Neuroplasticity

Mechanisms of development, learning, and recovery of function after injury

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QLI

Neuroplasticity Defined

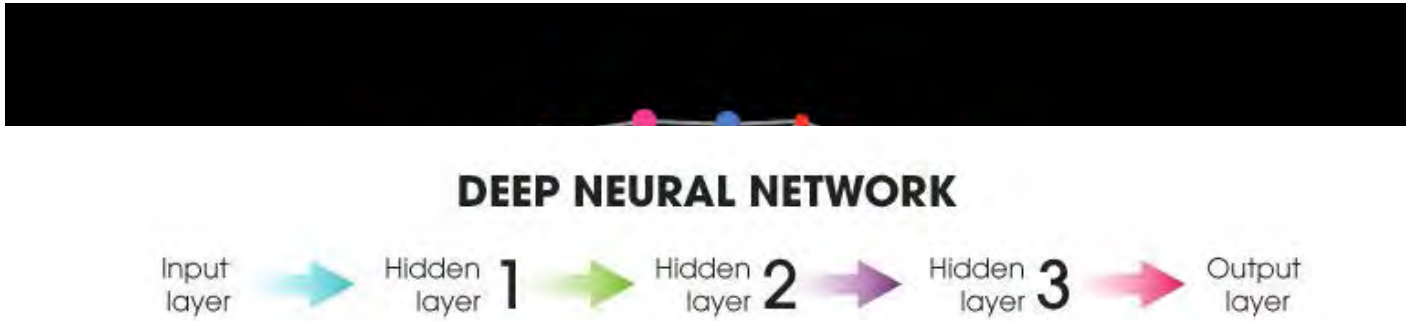
The ability of the brain to form and reorganize synaptic connections, especially in response to learning or experience or following injury.

Relates to adding or removing connections in response to development, learning, and experiences.

Physical and functional adaptation.

Neuroplasticity

A (really) brief history.



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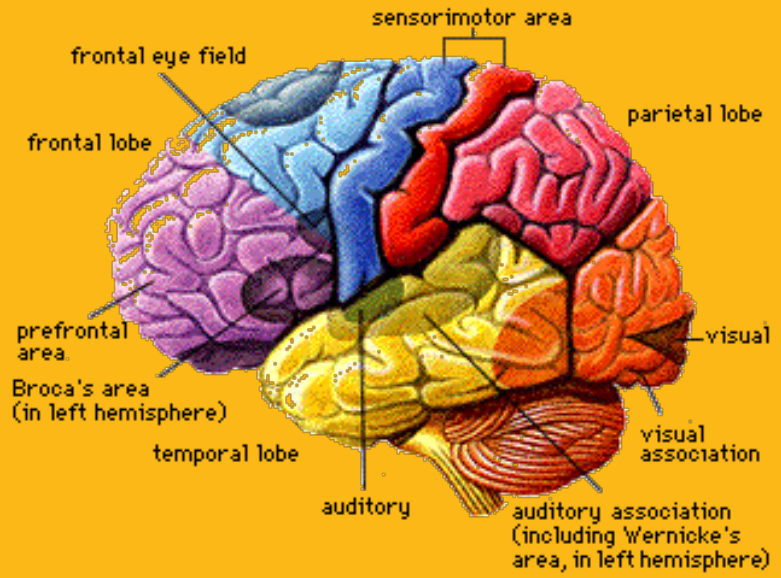
Development of the brain

Human brain development

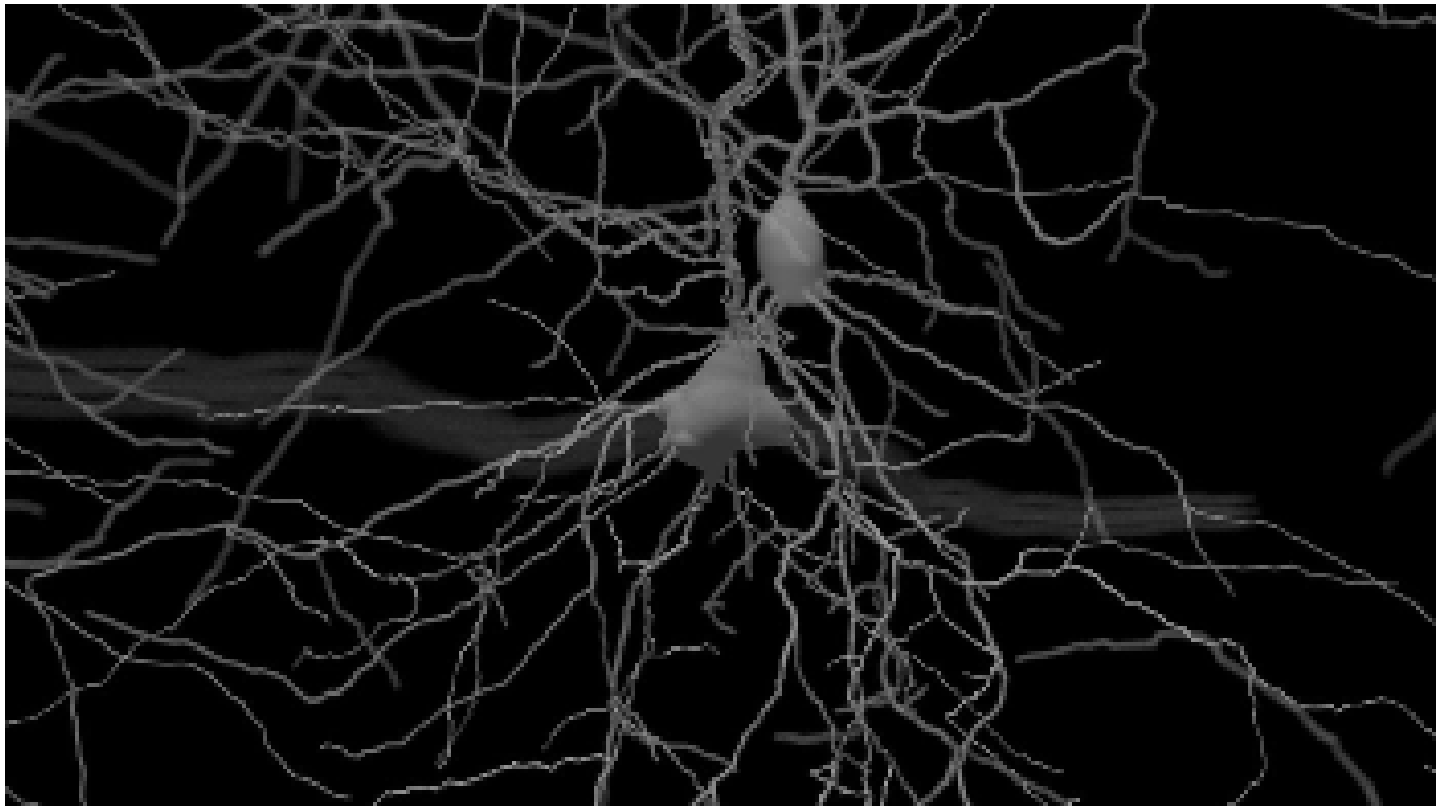
Is a prolonged process compared to non-human animals

