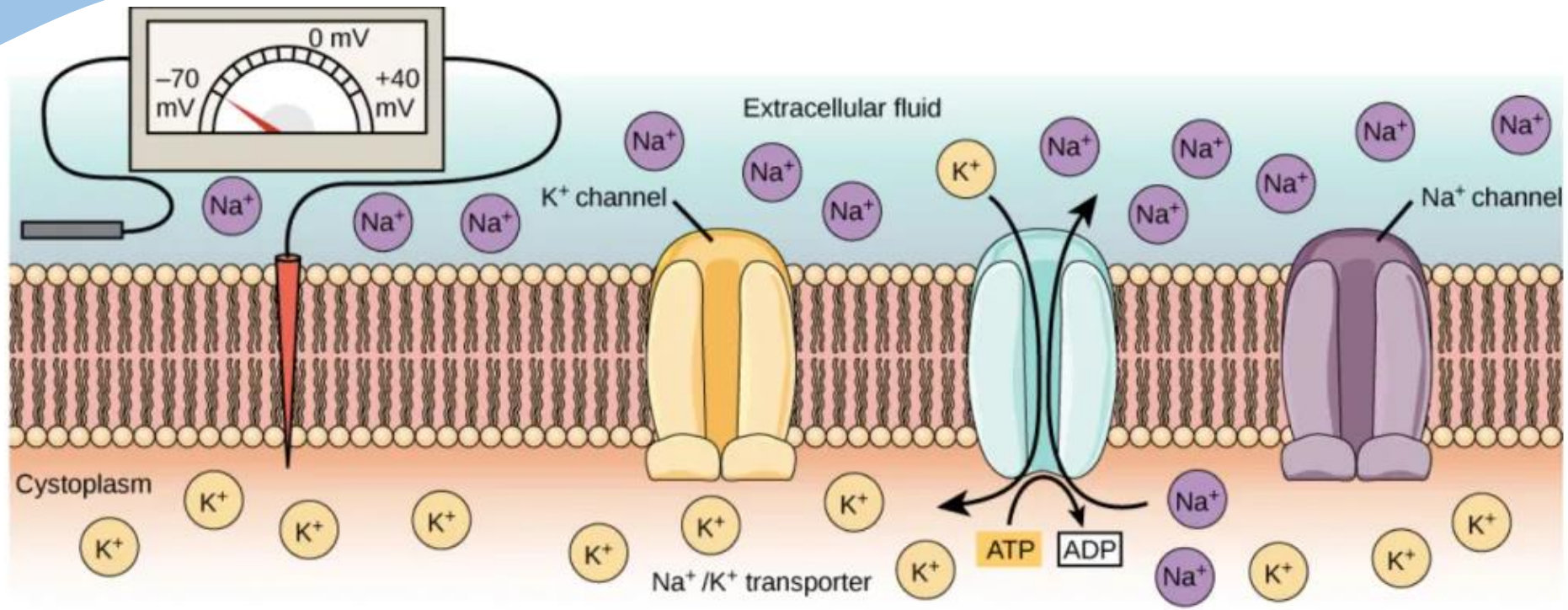
Neuroanatomy

Neuron Structure



Neural Signaling

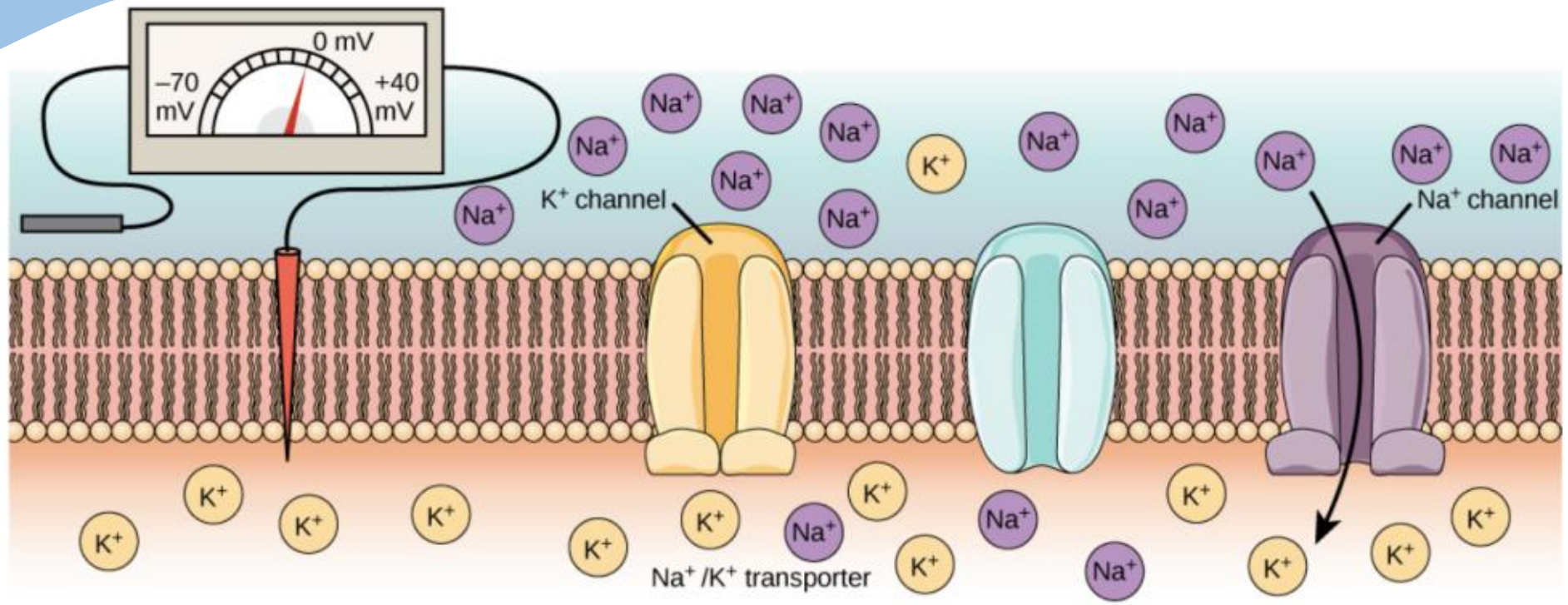
Resting Membrane Potential



At the resting potential, all voltage-gated Na^+ channels and most voltage-gated K^+ channels are closed. The Na^+/K^+ transporter pumps K^+ ions into the cell and Na^+ ions out.

