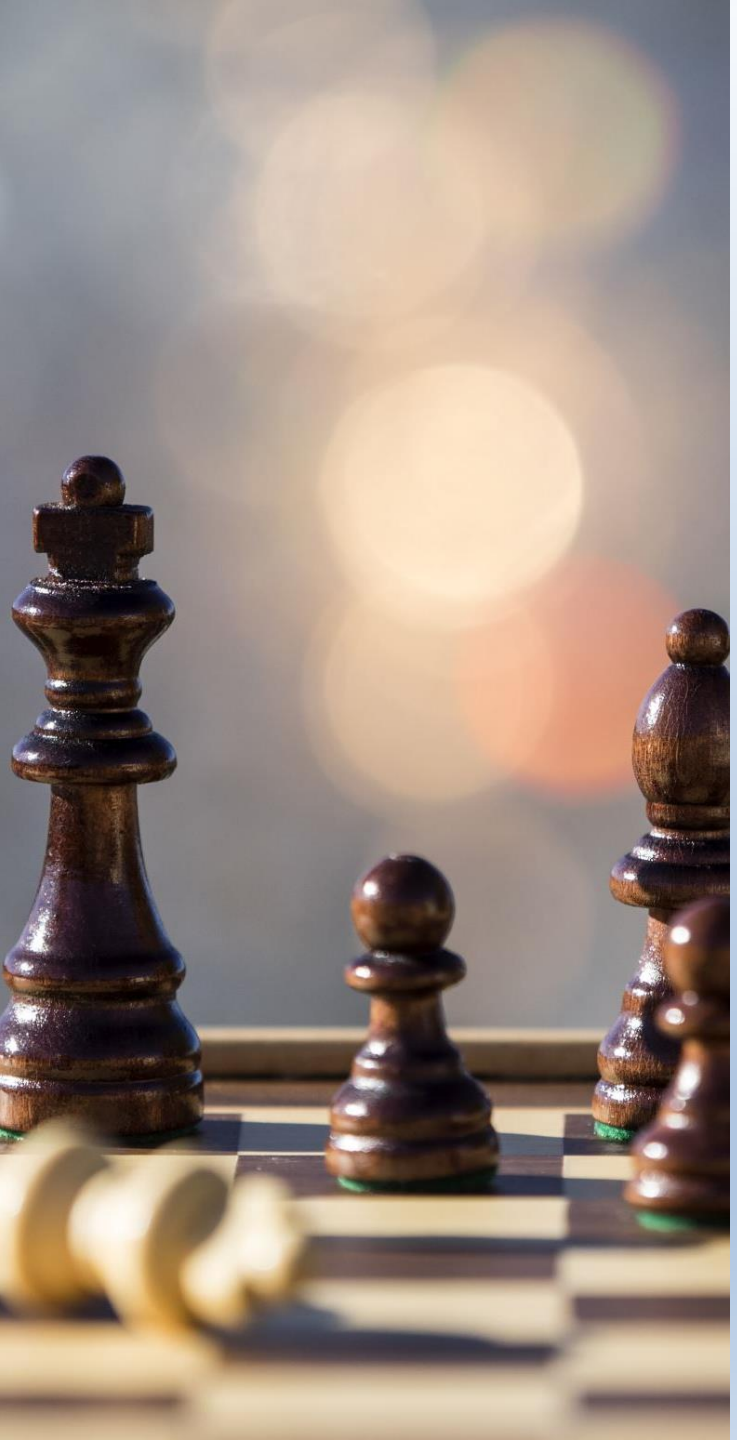
Role of Sphingomyelin in Cognition

ADAOBI BISI-ONYEMAECHI MBBS, MPH, MSc, FMCPaed
Senior Lecturer/Consultant Paediatrician(Neurology)
University of Nigeria/University of Nigeria Teaching Hospital , Enugu, Nigeria



NO CONFLICT OF INTEREST

OUTLINE

- Cognition
- Brain and Cognition
- Brain development
- Sphingomyelin in brain development

Cognition

Cognition refers to a range of mental processes relating to the acquisition, storage, manipulation, and retrieval of information.

These cognitive processes include thinking, knowing, remembering, judging, and problem-solving.

Types of cognitive processes

The cognitive processes have a wide-ranging impact that influences everything from daily life to overall health.