This is particularly true for the childhood and adolescent phases of development

Possibly related to the complexity of the human brain relative to other species



Neurocognitive Development

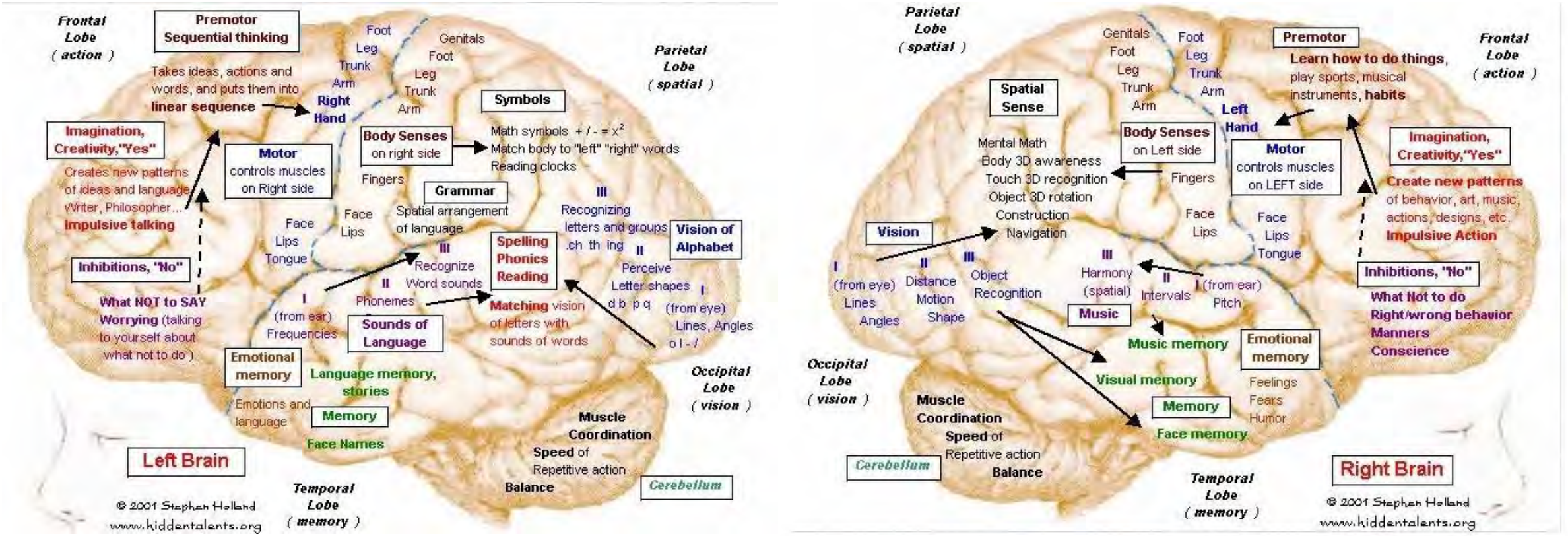


Dendritic branching

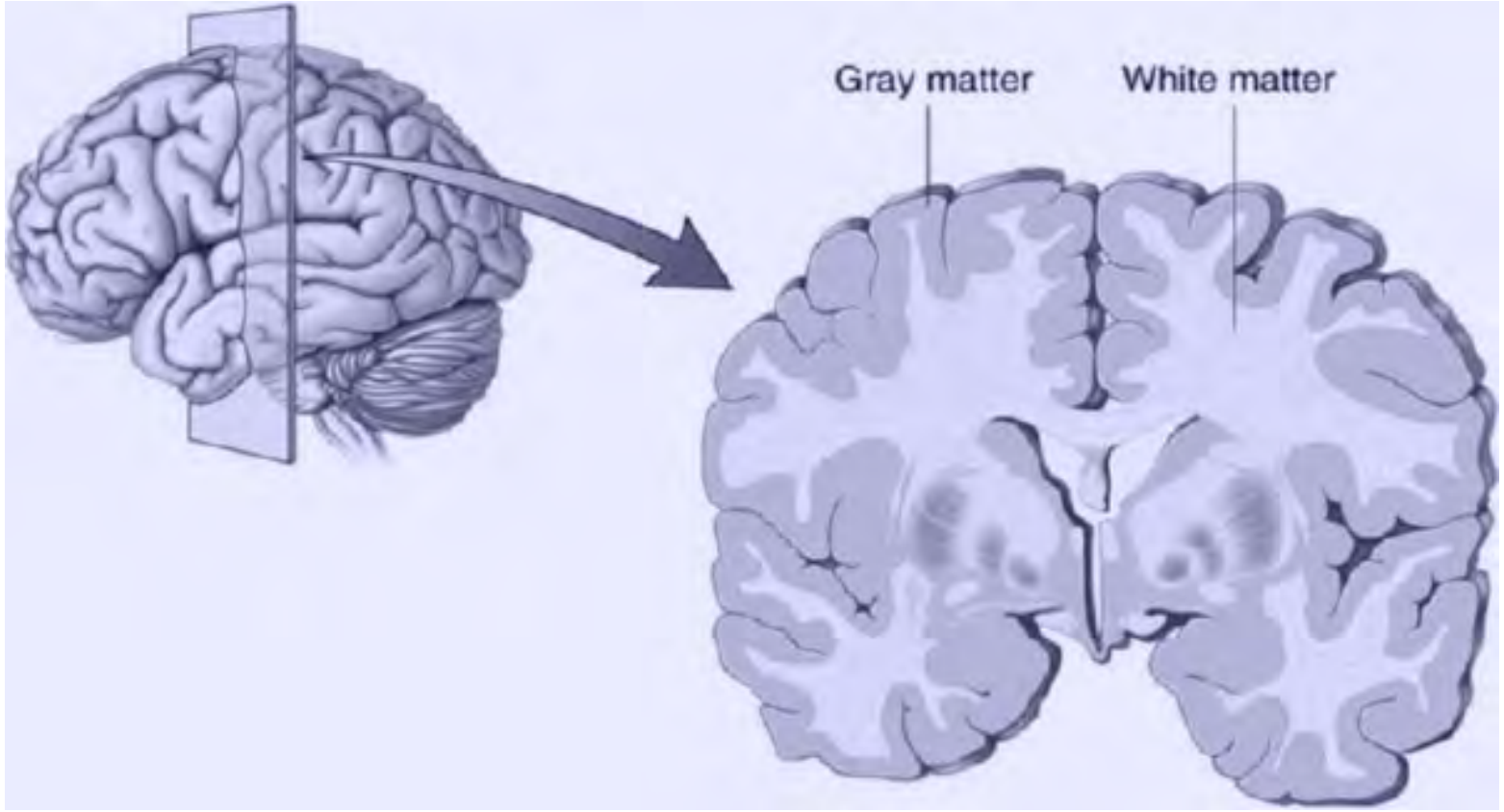
Development of neuroanatomy reflected in development of cognitive abilities

Development of the brain

Human brain development



Neurocognitive Development

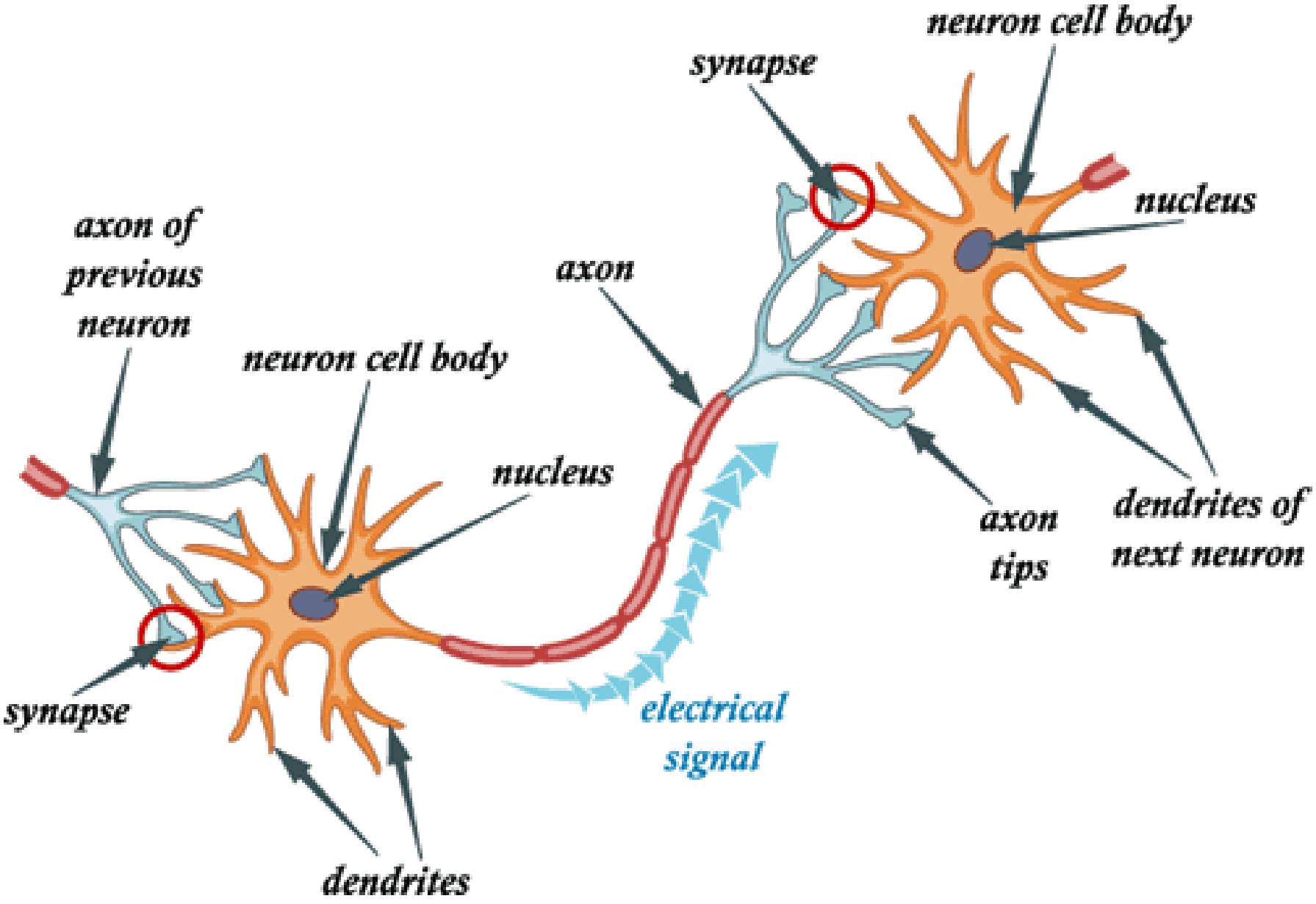


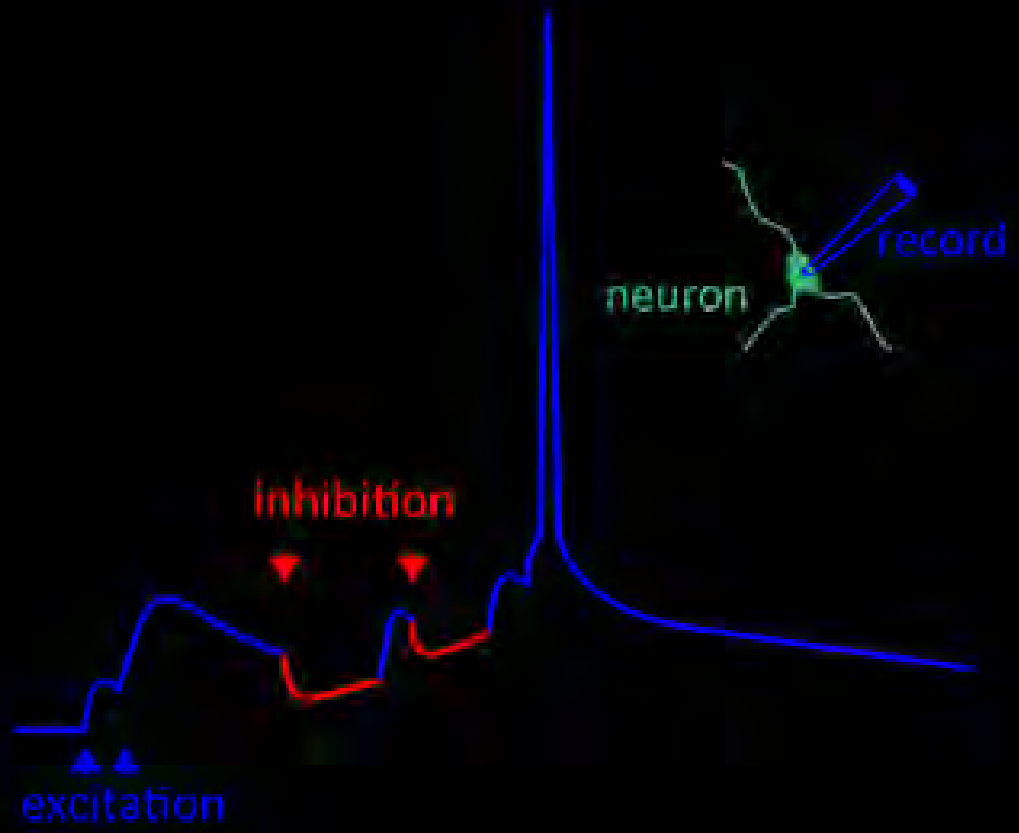
Dendritic branching

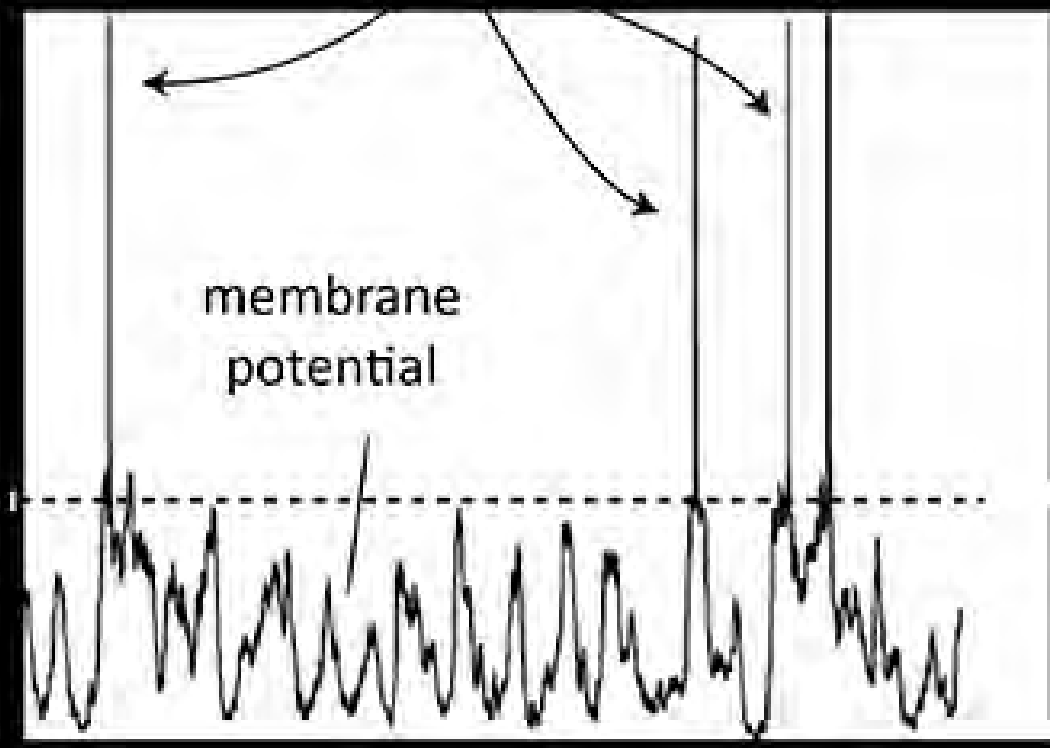
Changes in grey matter and white matter that occur in childhood/adolescence

Neuroplasticity

Pathways – “use ‘em or lose ‘em”