Neural Signaling

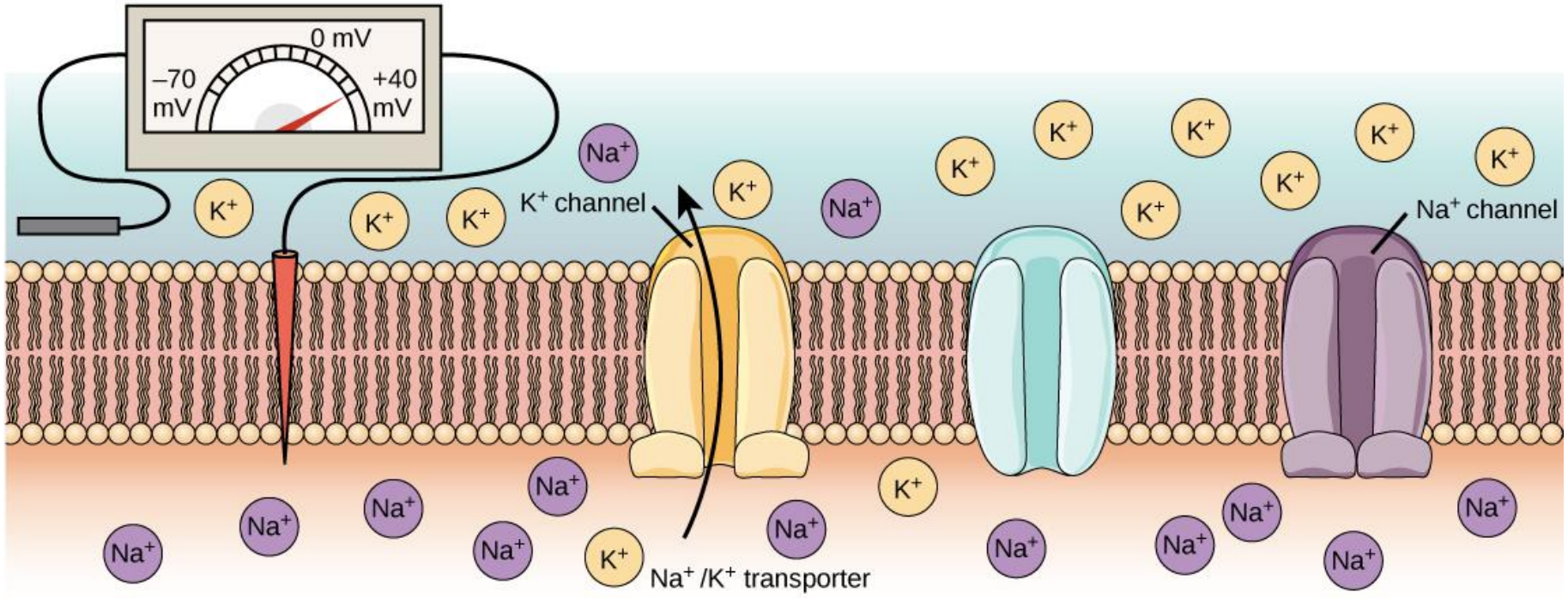
Depolarization



In response to a depolarization, some Na^+ channels open, allowing Na^+ ions to enter the cell. The membrane starts to depolarize (the charge across the membrane lessens). If the threshold of excitation is reached, all the Na^+ channels open.