Attention

Language

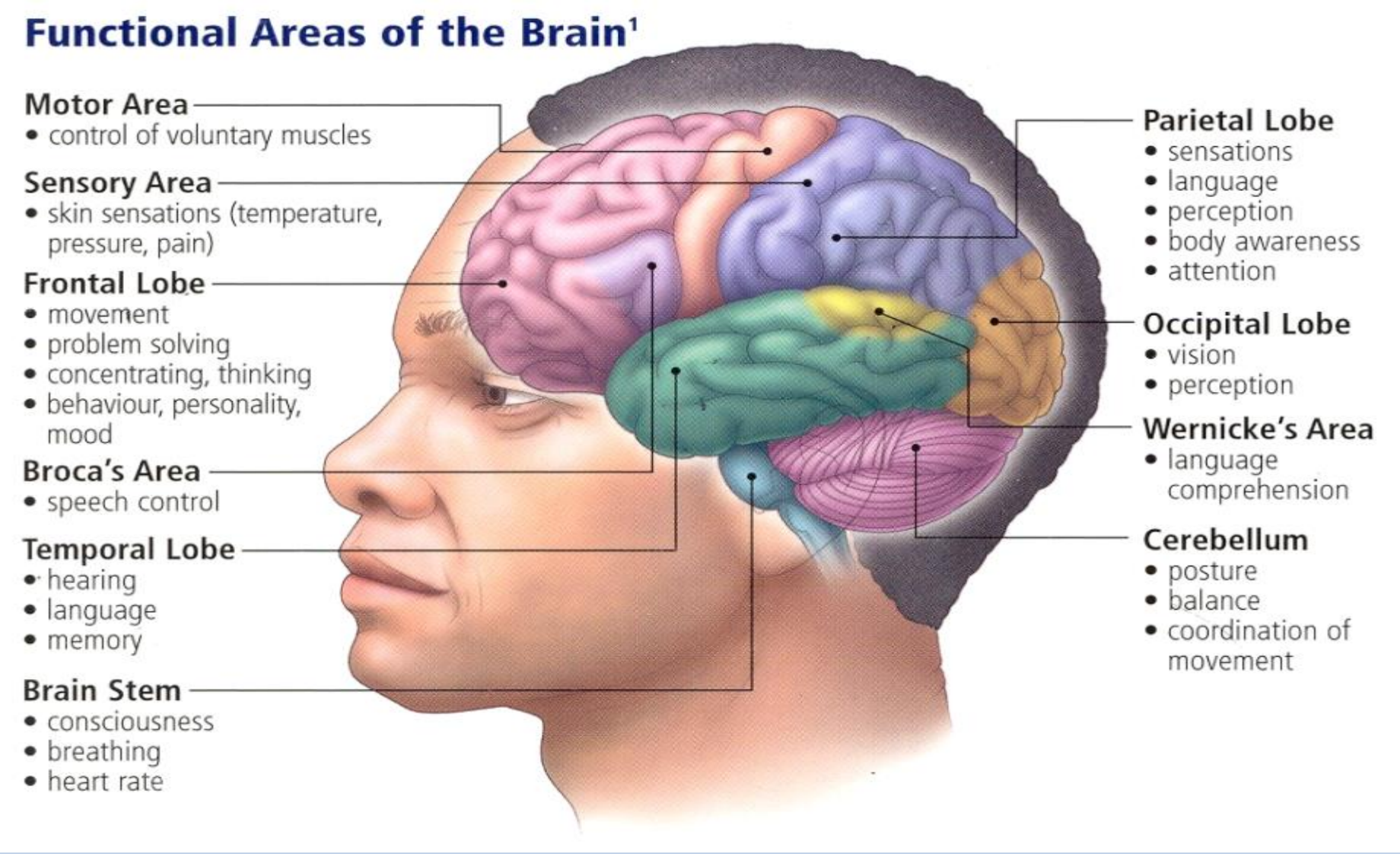
Learning

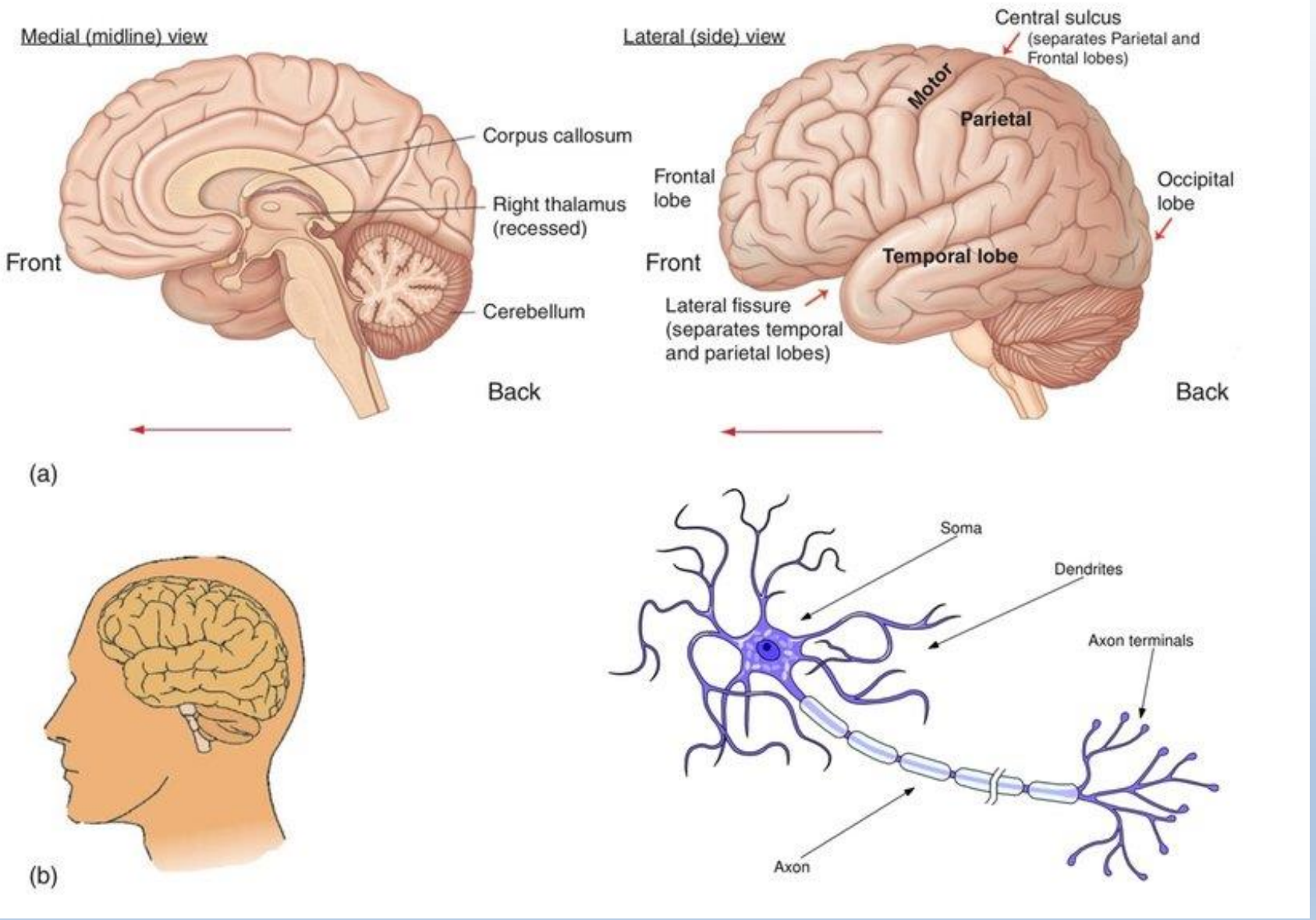
Memory

Perception

Thought

Brain and Cognition




Medial (midline) view
Corpus callosum
Right thalamus
(recessed)
Cerebellum
Front
Back
(a)
Lateral (side) view
Central sulcus
(separates Parietal and
Frontal lobes)
Motor
Parietal
Frontal
lobe
Occipital
lobe
Temporal lobe
Front
Lateral fissure
(separates temporal
and parietal lobes)
Back
(b)
Soma
Dendrites
Axon terminals
Axon