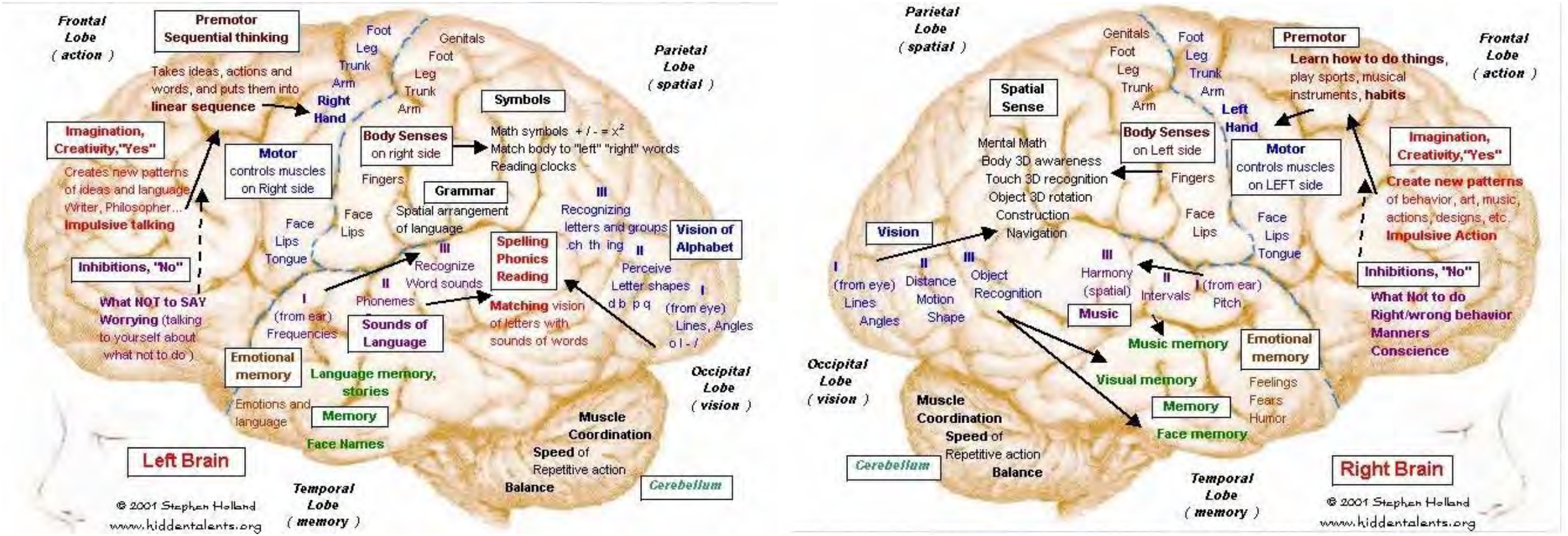

neuron cell body
synapse
nucleus
axon of previous neuron
axon
neuron cell body
nucleus
axon tips
dendrites of next neuron
synapse
electrical signal
dendrites


record
neuron
inhibition
excitation


membrane
potential

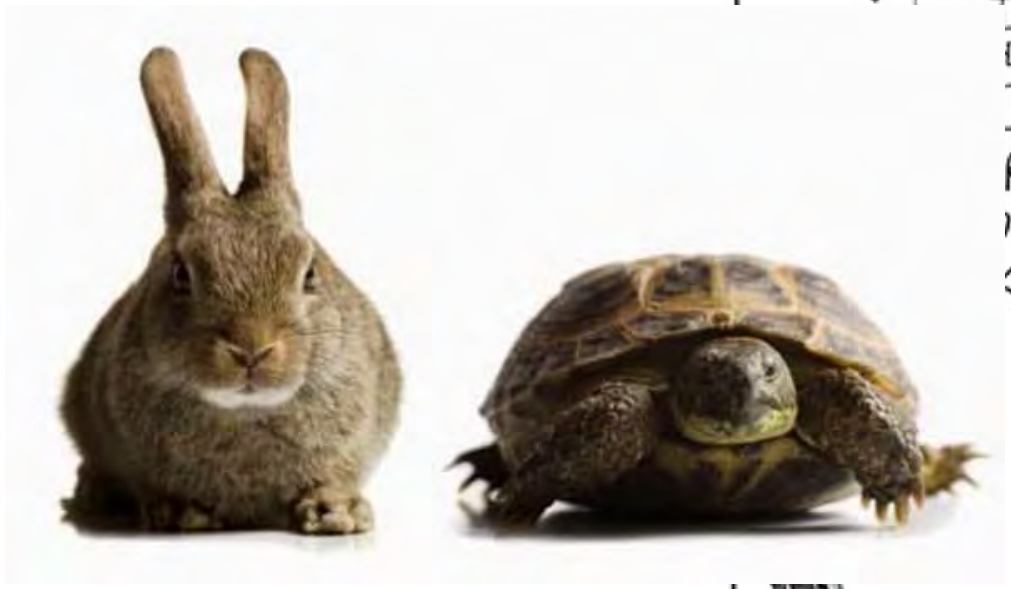
Development of the brain

Human brain development

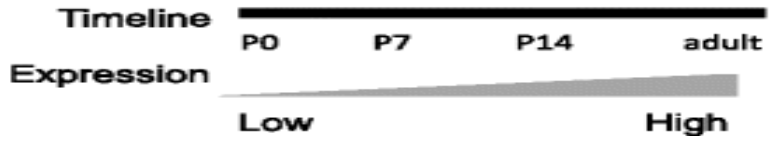


Mechanisms of Neuroplasticity

It's complicated!

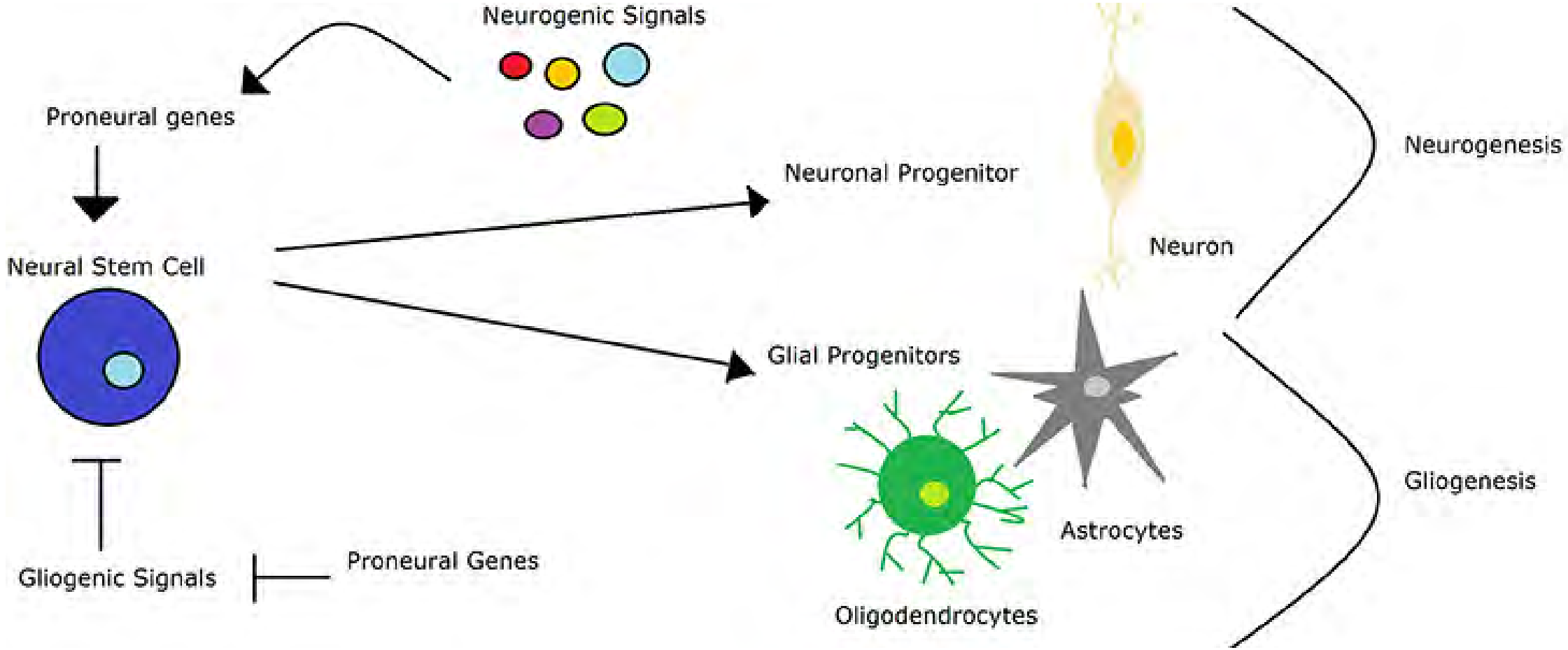


Cell type	Protein name	Ref.	Expression timeline
Neuronal	Synaptotagmin I	[132]	
	Synaptotagmin IV	[132]	
	Synaptophysin	[84]	
	Synapsin I	[134, 135]	
	VGlut1	[92-94]	
	VGlut2	[92, 94]	
	VGlut3	[92]	
	PSD95	[106]	
	Homer	[133]	
	GluA1	[97, 98]	
	GluA2	[98, 99]	
	GluN1, GluN2B	[100-102]	
	GluN2A	[100-102]	
	VGat	[98, 136]	
	Gephyrin	[98, 106]	
Astrocytic	Thrombospondin1	[17, 88]	
	Hevin	[20, 22]	
	SPARC	[20, 22]	
	Glypican4, 6	[18, 88]	