Neural Signaling

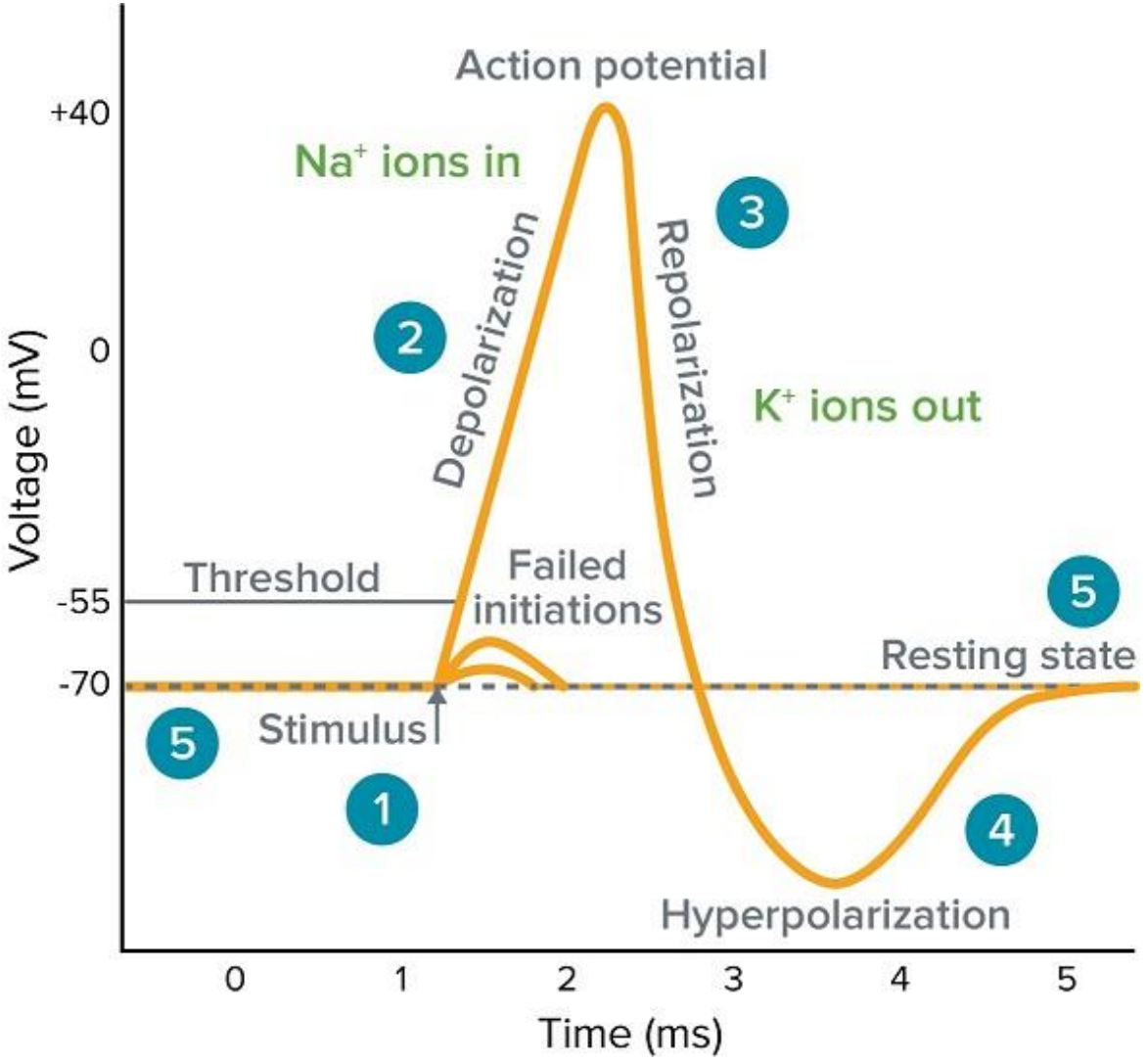
Repolarization



At the peak action potential, Na^+ channels close while K^+ channels open. K^+ leaves the cell, and the membrane eventually becomes hyperpolarized.