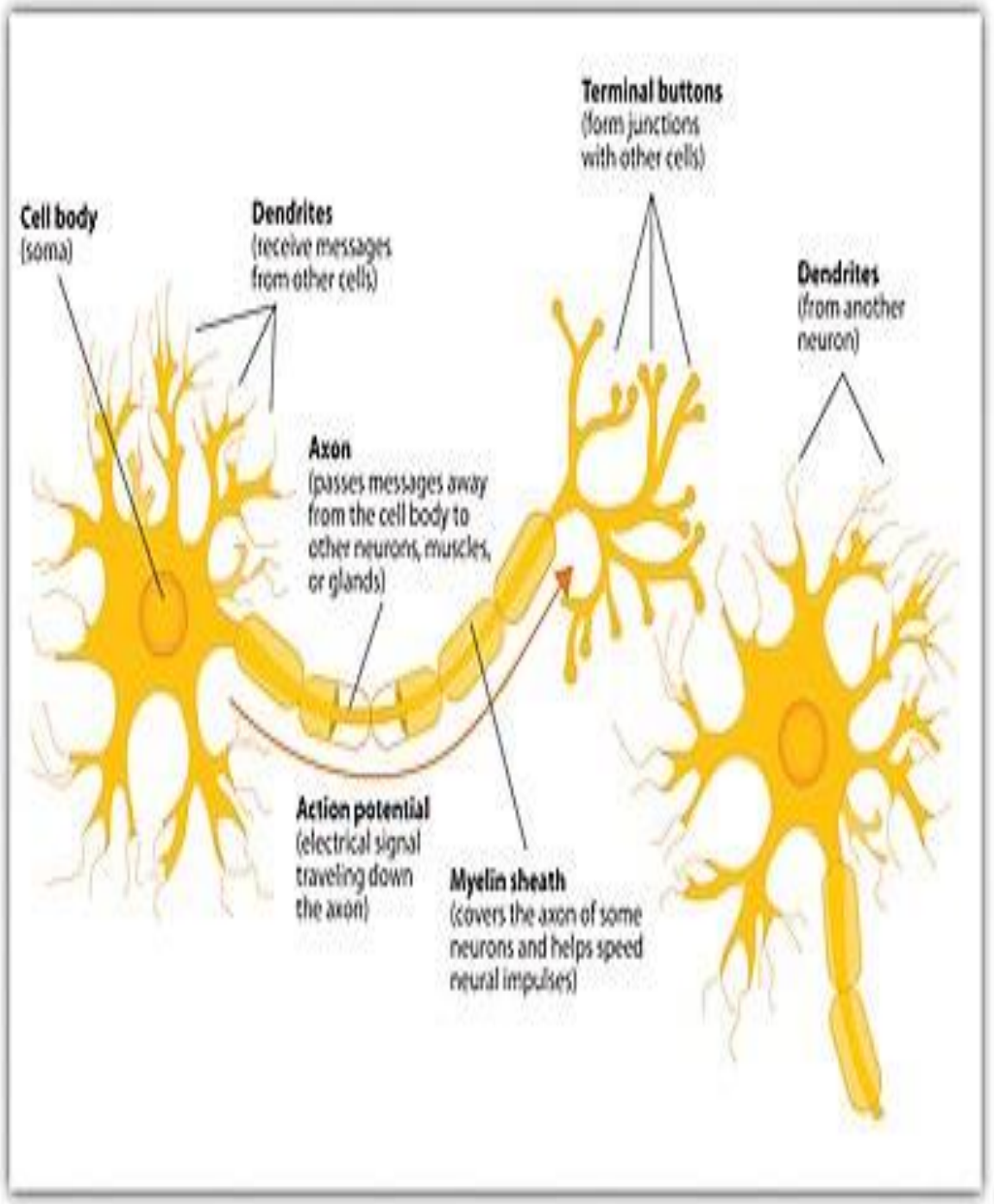
Neurons, also known as nerve cells

100 billion neurons (100,000,000,000)

100 km of nerves

100 billion non-neuron cells (100,000,000,000)

1 quadrillion synapses (1,000,000,000,000,000)



Neuroplasticity

- **This is the ability of the brain to re-organise neural pathways throughout lifespan as a result of experience.**
- **Brains ability to change with learning**
- **Without this ability, any brain, not just the human brain, would be unable to develop from infancy through to adulthood or recover from brain injury.**
- **It can be developmental or adaptive**
- **Developmental plasticity comprises four processes**