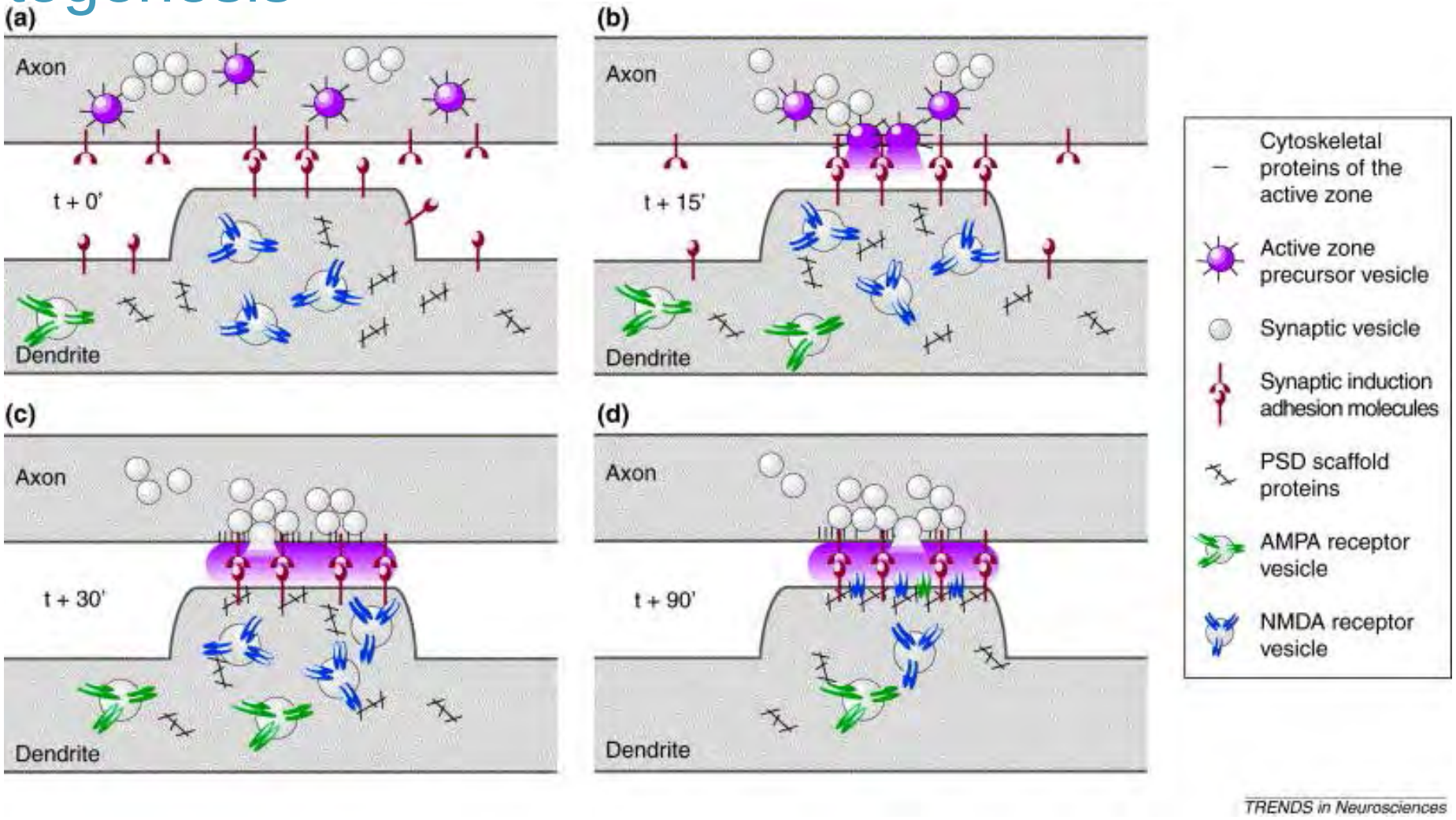
Mechanisms of Neuroplasticity

Neurogenesis



Mechanisms of Neuroplasticity

Synaptogenesis



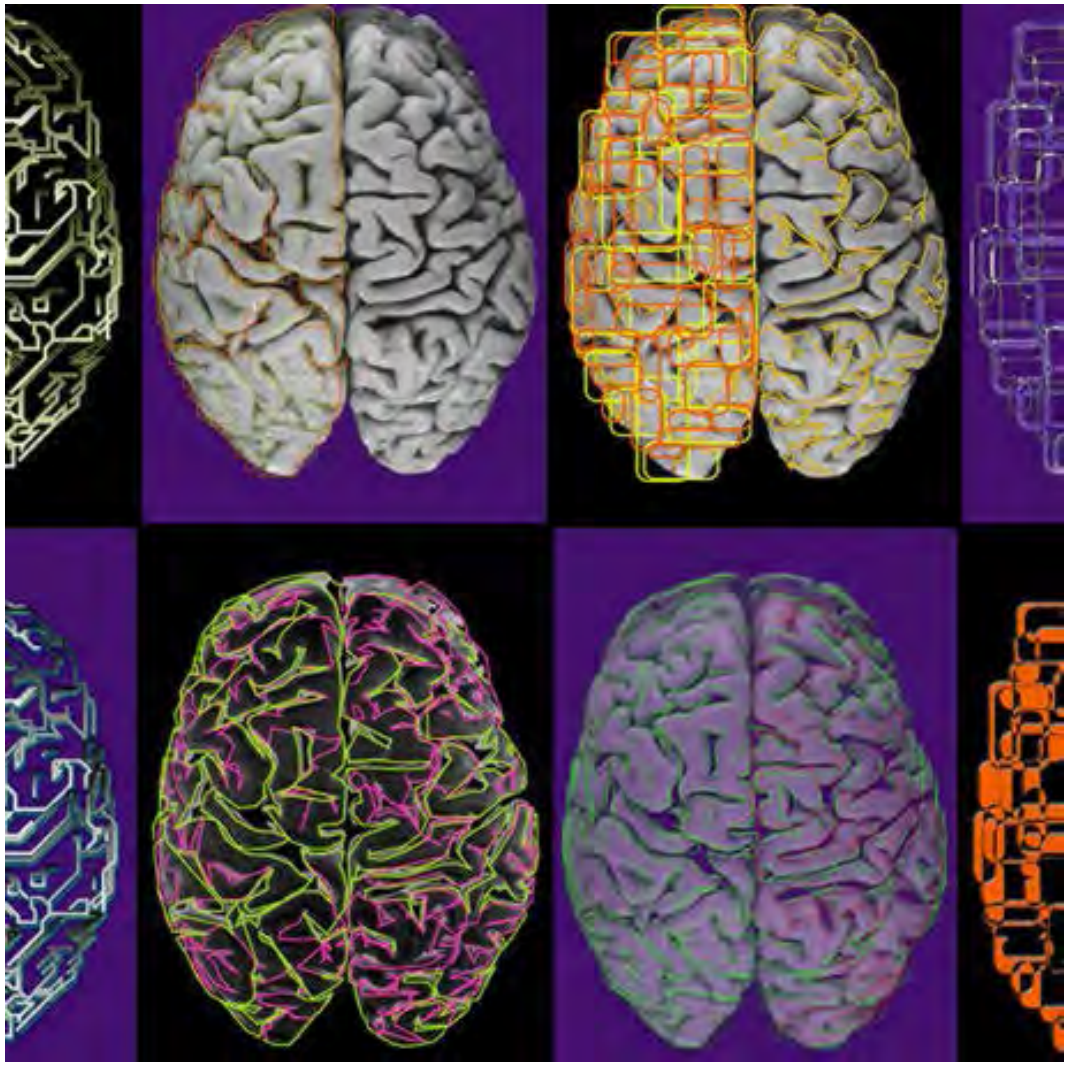
Mechanisms of Neuroplasticity

Neurodegeneration

Normal “pruning” of unused connections during developmental phases

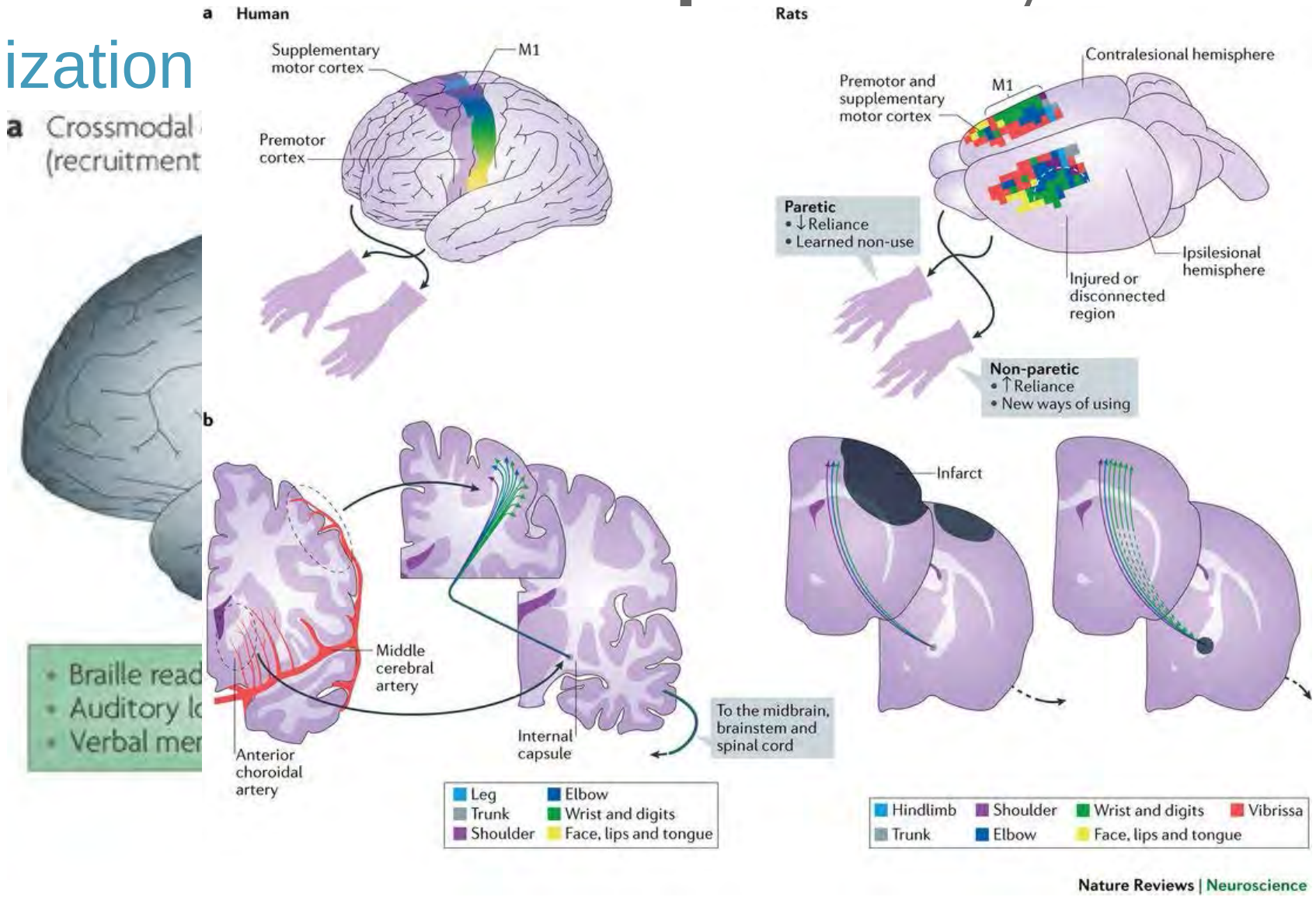
Programmed cell death (apoptosis)