Neural Signaling

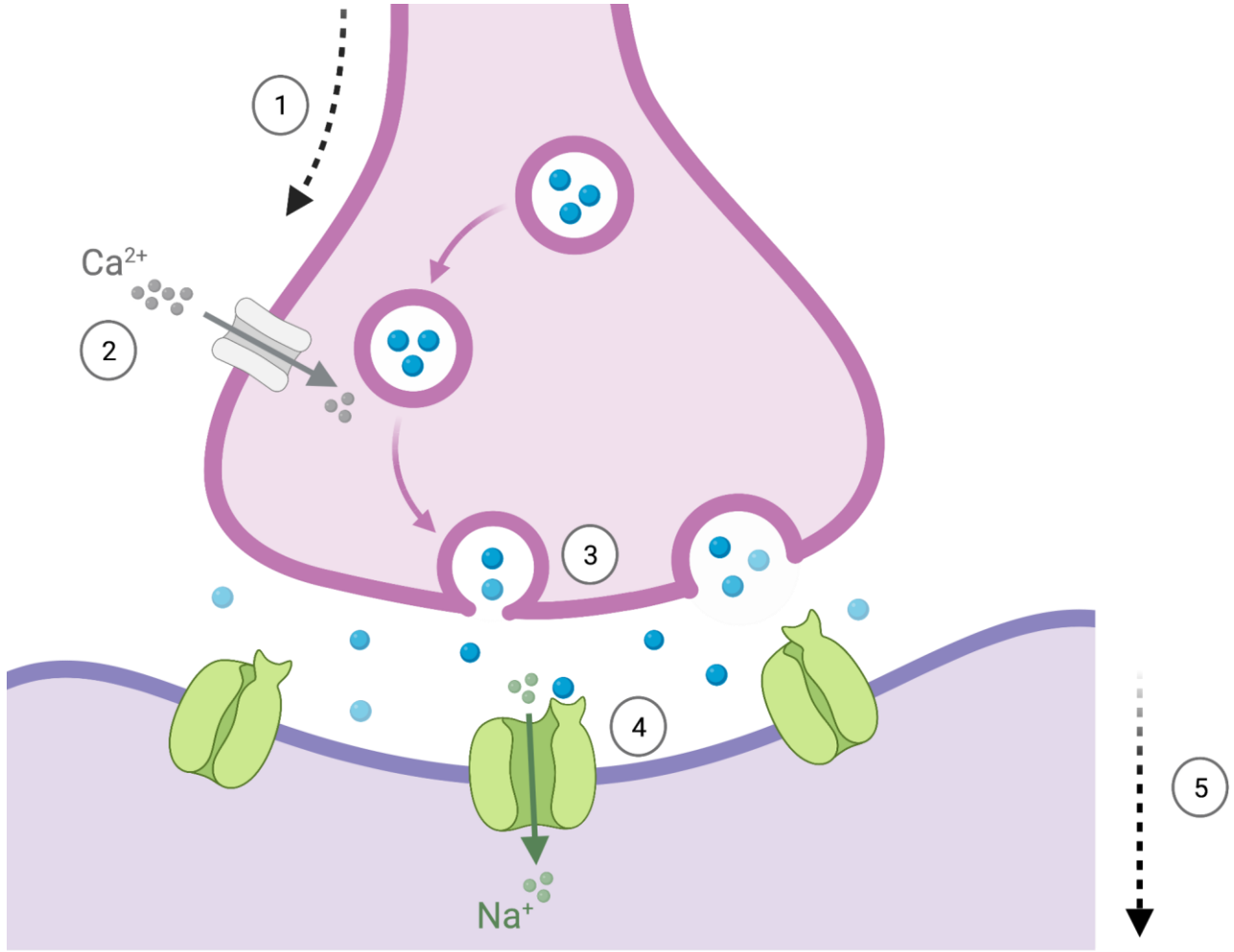
Action Potential



Neural Signaling

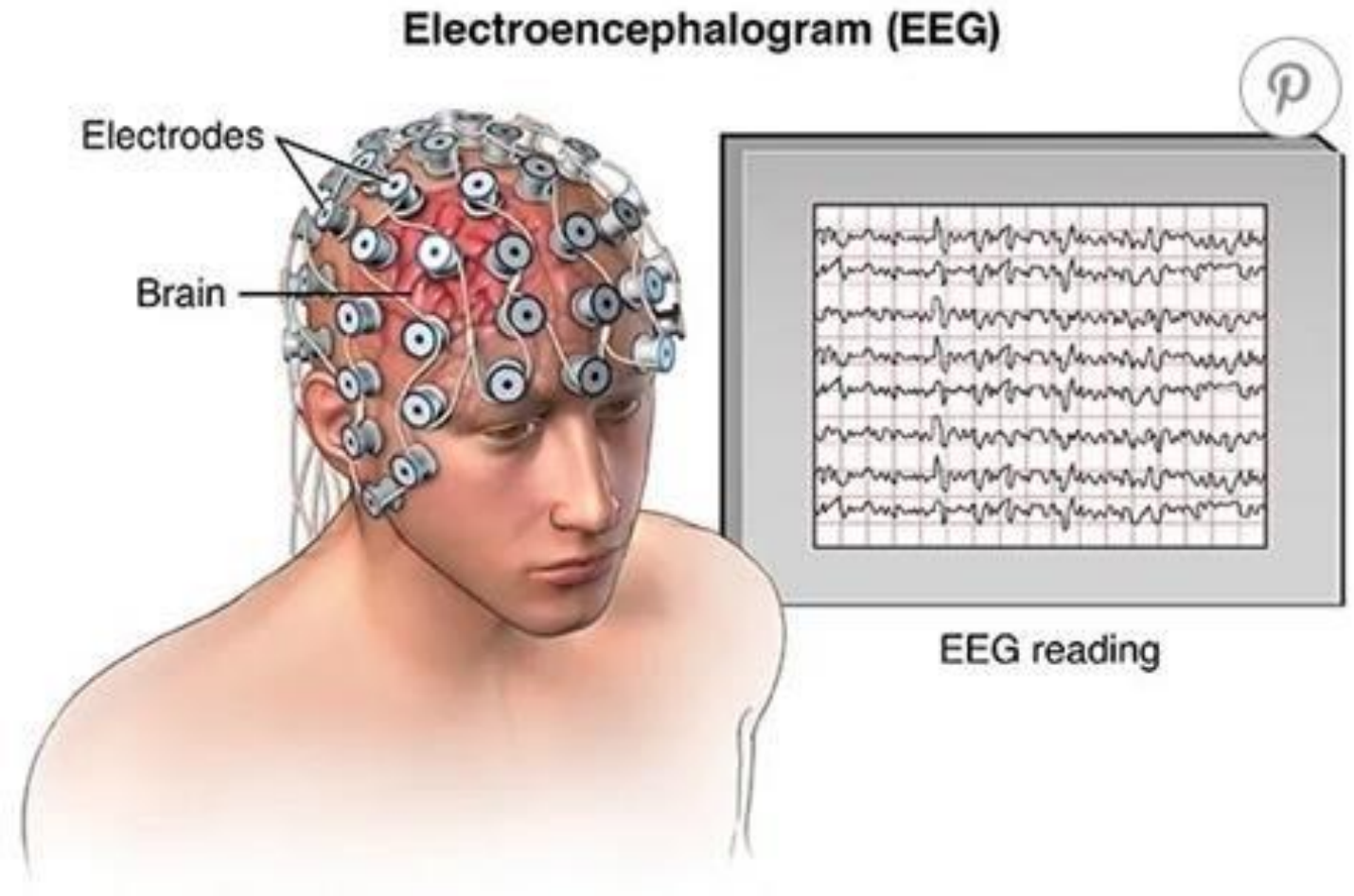
Neurotransmission

1. Axon potential arrives at the axon terminal.
2. Ca^{2+} influx via voltage-gated Ca^{2+} channels.