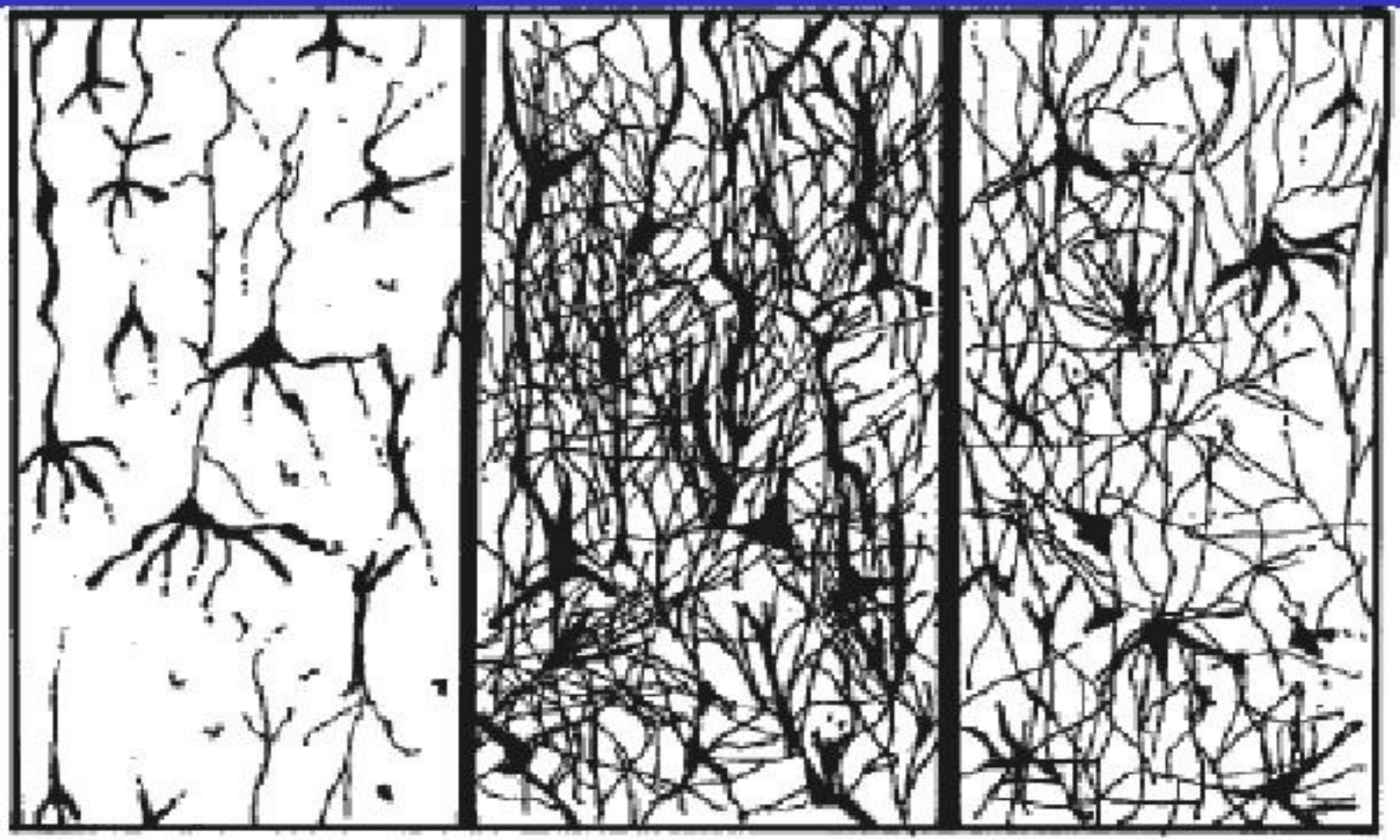
  Synaptogenesis,

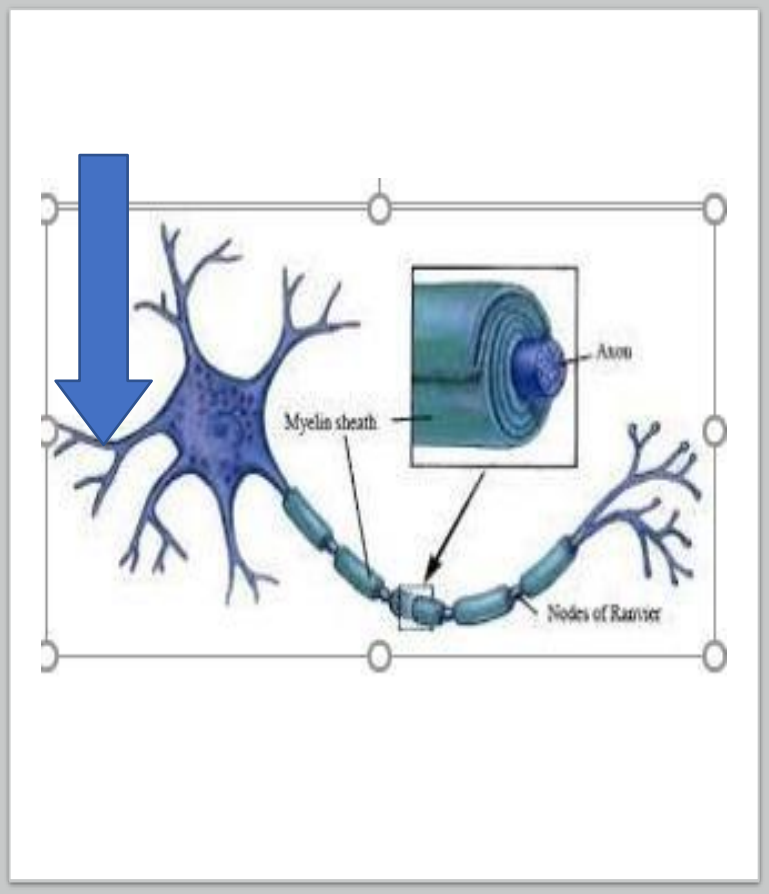
  Synaptic pruning,

  Neural migration and

  Myelination.

Developmental Plasticity





BRAIN MYELINATION PROMOTES

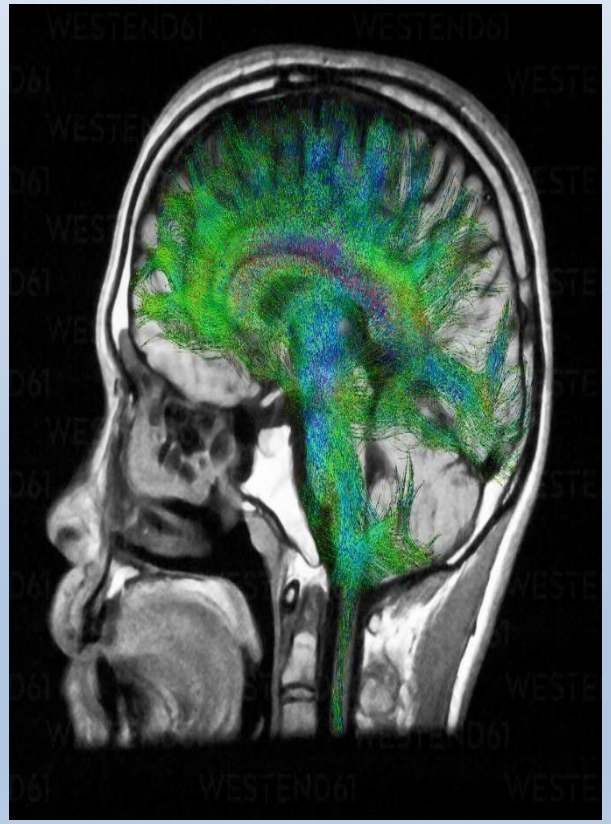
- General cognitive ability
- Good working memory
- Language and reading ability
- Sensory reactivity
- Processing speed

Supporting brain growth with key nutrients can positively affect brain development.

Choline

Sphingomyelin

Iodine



Lutein

DHA

HMOs

SPHINGOMYELIN(SM)

- SM is a type of sphingolipid found in animal cell membranes.
- Consists of phosphocholine and ceramide, therefore, classified as sphingophospholipids.
- In humans, SM represents ~85% of all sphingolipids, and typically make up 10–20 % of plasma membrane lipids.
- Sphingomyelin content in mammals ranges from 2 to 15% in most tissues, with higher concentrations found in nerve tissues, red blood cells, and the ocular lenses.