Pruning of neural connections in states of increased dendritic sprouting



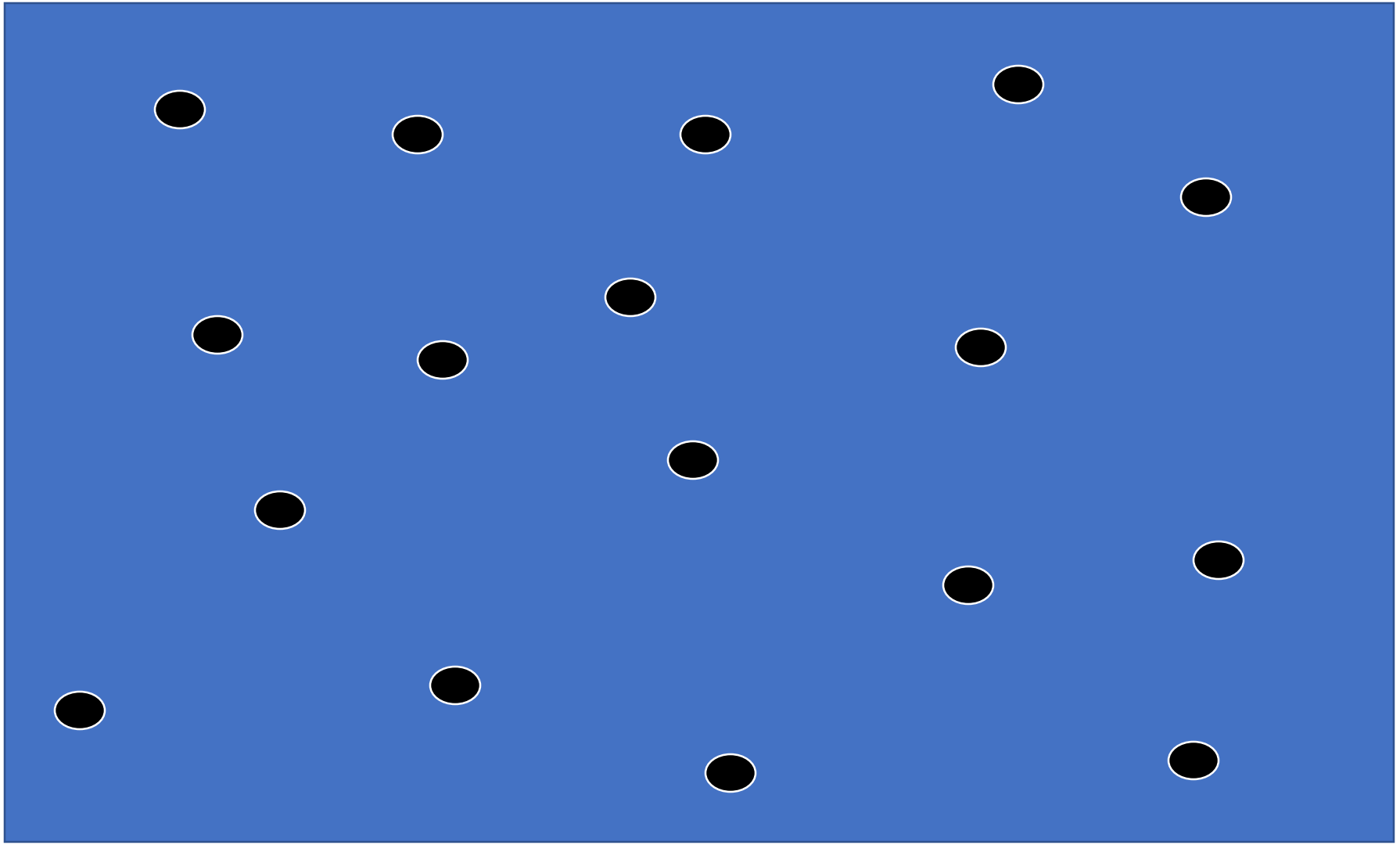
Mechanisms of Neuroplasticity

Reorganization

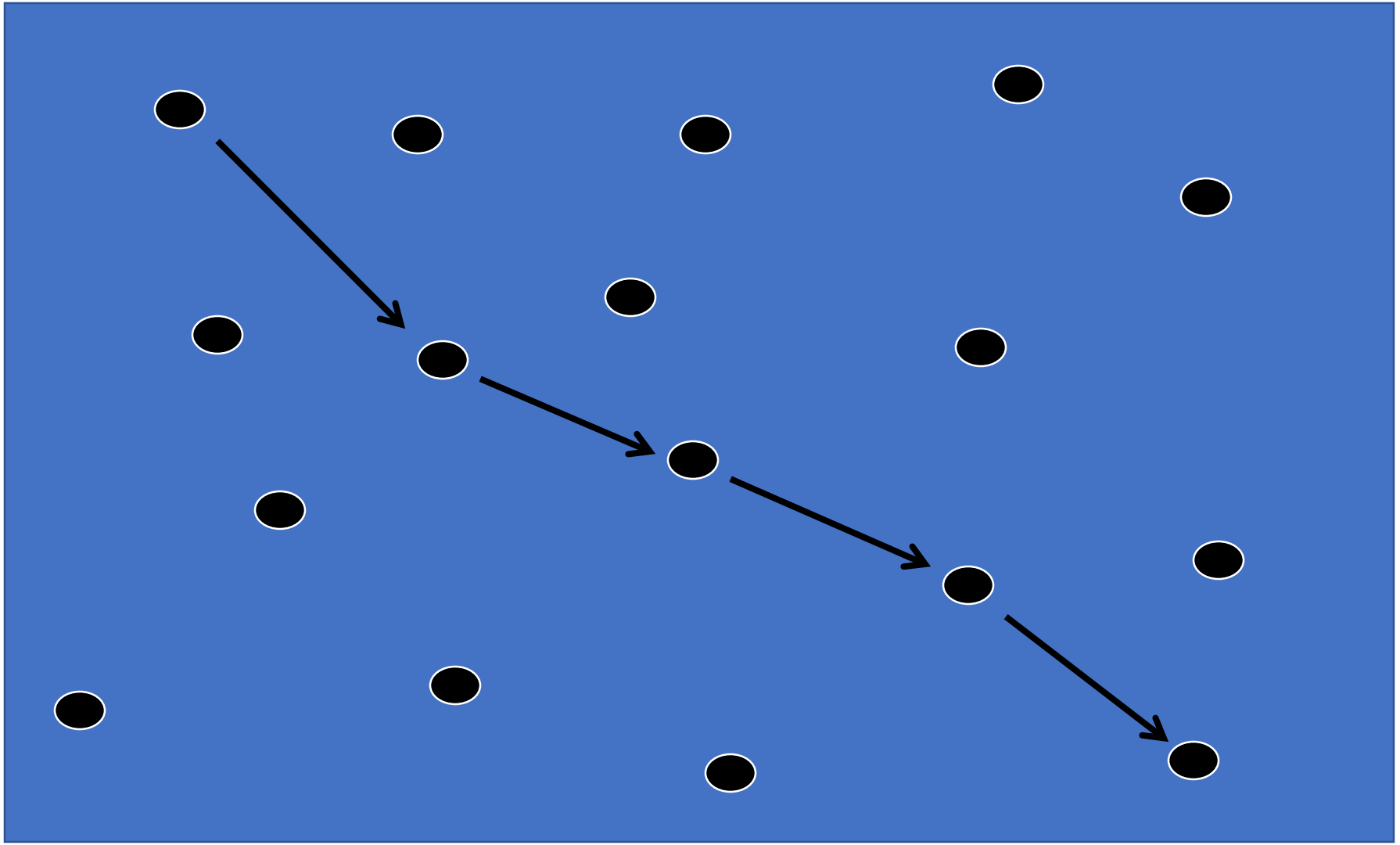


Nature Reviews | Neuroscience

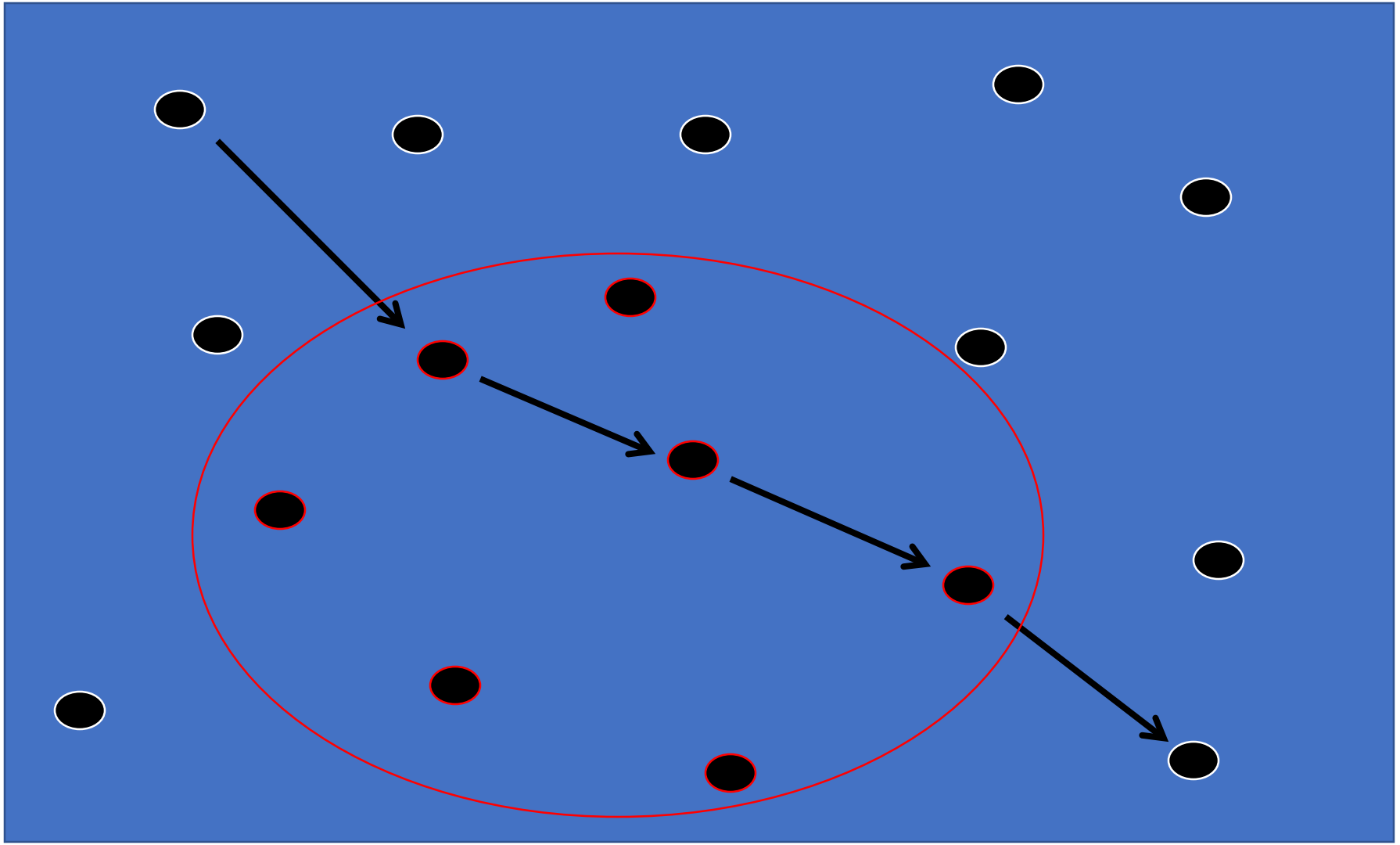
Pathways



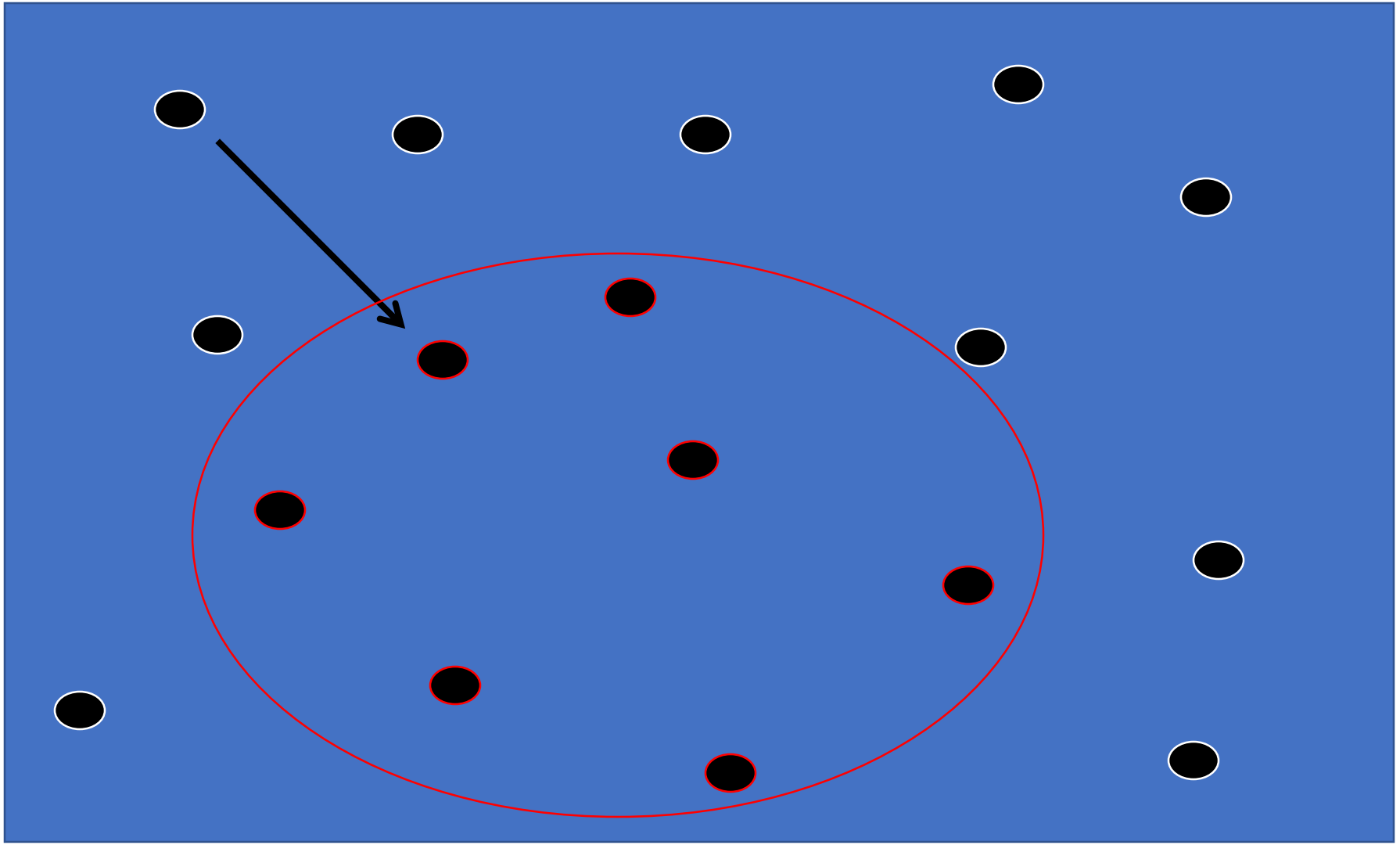
Pathways



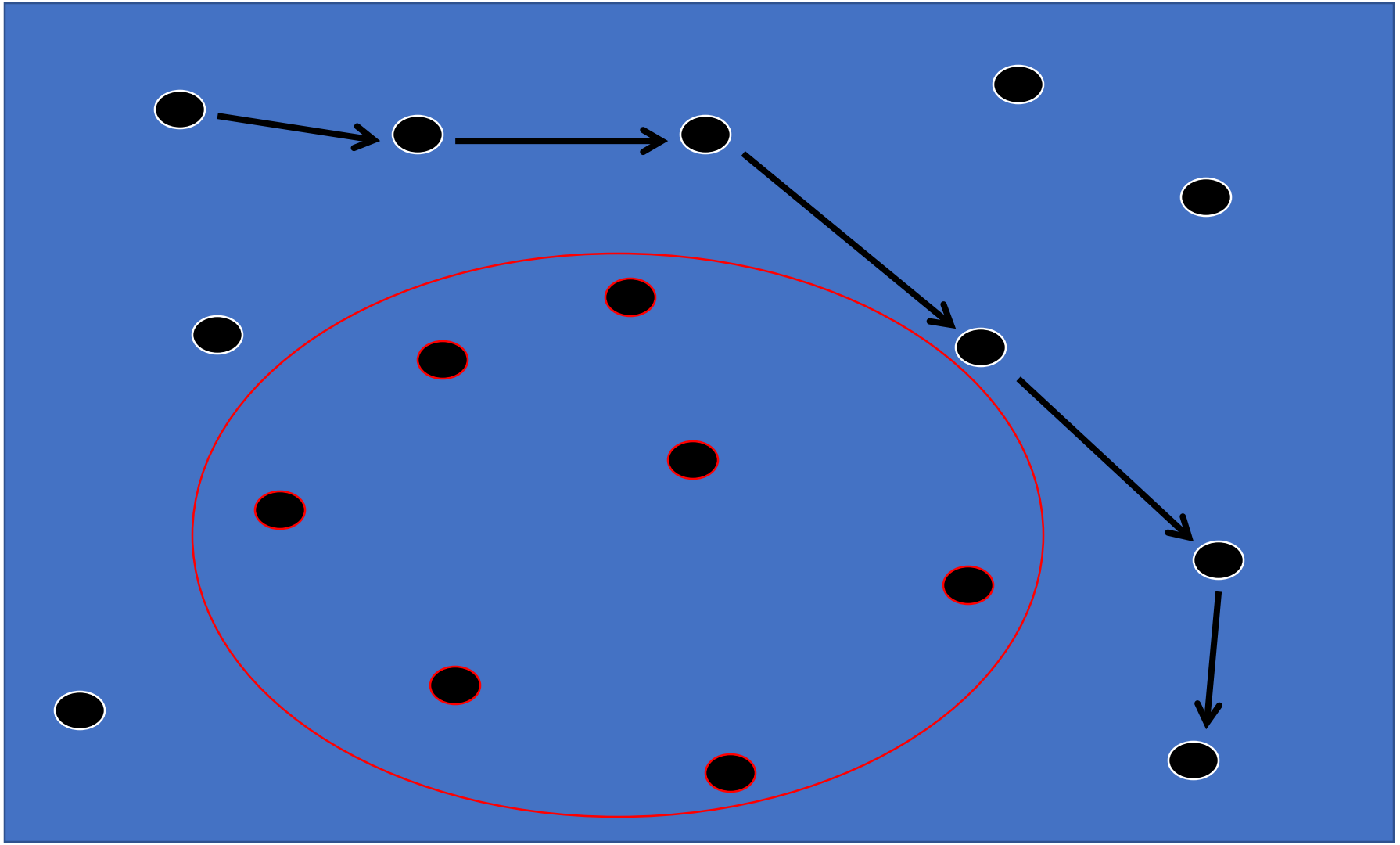
Pathways



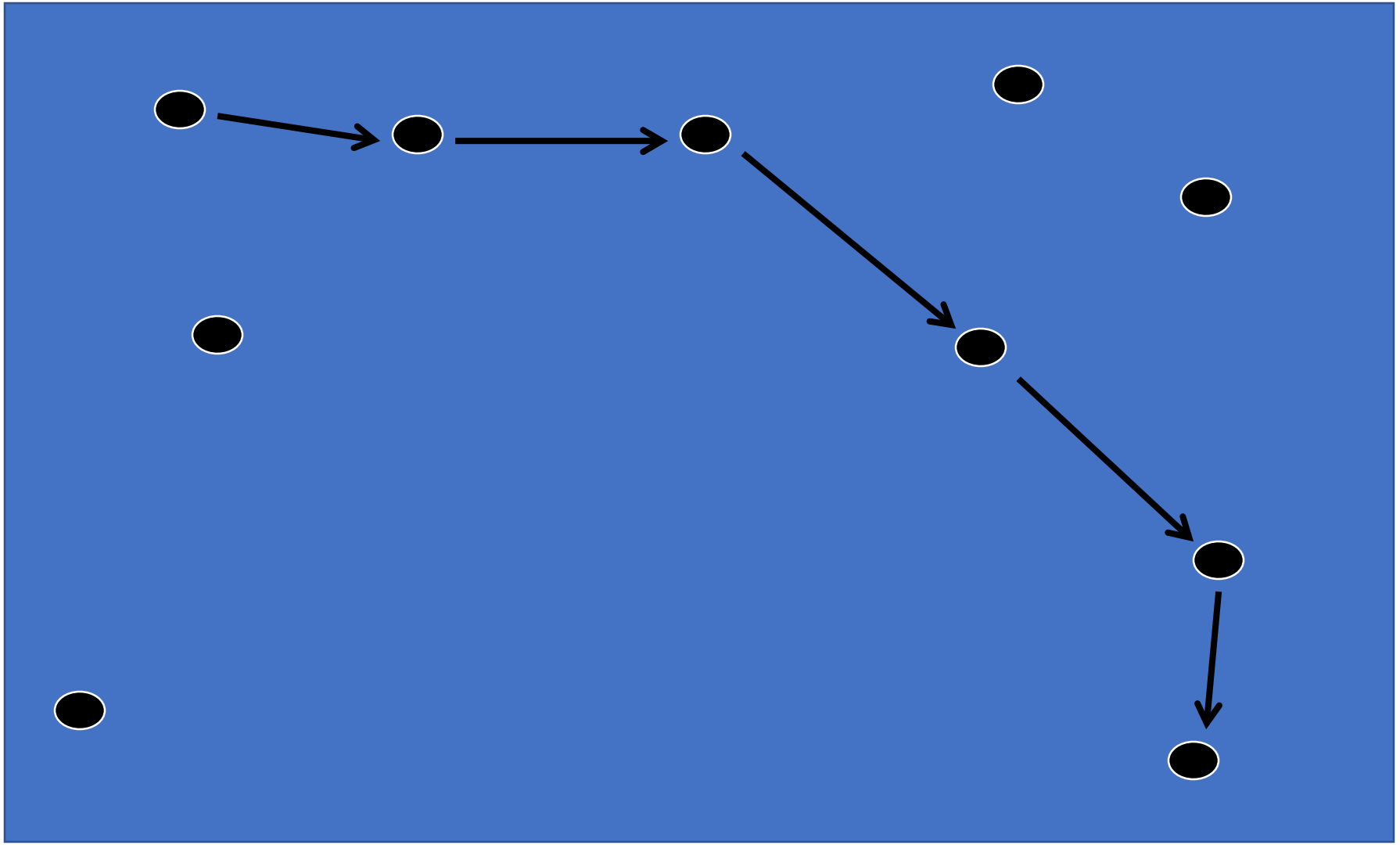
Pathways



Pathways

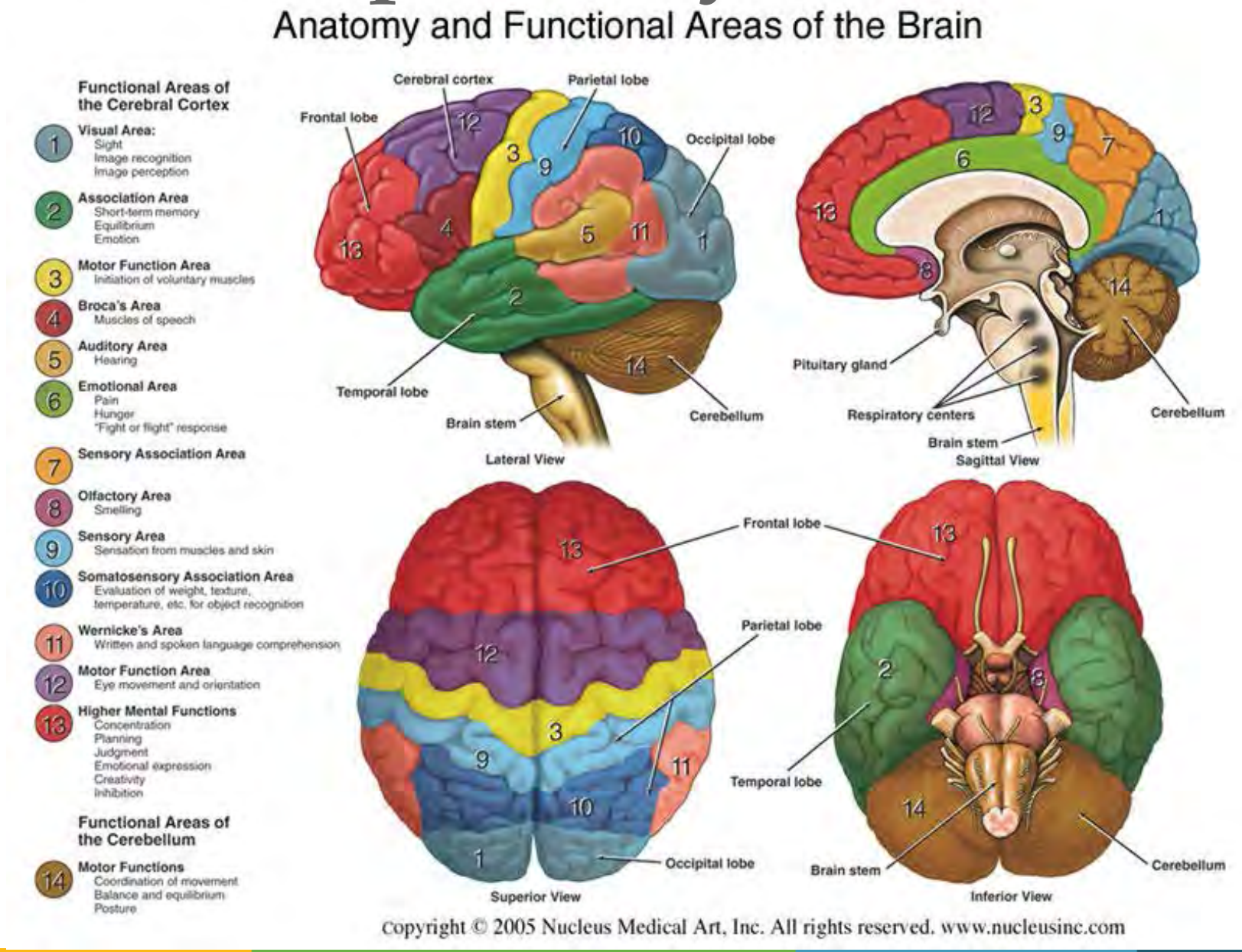


Pathways



Mechanisms of Neuroplasticity