3. Ca^{2+} induces exocytosis of neurotransmitters into the synaptic cleft.
4. Neurotransmitters bind to post-synaptic channels causing Na^{+} influx.
5. Depolarization and generation of an action potential.

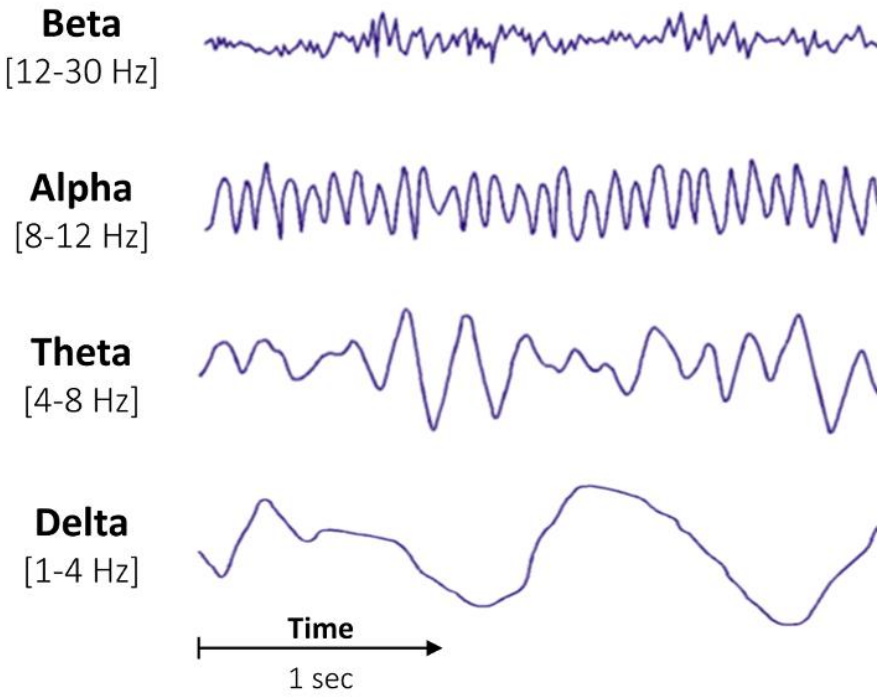


Neural Signaling

Electroencephalography (EEG)