SPHINGOMYELIN (SM)

- Abundant in myelin sheath and important in myelin integrity, and axonal maturation
  - Myelination is the process by which fatty coating of the axon of neuron with myelin occurs
  - Myelin protects the neuron and ensures it conducts signals effectively
  - Begins before birth in the brain stem and cerebellum and completed in the frontal lobe in late adolescence
  - Human milk plays a vital role to a more rapid myelination in the brain

- SM is a relevant lipid during brain development.
- SM plays a prominent role from mid-gestation to the end of the first postnatal year when CNS myelin dramatically increases.
- SM plays an important role in cell processes , the regulation of inflammatory responses , and signal transduction .
- In summary, it is critical in myelin integrity and function

Effects of Dietary Sphingomyelin on Central Nervous System Myelination in Developing Rats

- **30 male rats were divided to 3 groups. Two groups were treated with an inhibitor to SM de novo synthesis, L-Cycloserine (LCS).**
  - **1. LCS group received treatment but no supplementation**
  - **2. SM-LCS group received treatment and supplementation**
  - **3. Non LCS group did not receive treatment or SM supplements (control)**
- **SM-LCS group had higher levels of brain weight, myelin dry weight and myelin total lipid content compared to LCS group**
- **But significantly lower in LCS and SM-LCS groups than non LCS group**

Oshida et al. Pediatric Research 2003; 53(4):589-93

Effects of Dietary Sphingomyelin on Central Nervous System Myelination in Developing Rats

- Results

	Experimental group		
	Non-LCS	LCS	SM-LCS
Brain wet wt (g)	1.67 ± 0.01[a]	1.55 ± 0.01[b]	1.64 ± 0.01[a]
Myelin dry wt (mg/brain)	24.4 ± 0.5[a]	12.9 ± 0.5[b]	21.7 ± 0.8[c]
Myelin total lipid content (mg/brain)	17.2 ± 0.5[a]	8.5 ± 0.2[b]	14.8 ± 0.4[c]

Values are mean ± SEM (n = 6)

*Values with different letters are significantly different at $p < 0.05$

Published in final edited form as:
Neuroimage. 2018 September ; 178: 649–659. doi:10.1016/j.neuroimage.2017.12.056.

Early nutrition influences developmental myelination and cognition in infants and young children

Sean Deoni[a,*], **Douglas Dean III**[b], **Sarah Joelson**[a], **Jonathan O'Regan**[c], and **Nora Schneider**[d]

[a]Advanced Baby Imaging Lab, Memorial Hospital of Rhode Island, Pawtucket, RI, United States [b]University of Wisconsin-Madison, Waisman Centre, Madison, WI, United States [c]Nestle Development Centre, Askeaton Co, Limerick, Ireland [d]Nestle Research Centre, Nestec Ltd, Neurodevelopment & Cognition, Lausanne, Switzerland

Longitudinal growth curves for each investigated brain region between the exclusively breastfed and formula-fed infants.

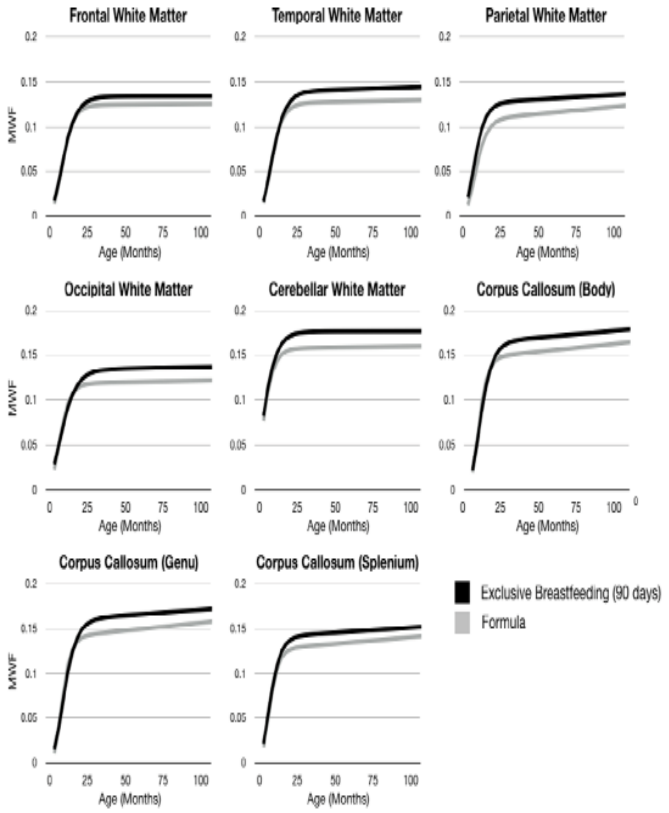
Scientific hypothesis: Certain ingredients in infant nutrition support de novo myelination and subsequent cognitive development and learning