Reorganization



Ladies and Gentlemen – The QLI Orchestra!

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Ladies and Gentlemen – The QLI Orchestra!

Options?

Options for the Orchestra?

Hire new trombone players.

Change the musical repertoire so that trombones are not needed.

Let other instruments play the trombone parts.

Teach other musicians in the orchestra to play trombone.

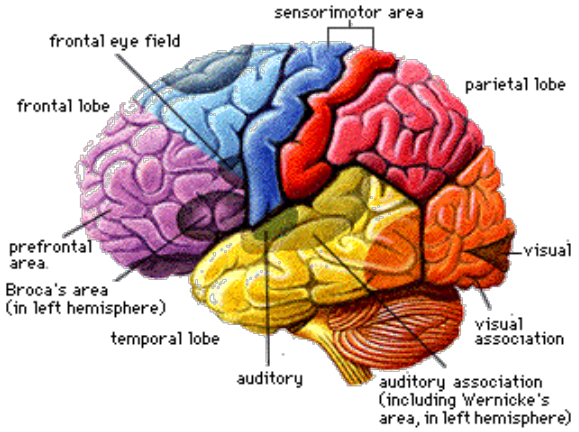
Options for the Brain?

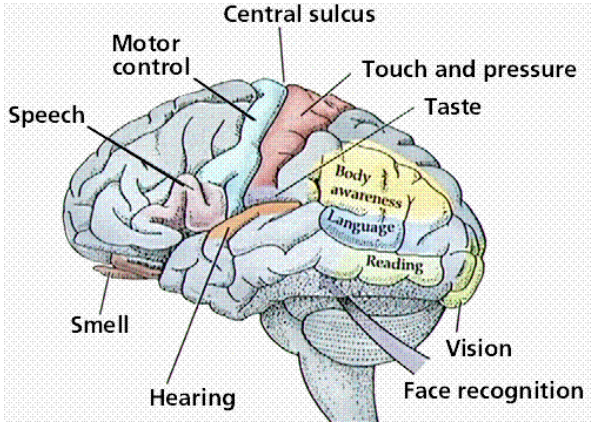
We can't put in new brain tissue (yet) after damage.