Neural Signaling



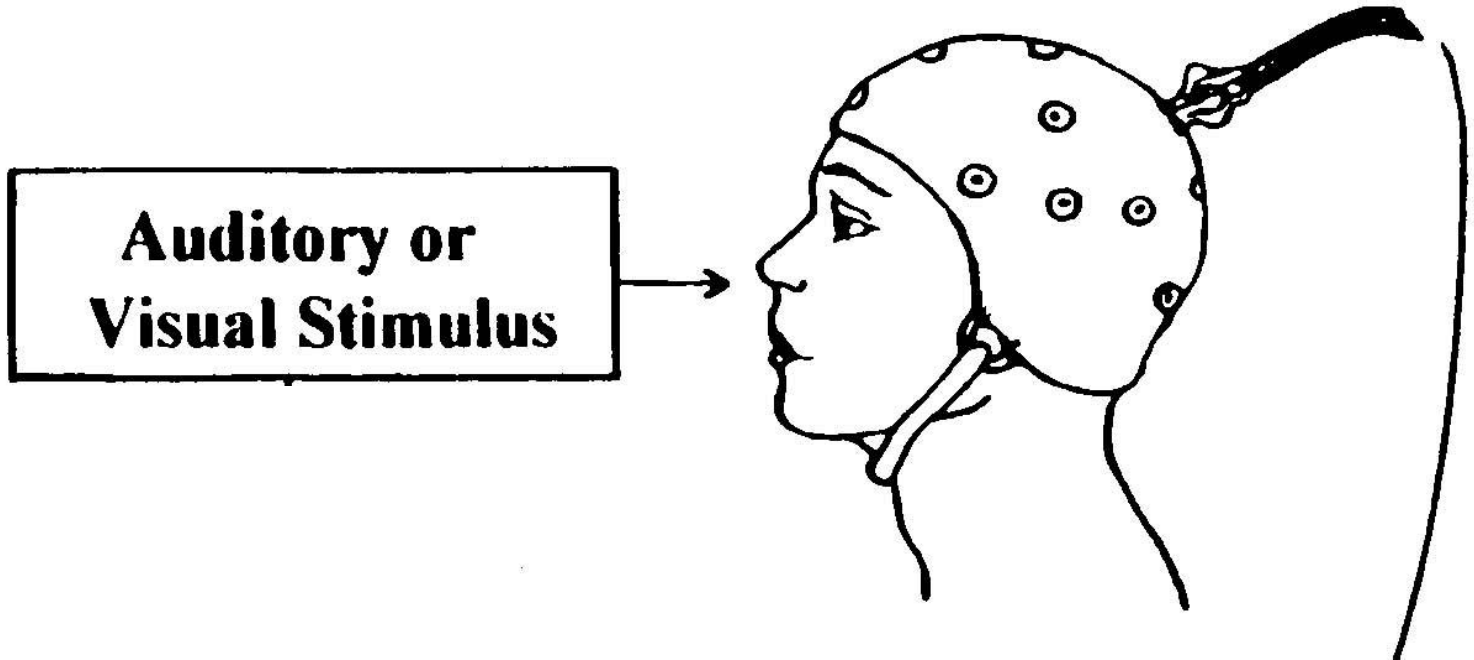
EEG Signal

- Records electrical activity by measuring voltage differences in particular brain regions
  - (Remember that there are changes in voltage during neural signaling)
- Specifically, it records excitation in the dendrites of the post-synaptic neuron
- There are distinct EEG patterns during different cognitive processes