Objectives

- To evaluate the longitudinal trajectories of brain and cognitive development in children exclusively breastfed versus formula-fed for at least 3 months
- To examine development between children who received different formula compositions

Study population: 62 breast-fed and 88 formula-fed infants

Longitudinal growth curves for each investigated brain region between the exclusively breastfed and formula-fed infants



Outcome:

- Exclusively breast-fed infants had significantly improved myelination as well as higher cognitive scores (within normal ranges) compared to exclusively formula-fed infants.

- Retrospective analyses of individual nutrients showed significant associations with myelin content for DHA, ARA, folic acid, sphingomyelin, iron, and phosphatidylcholine

Conclusion

- *Healthy human brain development represents the foundation of our civilization because the brain is the organ from which all our cognition and emotion originate.*

  Therefore, there is perhaps nothing more important for a society than to foster and protect the development of the brain of our children.

- LUBY JI JAMA PEDIATR. JULY 20, 2015. EDITORIAL.

References

1. Barbara MacFarland et al. Sphingomyelin Content in Breast Milk and Infant Formula: A Nutrient That May Affect Neurodevelopment. Advances in Nutrition 2017
2. Berger PK, Plows JF, Jones RB, et al. Human milk oligosaccharide 2'-fucosyllactose links feedings at 1 month to cognitive development at 24 months in infants of normal and overweight mothers. PLoS One. 2020;15(2):e0228323. Published 2020 Feb 12. doi:10.1371/journal.pone.0228323.
3. Hanson JL, Hair N, Shen DG, Shi F, Gilmore JH, Wolfe BL, et al. (2013) Family Poverty Affects the Rate of Human Infant Brain Growth. PLoS ONE 8(12): e80954. https://doi.org/10.1371/journal.pone.0080954
4. Deoni S, Dean D 3rd, Joelson S, O'Regan J, Schneider N. Early nutrition influences developmental myelination and cognition in infants and young children. Neuroimage. 2018 Sep;178:649-659. doi: 10.1016/j.neuroimage.2017.12.056.
5. Collell G and Fauquet J (2015) Brain activity and cognition: a connection from thermodynamics and information theory. Front. Psychol. 6:818. doi: 10.3389/fpsyg.2015.00818
6. World Development Report (2018). Poverty hinders biological development and undermines learning. In: Learning to realize education's promises. https://files.eric.ed.gov/fulltext/ED604389.pdf.
7. Oshida et al. Effects of Dietary Sphingomyelin on Central Nervous System Myelination in Developing RatsPediatric Research 2003; 53(4):589-93
8. . Leuret and Gratiolet, 1854; 2. Kasthuri N, et al. *Cell* 2015;162:648–681; 3. Wong A, et al. *Front Neuroengineering* 2013;6:1–22; 4. Ascoli G. *N Eng J Med* 2015;373:1170–2.
9. Yu ZT, Chen C, Kling DE, et al. The principal fucosylated oligosaccharides of human milk exhibit prebiotic properties on cultured infant microbiota. Glycobiology. 2013;23(2):169-177. doi:10.1093/glycob/cws138.


THANK YOU
MERCI
DANKE
GRACIAS
TERIMA KASIH
TAK
DANK U
DANKE
TACK
DANKESCHÖN
ありがとう
СПАСИБО
OBRIGADO
GRAZIE
MERCI
DANKESCHÖN
شكرا لك
GRACIAS
ĎAKUJEM
DZIĘKUJĘ
ΣΑΣ ΕΥΧΑΡΙΣΤΩ
תודה
KIITOS
OBRIGADO
TEŞEKKÜR EDERIM
DANK U
DANKESCHÖN
LOGOTYPE
MERCI
ORGANIZATION
THANK YOU
OBRIGADO
GRATIAS TIBI
TAKK
KÖSZÖNÖM
ÞAKKA ÞÉR
GRAZIE
GRATIAS
OBRIGADO
GRAZIE
#59472456