Change the behavioral/cognitive repertoire so that that particular brain function is less/not needed.

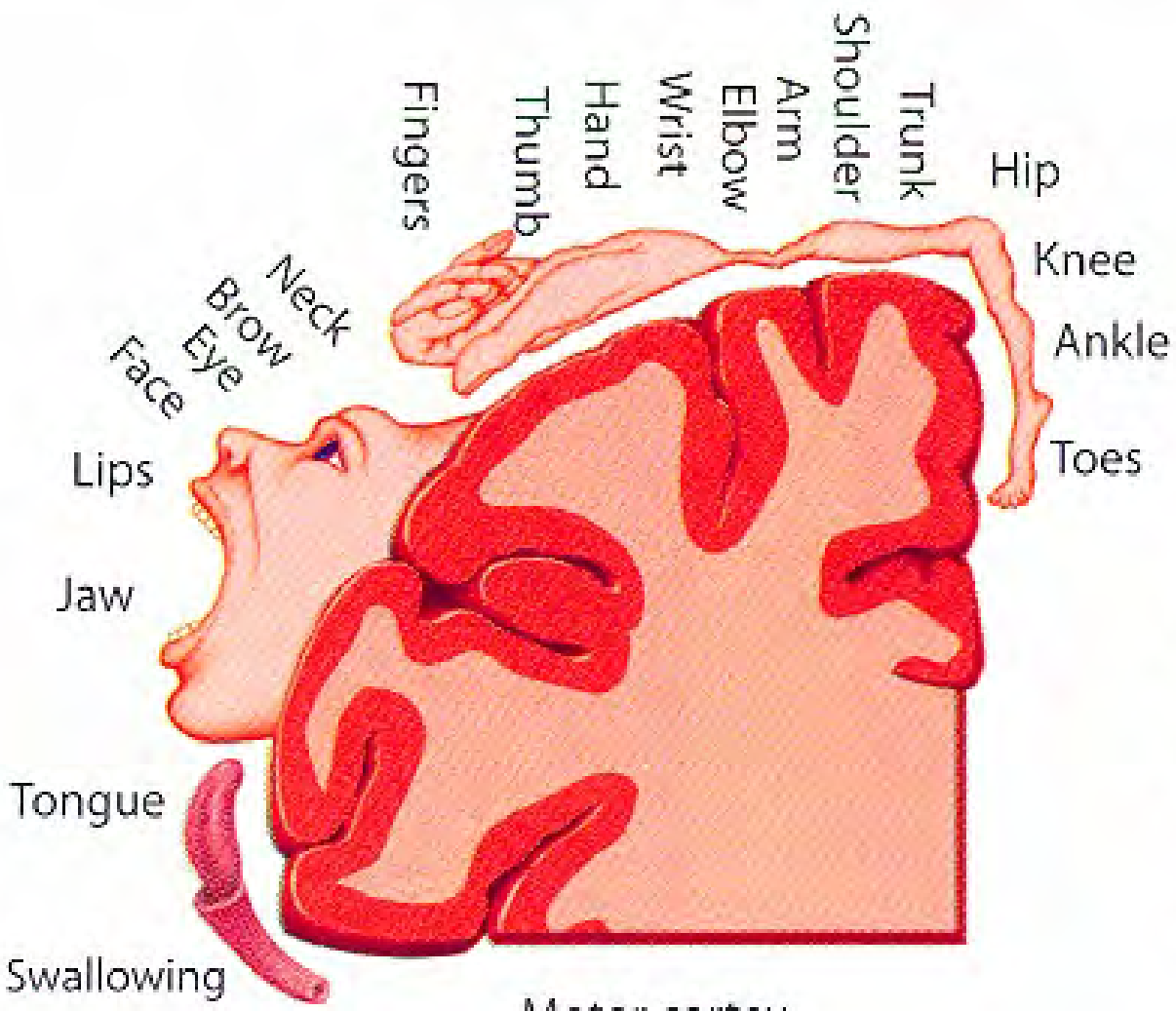
Let other functions "fill in" for the missing parts.

Teach other neurons in the brain (typically immediately adjacent to the damaged area) to replace area.

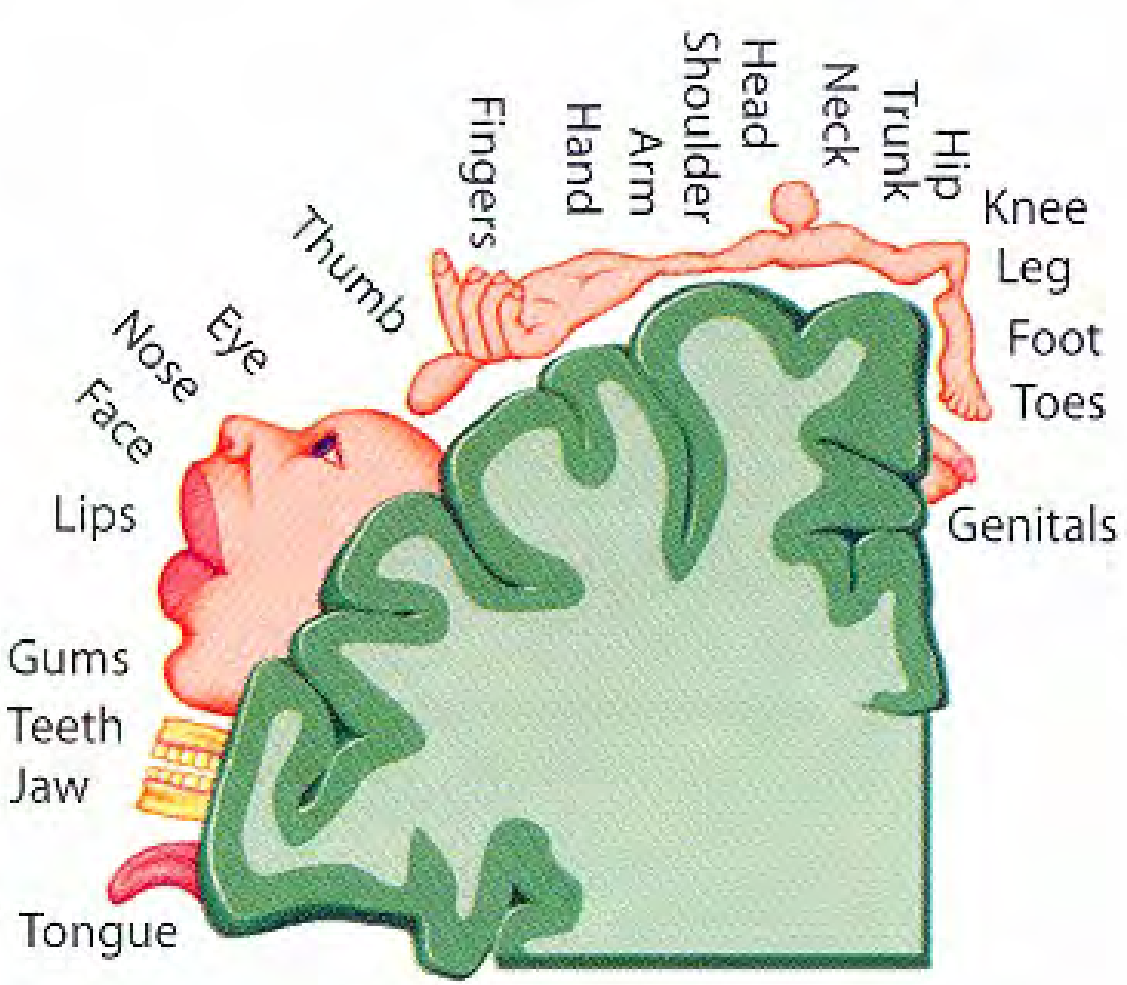




Reorganization



Motor cortex



Somatosensory cortex

Reorganization

Newer data indicate that this can occur at the macro level (brain regions) including areas more distant from the impaired area.