Neural Signaling

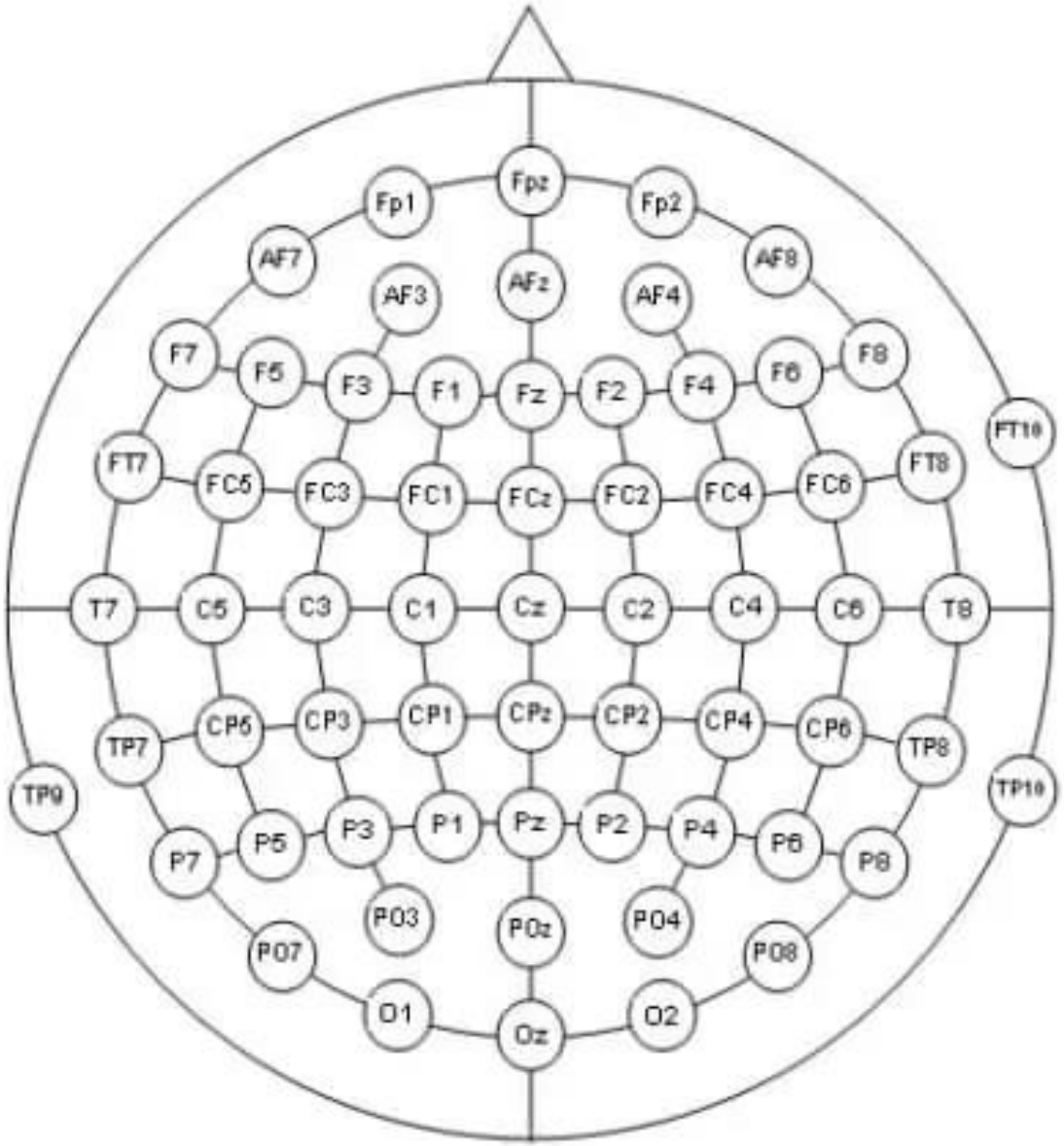
Event Related Potentials

- Changes in electrical activity in response to a particular stimulus



Activity

1. Pick an electrode



Activity

1. Pick an electrode
2. Find the associated Brodmann area using the table

Table 2
Macro-anatomical and cytoarchitectonic variabilities of cortical projections in the 10–10 system