Includes contralateral regions as well as areas of the brain responsible for monitoring (executive functioning) cognitive activity

Reorganization

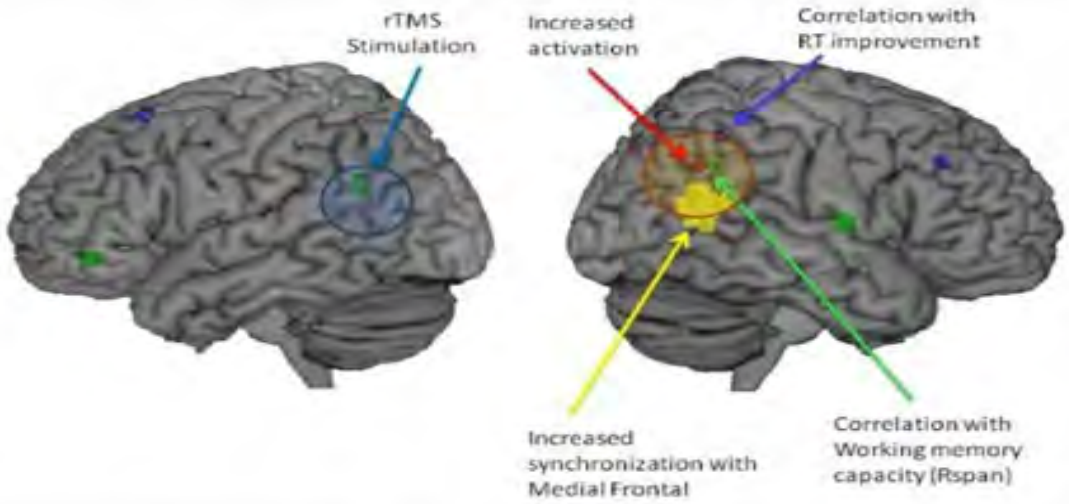
Press Release: New Carnegie Mellon Research Reveals Exactly How the Human Brain Adapts to Injury

Findings Also Illustrate How Individuals Can Train Their Brains To Handle Injuries More Efficiently

Contact: Shilo Rea / 412-268-6094 / shilo@cmu.edu

PITTSBURGH—For the first time, scientists at Carnegie Mellon University's Center for Cognitive Brain Imaging (CCBI) have used a new combination of neural imaging methods to discover exactly how the human brain adapts to injury. The research, published in Cerebral Cortex, shows that when one brain area loses functionality, a "back-up" team of secondary brain areas immediately activates, replacing not only the unavailable area but also its confederates.

Four sources of evidence of takeover by a right-hemisphere area (right-hand panel) following disablement of its left hemisphere counterpart (Wernicke's area)



"The human brain has a remarkable ability to adapt to various types of trauma, such as traumatic brain injury and stroke, making it possible for people to continue functioning after key brain areas have been damaged," said Marcel Just, the D. O. Hebb Professor of Psychology at CMU and CCBI director. "It is now clear how the brain can naturally rebound from injuries and gives us indications of how individuals can train their brains to be prepared for easier recovery. The secret is to develop alternative thinking styles, the way a switch-hitter develops alternative batting styles. Then, if a muscle in one arm is injured, they can use the batting style that relies more on the uninjured arm."

Factors affecting neuroplasticity

Positive factors of the organism as a whole

Health

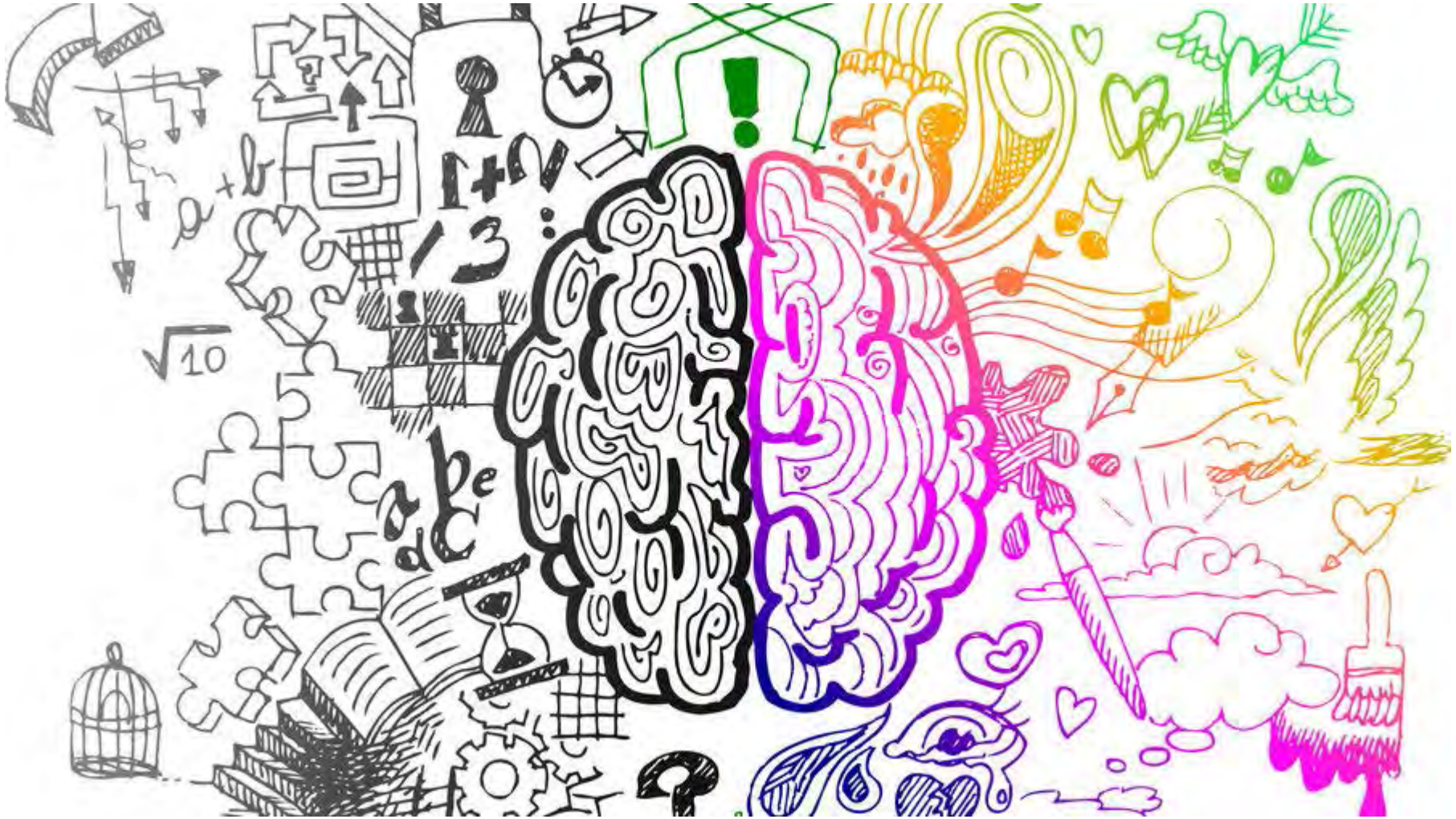
Sleep

Diet

Exercise

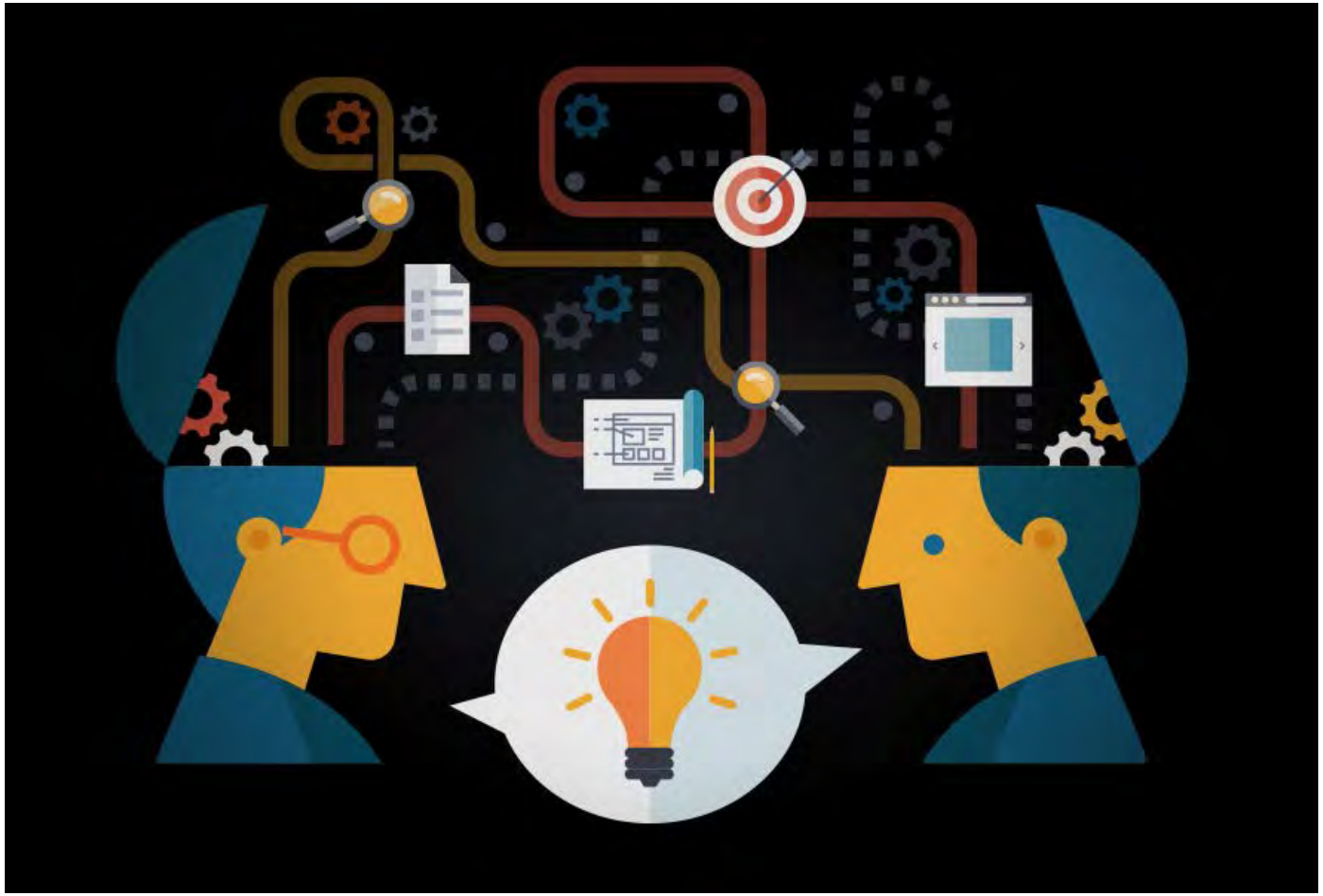
Factors affecting neuroplasticity

Practice, practice, practice



Factors affecting neuroplasticity

Errorless learning



"Practice doesn't make perfect. Only perfect practice makes perfect."

- Vince Lombardi

Neuroplasticity

The “So what” of what we’ve talked about!

- Lifelong learning/change
- Body and brain health are not separate
- Through learning and repetition you physically change your brain
- Purposeful practice, effort and time

> “We would accomplish many more things if we did not think of them as impossible.”
>
> – Vince Lombardi

Resources / References

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Thank you!

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