Labels	Macro-anatomical variabilities	Main macro-anatomical structures	Main BA	Cytoarchitectonic (Brodmann) variabilities
Fp1	GFS (65%) GFM (35%)	Superior frontal G	10	10 (100%)
Fpz	GFd (66%) SI (17%) GFM (17%)	Medialis frontal G	10	10 (100%)
Fp2	GFS (75%) GFM (25%)	Superior frontal G	10	10 (100%)
AF7	GFM (100%)	Middle frontal G	10	10 (75%), 46 (25%)
AF3	GFS (56%) GFM (44%)	Superior frontal G	9	9 (75%), 10 (19%), 8 (6%)
AFz	GFS (75%) GFd (19%) SI (6%)	Superior frontal G	9	9 (62,5%), 6 (12,5%), 8 (19%), 10 (6%)
AF4	GFS (75%) GFM (25%)	Superior frontal G	9	9 (69%), 10 (25%), 8 (6%)
AF8	GFM (81%) GFS (13%) GFI (6%)	Middle frontal G	10	10 (81%), 49 (19%)
F7	GFI (100%)	Inferior frontal G	45	45 (56%), 47 (38%), 46 (6%)
F5	GFM (88%) GTS (6%) GFI (6%)	Middle frontal G	46	46 (50%), 9 (38%), 45 (6%), 22 (6%)
F3	GM (75%) GFS (25%)	Middle frontal G	8	8 (75%), 6 (19%), 46 (6%)
F1	GFS (88%) GFM (12%)	Superior frontal G	6	6 (63%), 8 (31%), 9 (6%)
Fz	GFS (81%) SI (19%)	Superior frontal G	6	6 (81,5%), 8 (12,5%), 9 (6%)
F2	GFS (75%) GFM (25%)	Superior frontal G	6	6 (69%), 8 (31%)
F4	GFM (63%) GFS (31%) GPREC (6%)	Middle frontal G	8	8 (69%), 6 (6%), 9 (25%)
F6	GFM (75%) GFI (25%)	Middle frontal G	9	9 (43,5%), 46 (37,5%), 45 (19%)
F8	GFI (88%) GFM (12%)	Middle frontal G	45/47	45 (37,5%), 47 (37,5%), 46 (25%)
FT7	GTS (82%) GTM (12%) GFI (6%)	Superior temporal	22	22 (75,5%), 21 (12,5%), 38 (6%), 44 (6%)
FC5	GPREC (63%) GFI (37%)	Precentral G	6	6 (63%), 9 (25%), 44 (6%), 45 (6%)
FC3	GFM (63%) GPREC (37%)	Middle frontal G	6	6 (75%), 4 (12,5%), 8 (12,5%)
FC1	GFS (88%) GFM (12%)	Superior frontal G	6	6 (100%)
FCz	SI (50%) GFS (31%) GFM (19%)	Interhemispheric sulcus	6	6 (100%)
FC2	GFS (56%) GFd (38%) GPREC (6%)	Superior frontal G	6	6 (100%)
FC4	GFM (75%) GPREC (19%) GPSTC (6%)	Middle frontal G	6	6 (82%), 123 (6%), 8 (6%), 9 (6%)
FC6	GPREC (63%) GFI (25%) GFM (6%) GPSTC (6%)	Precentral G	6	6 (56,5%), 9 (19,5%), 43 (6%), 44 (6%), 45 (6%), 8 (6%)
FT8	GTS (81%) GTM (13%) GPREC (6%)	Superior temporal G	22	22 (75%), 21 (13%), 38 (6%), 44 (6%)
T7	GTM (69%) GTS (19%) GPSTC (12%)	Middle temporal G	21	21 (81,5%), 22 (12,5%), 43 (6%)
C5	GPSTC (69%) LPI (25%) GPREC (6%)	Postcentral G	123	123 (44%), 40 (37,5%), 43 (12,5%), 6 (6%)
C3	GPSTC (69%) GPREC (19%) LPI (12%)	Postcentral G	21	21 (62,5%), 22 (25%), 20 (6,5), 42 (6%)
C1	GPREC (63%) GPSTC (25%) GFS (13%)	Precentral G	4/6	4 (37,5%), 6 (37,5%), 123 (25%)
Cz	SI (81%) GFS (6%) GFM (6%) LPARAC (6%)	Interhemispheric scissure	4	4 (62,5%), 6 (37,5%)
C2	GPREC (63%) GPSTC (25%) GFS (13%)	Precentral G	123	123 (56,5%), 40 (25,5%), 4 (12,5%), 6 (6%)
C4	GPSTC (81%) GPREC (13%) LPI (6%)	Postcentral G	123	123 (81,5%), 6 (12,5), 40 (6%)
C6	GPSTC (50%) LPI (25%) GPREC (25%)	Postcentral G	123/40	123 (25%), 40 (25%), 4 (12,5%), 6 (12,5%), 43 (12,5%), 2 (12,5%)
T8	GTM (56%) GTS (38%) GTI (6%)	Middle temporal G	4	4 (50%), 123 (25%), 6 (25%)
TP7	GTM (82%) GTI (12%) GTS (6%)	Middle temporal G	21	21 (50%), 37 (25%), 22 (19%), 20 (6%)
CP5	GTS (5%) GSM (24%) GTM (13%) LPI (13%)	Superior temporal G	22	22 (44%), 40 (37,5%), 39 (12,5%), 21 (6%)
CP3	LPI (75%) GPSTC (13%) LPS (6%) GA (6%)	Inferior parietal L	40	40 (82%), 123 (6%), 5 (6%), 39 (6%)
CP1	LPS (50%) GPSTC (50%)	Postcentral G–Superior parietal L	7	7 (62,5%), 5 (31,5%), 123 (6)
CPz	GPSTC (44%) SI (38%) PC (18%)	Postcentral G	7	7 (56%), 5 (19%), 123 (12,5%), 4 (12,5%)
CP2	GPSTC (56%) LPS (44%)	Postcentral G	5	5 (62,5%, 7 (25%), 123 (12,5%)
CP4	LPI (88%) GPSTC (12%)	Inferior parietal L	40	40 (77,5%), 123 (12,5%)
CP6	GSM (38%) GTS (38%) LPI (24%)	Superior temporal G–GSM	40	40 (62,5%0), 22 (37,5%)
TP8	GTM (56%) GTI (31%) GTS (13%)	Middle temporal G	21	21 (62,5%), 22 (12,5%), 20 (12,5%), 37 (12,5%)
P7	GOM (38%) GTM (25%) GTI (25%) GTS (6%) GF (6%)	Middle occipital G	37	37 (44%), 19 (38%), 39 (18%)
P5	GTM (56%) GA (13%) GOM (13%) GSM (6%) GTS (6%) LPI (6%)	Middle temporal G	39	39 (62,5%), 19 (19%), 37 (12,5%), 40 (6%)
P3	LPI (38%) PC (25%) GA (19%) LPS (12%) GTM (6%)	Inferior parietal L	39	39 (37,5%), 7 (25%), 19 (25%), 40 (12,5%)
P1	PC (50%) LPS (44%) GPSTC (6%)	Precuneus	7	7 (87,5%), 19 (12,5%)
Pz	PC (62%) LPS (19%) SI (19%)	Precuneus	7	7 (88%), 5 (6%), 19 (6%)
P2	PC (63%) LPS (31%) GPSTC (6%)	Precuneus	7	7 (81,5%), 19 (12,5%), 5 (6%)
P4	LPI (31%) GA (31%) LPS (19%) PC (13%) GOS (6%)	Inferior parietal L	39	39 (31%), 7 (25%), 40 (25%), 19 (19%)
P6	GTM (69%) GA (13%) LPI (6%) GTS (6%) GOM (6%)	Middle temporal G	39	39 (75,5%), 19 (12,5%), 40 (6%), 37 (6%)
P8	GTI (44%) GOM (31%) GTM (19%) GTS (6%)	Inferior temporal G	19	19 (56%), 37 (19%), 20 (12,5), 39 (12,5%)
PO7	GOM (63%) GOI (31%) GA (6%)	Middle occipital G	19	19 (62,5%), 18 (31%), 39 (6,5%)
PO3	GOM (50%) PC (18%) C (13%) GOS (13%) GTM (6%)	Middle occipital G	19	19 (75,5%), 7 (6%), 39 (6%), 18 (12,5%)
POz	C (69%) PC (25%) LPS (6%)	Cuneus	19	19 (56%), 18 (25%), 7 (19%)
PO4	GOM (38%) GOS (19%) GTM (19%) C (12%) LPS (6%) PC (6%)	Middle occipital G	19	19 (69%), 39 (12,5%), 18 (12,5%), 7 (6%)
PO8	GOM (44%) GOI (44%) GOS (6%) GTM (6%)	Middle occipital G	19	19 (69%), 18 (31%)
O1	GOM (38%) C (19%) GL (19%) GOI (19%) PC (5%)	Middle occipital G	18	18 (81%), 19 (19%)
Oz	C (98%) GL (5%) GOM (6%)	Cuneus	18	18 (62,5), 17 (31%), 19 (6,5%)
O2	C (38%) GOM (31%) GL (25%) GOI (6%)	Cuneus	18	18 (81%), 19 (19%)

Koessler et al., 2009

Activity

1. Pick an electrode
2. Find the associated Brodmann area using the table
3. Look it up! ☺

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Thank you!